because the times during which these species move are well defined. Reducing flow through turbines beyond the design operating range can induce excessive vibration that can damage equipment. In addition, turbine efficiency decreases significantly when turbine flows are reduced below the optimal range of operation, which reduces energy generation. Deliberately reducing generation is not a viable option for protecting fish at the Chippewa River projects because no diadromous fish species are present in their vicinity and because of the potential to damage equipment.

4.3.2 FISH-FRIENDLIER TURBINES

Two turbine designs promoted as being "fish friendly" are the helical Alden turbine designed by Alden Research Laboratory, Inc., and the minimum gap runner (MGR), a type of Kaplan turbine designed by Voith. Alden turbines have been tested primarily using computational fluid dynamic models that have not been verified in the field. Studies of an MGR installed at Bonneville dam in Washington State demonstrated a 2 percent reduction in mortality (down from 4 percent for a standard Kaplan turbine) for fish near the blade tip. Fish along the mid-blade area sustained lower mortality (about 1 percent, down from 2 percent); however, at the hub of the turbine, fish mortality at the MGR was 0.5 percent greater than the mortality expected at a standard Kaplan turbine. A 2007 assessment of an MGR installed at Wanapum Dam (Washington State) demonstrated no statistical difference in blade strike, shear, or other types of injury compared to conventional Kaplan turbines (Dauble et al. 2007).

The helical Alden turbine was originally designed for use with net head between 75 feet and 100 feet, although design modifications are speculated to extend feasible use to a lower limit of 30 feet. The Chippewa Falls and Dells projects have just below 30 feet of gross head; the other four projects evaluated herein have gross heads ranging between 37 and 57 feet. The modified design with the extended range, therefore, could be applied to these projects, but doing so would constitute pilot tests of the Alden turbine outside of the current design range. The MGR turbines are custom-designed Kaplan machines with spherical hubs, and blades contoured to match a spherical discharge ring insert. The applicability to projects, therefore, is identical to that of Kaplan machines. Each of the Chippewa River projects has a gross head well within the range of the Kalpan turbine.

Cost estimates for the Alden turbine are indexed by 3 percent annually for a 2016 cost of $1,680 a kilowatt (EPRI 2011). This cost estimate includes the generator, which would have to be replaced at some projects to accommodate the slower rate of rotation associated with the Alden design, but does not include costly civil modification of the powerhouses that would be necessary at every project because of the different geometry of the Alden turbine. The total cost to install Alden turbines is estimated to range between $20 million and $94 million for each hydroelectric project.

The cost to install the MGR turbines was estimated using recent bids for Kaplan turbines, which average approximately $530 a kilowatt, resulting in an equipment cost ranging between $6 and $30 million. No actual MGR quotes were solicited for this effort, but equipment costs would be expected to exceed this indexed estimate due to custom-designed elements associated with the technology. Moreover, this indexed cost does not include equipment installation or civil modifications, the combination of which could easily match or surpass estimated equipment costs. The total cost of installing MGR turbines is estimated to range between $12 million and $60 million for each hydroelectric project.

Given the expense, the major structural upgrades required (similar in scale to completely redeveloping a site), and the uncertainty concerning the biological benefits, installing fish-friendlier turbines is not a viable alternative for protecting fish at the Chippewa River projects.

5.0 DETAILED EVALUATION OF SELECTED ALTERNATIVES

Limited advancements in downstream fish passage and protection technologies at hydropower projects have been made in the past 10 to 20 years. Many of the physical, behavioral, and operational alternatives described in Section 4.0 are likely to be ineffective for protecting small resident fish in the Chippewa River; would require major, costly changes that exceed the funds that Xcel Energy has dedicated to fish protection pursuant to the Settlement; or are in various stages of development. Newly constructed downstream fish protection systems at hydropower projects typically rely on existing, straight-forward technologies such as narrowly spaced trashrack systems, full-depth or partial-depth guidance devices leading to downstream fish bypasses, angled rack structures, or barrier nets; therefore, we reviewed the feasibility of these standard protection alternatives for resident fish species at the Holcombe, Cornell, Jim Falls, and Dells hydroelectric projects. Fish protection technologies at hydropower intakes have not changed significantly since Xcel Energy completed its fish protection study at the Wissota Project in 1997; therefore, we selected two options identified in the 1997 study and updated the opinion of probable construction costs to the current dollar value.

Our analysis focuses on screening measures (i.e., trashrack bars) that have 1-inch clear openings, which is a standard USFWS design recommendation for fish protection at hydropower intakes. Although narrower screens can be used, they are not likely to be biologically effective or cost-effective because they will result in water velocities that may impinge fish, cause more head loss across the trashracks, and significantly increase debris loading and maintenance. Based on the results of Xcel Energy's fish entrainment study at the Wissota Project in the late 1990s, which demonstrated that the majority of entrained fish were less than 3 inches long and 96% were less than 6 inches long (GLEC 2000), fish protection measures with trashrack bars spaced wider than 1-inch were excluded from this evaluation because they would not prevent the entrainment of small resident fish species. Table 2 provides a summary of the options that we considered for each site. The intake at the Jim Falls minimum flow powerhouse already has narrowly spaced bar racks with approach velocities less than 2.0 fps; therefore, we considered no additional alternatives for that unit. The Chippewa Falls Project intake is also retrofitted with 1-inch clear spacing between bars; therefore, that facility was excluded from the fish protection alternatives analysis.

TABLE 2 FISH PROTECTION ALTERNATIVES AT THE DELLS, JIM FALLS, CORNELL, AND HOLCOMBE HYDROELECTRIC PROJECTS

ALTERNATIVE DESCRIPTION	HOLCOMBE	CORNELL	JIM FALLS	WISSOTA	DELLS
Replace existing trashracks with narrowly spaced trashracks	x	x	x		x
Inclined bar rack structure with full-depth, narrowly spaced trashracks	x			x	x
Angled bar rack structure with full-depth, narrowly spaced trashracks		x	x		
Floating barrier net system	x	x	x	x	

Our analysis of these alternatives considered the following:

- engineering feasibility;
- material selection;
- civil/structural concerns with regard to location, concept configurations, and loads on system elements;
- operation and maintenance requirements;
- general acceptability of technology with resource agencies; and,
- biological effectiveness.

In addition, we prepared opinions of probable construction and maintenance costs, analyzed head loss and effects on energy generation, assessed the effects of the measures on turbine operations, and assessed the potential for entrainment and impingement of resident species of management interest, where applicable.

5.1 TRASHRACKS WITH NARROWLY SPACED BARS

This option involves replacing the existing trashracks at the Holcombe, Cornell, Jim Falls, and Dells projects with new trashracks that have narrowly spaced steel bars. Vertical trashrack bars would be 0.375-inch thick with horizontal tie-rods placed at 3-foot intervals to prevent spreading as a result of debris accumulation. Although a trashrack system with narrowly spaced bars would deter fish from swimming through the intakes volitionally and would reduce entrainment of large-bodied fish, through-rack velocities (i.e., the velocity of the water as it accelerates through the trashrack bars) would increase, potentially increasing the number of fish impinged on the racks. Appendix A provides calculations of through-rack velocity at each turbine intake resulting from the installation of narrowly spaced trashracks (i.e., 1-inch clear opening).

Table 3 summarizes our assessment of the operational requirements and maintenance requirements, engineering feasibility, and biological feasibility of this option. Table 4 provides our opinion of probable construction costs and the estimated annual operation and maintenance costs. This estimate does not include additional indirect costs associated with owner's administration, finance, insurance, outages associated with installation, or other non-capital costs. We expect Xcel Energy would not be able to use the existing debris raking systems, and replacement estimates are provided.

Additional cleaning and rack maintenance would be required, including semiannual underwater inspections to assess rack integrity and clear debris that becomes wedged between vertical bars. A system for monitoring head on both sides of the racks also would be necessary to detect head loss resulting from excessive debris loading. Narrowing the spacing between bars in trashracks may result in accumulation of frazil ice (i.e., super-cooled slush freezing to structures on contact) by intercepting more ice and providing more nucleation surface upon which ice can form, which would increase head loss and reduce generation. Frazil ice can accumulate rapidly and can completely cover a trashrack. For these reasons, a fully automated raking system would be required to keep racks clear.

TABLE 3 FEASIBILITY CONSIDERATIONS FOR TRASHRACKS WITH NARROWLY SPACED BARS

ENGINEERING FEASIBILITY?	FEASIBLE
Material selection	Steel bar-rack system
Construction methods/techniques	Replacement of existing trashracks (in the wet)
Civil/structural issues	Assumes the existing intake structure is capable of supporting the loads from the new racks
Operation and maintenance requirements	Additional cleaning and monitoring, increased debris load, will require modifications of the existing trash rake, potential frazil ice issues
Construction/installation concerns	Assumes the existing intake support structures are in good condition and will not require replacement
Acceptability of technology	Standard recommended by resource agencies
Biological considerations	1-inch spacing unlikely to prevent entrainment of juvenile resident fish species; increased through-rack velocities for trashracks less than or equal to 1-inch likely to increase number of fish impinged

TABLE 4 OPINION OF PROBABLE COSTS FOR TRASHRACKS WITH NARROWLY SPACED BARS

PROJECT	CONSTRUCTION COSTS	ANNUAL O & M COSTS*
Holcombe	$1,872,000	$41,000/yr.
Cornell	$1,207,000	$41,000/yr.
Jim Falls	$1,734,000	$41,000/yr.
Dells	$1,900,000	$41,000/yr.
TOTAL	**$6,713,000**	**$164,000/yr.**

*Assumes that two operators have to spend an average of one additional hour every other day to clean the racks.

5.2 ANGLED BAR RACK WITH NARROWLY SPACED BARS

This option would involve installing new, full-depth, angled bar rack structures upstream of the intakes for the Cornell and Jim Falls projects. The angled bar rack structures would extend from the spillway side of each powerhouse upstream to the forebay wall at an angle of 15 to 45 degrees. The structures would have narrowly spaced, steel-bar racks with 0.375-inch-thick bars and horizontal tie-rods placed at 3-foot intervals to prevent spreading as a result of debris accumulation. The angle of the bar rack would be selected to provide enough rack area to limit approach velocities to 2.0 fps to reduce entrainment and impingement.

Figure 2 below shows an example of what an angled bar rack structure would look like at a generic hydroelectric site. Detailed sketches of the proposed layout of angled bar rack structures at the Cornell and Jim Falls Projects are included in Appendix F.

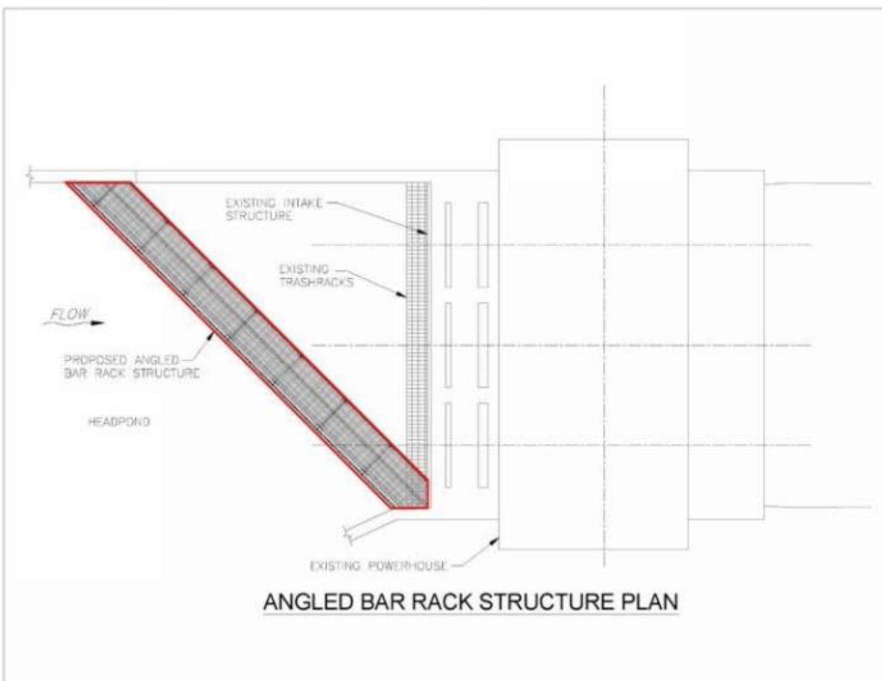

FIGURE 2 ANGLED BAR RACK STRUCTURE - PLAN VIEW

Table 5 summarizes our assessment of the operations and maintenance requirements, engineering feasibility, and biological feasibility of this option. Table 6 provides our opinion of probable construction costs and the estimated annual operation and maintenance costs. This estimate does not include additional indirect costs associated with owner's administration, finance, insurance, outages associated with installation, or other non-capital costs. Our cost estimate assumes that Xcel Energy would need to install new debris-cleaning rakes.

Additional cleaning and rack maintenance would be required, including semiannual underwater inspections to assess rack integrity and clear debris that becomes wedged between vertical bars. New fully automated mechanical trash rakes would be required for cleaning and maintaining the angle bar racks. A system for monitoring head on both sides of the racks also would be necessary to detect head loss resulting from excessive debris loading. Narrowing the rack bar spacing may result in increased accumulation of frazil ice (i.e., super-cooled slush freezing to structures on contact) by intercepting more ice and providing more nucleation surface upon which ice can form, which would increase head loss and reduce generation.

An angled bar rack is impractical at the Holcombe Project because of the high cost of construction and because the existing approach velocities are already very close to 2.0 fps.

TABLE 5 FEASIBILITY CONSIDERATIONS FOR ANGLED BAR RACK SYSTEM

ENGINEERING FEASIBILITY?	FEASIBLE
Material selection	Steel bar-rack system
Construction methods/techniques	New construction (in the wet)
Civil/structural issues	Assume bedrock is present for intake structure foundation; structural design for fully blinded racks due to increased potential for ice buildup
Operation and maintenance requirements	Additional cleaning and monitoring, increased debris load
Construction/installation concerns	Construction will likely need to be completed in the wet with a barge and divers
Acceptability of technology	Recommended by resource agencies on site-specific basis
Biological considerations	1-inch spacing unlikely to prevent entrainment of juvenile resident fish species

TABLE 6 OPINION OF PROBABLE COSTS FOR ANGLED BAR RACK SYSTEM

PROJECT	CONSTRUCTION COSTS	ANNUAL O & M COSTS*
Cornell	$6,984,000	$131,000/yr.
Jim Falls	$4,681,000	$111,000/yr.
TOTAL	**$11,665,000**	**$242,000/yr.**

* Assumes that two operators have to spend an average of two additional hours per day every other day to clean the racks.

5.3 INCLINED BAR RACK WITH NARROWLY SPACED BARS

This option would involve installing new, inclined trashracks at the Holcombe, Wissota, and Dells projects. The inclined trashracks would be positioned slightly upstream of the powerhouse intake area for each turbine; the angle of the racks would range from approximately 15 to 45 degrees. The structure would have narrowly spaced 0.375-inch-thick steel bars and horizontal tie-rods placed at 3-foot intervals to prevent spreading as a result of debris accumulation. The narrowly spaced bars would reduce the ability of fish to swim through volitionally or to be entrained through the intake. The inclination of the rack would be selected to provide enough rack area to limit approach velocities to 2.0 fps to reduce entrainment and impingement. This option was not considered at other intakes because the inclined racks would result in approach velocities greater than 2.0 fps.

Figure 3 and Figure 4 show an example of what an inclined trashrack structure would look like at a generic hydroelectric site. Detailed sketches of the proposed layout of inclined trashrack structures at the Holcombe, Wissota and Dells Projects are included in Appendix F.

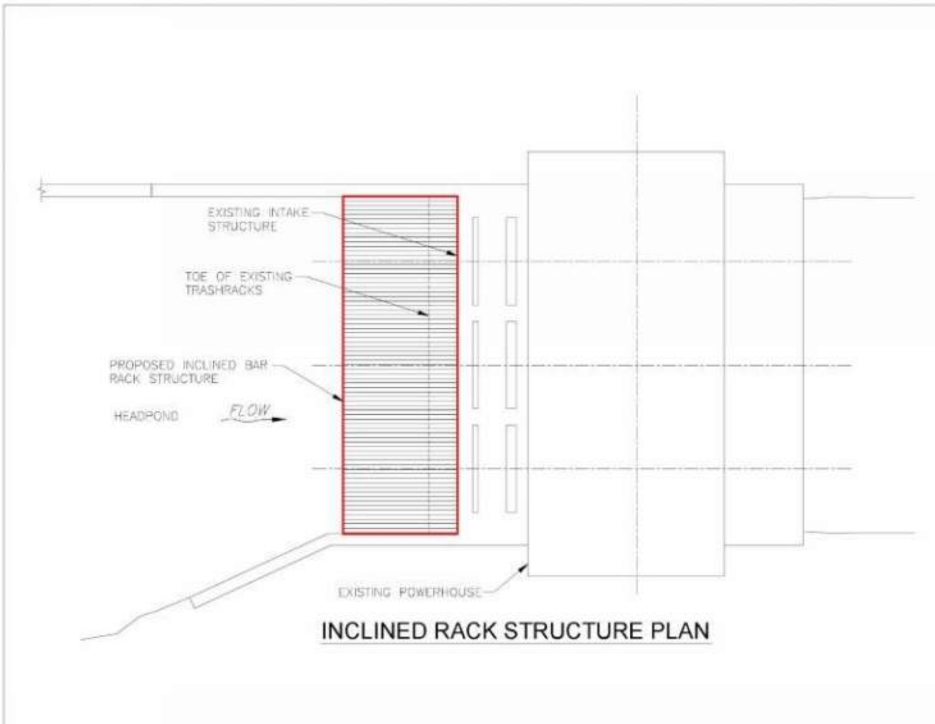

FIGURE 3 INCLINED TRASHRACK STRUCTURE - PLAN VIEW

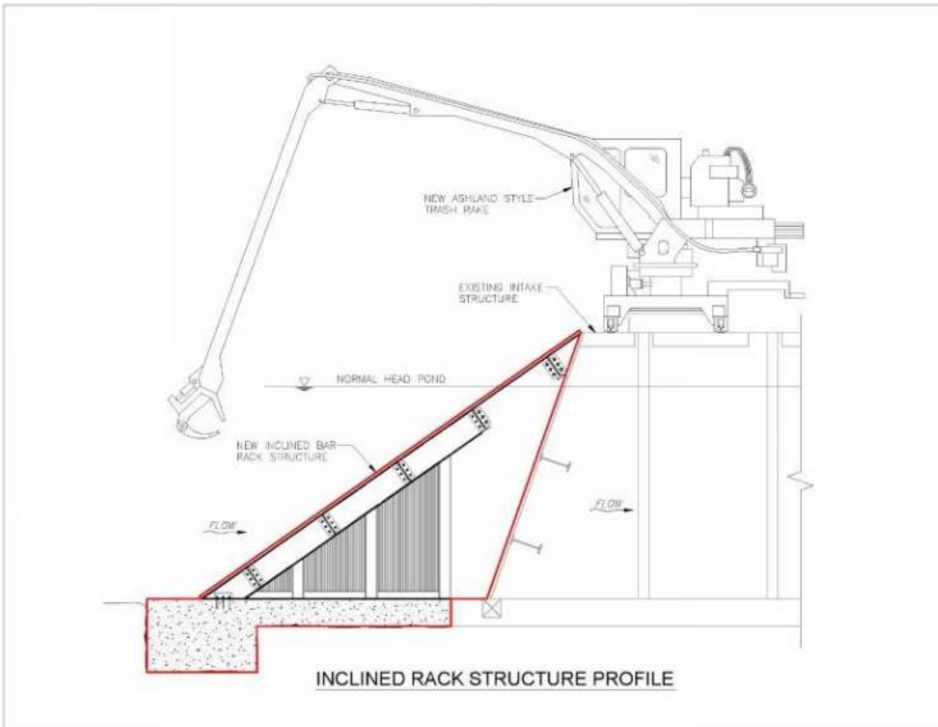

FIGURE 4 INCLINED TRASHRACK STRUCTURE - PROFILE VIEW

Table 7 summarizes our assessment of the operations and maintenance requirements, engineering feasibility, and biological feasibility of this option. Table 8 provides our opinion of probable construction costs and the estimated annual operation and maintenance costs. This estimate does not include additional indirect costs associated with owner's administration, finance, insurance, outages associated with installation, or other non-capital costs.

New fully automated mechanical trash rakes would be required for cleaning and maintaining the racks. Additional cleaning and rack maintenance would be required, including semiannual underwater inspections to assess rack integrity and clear debris that becomes wedged in between vertical bars. A system for monitoring head on both sides of the racks also would be necessary to detect head loss resulting from excessive debris loading. The inclined rack may result in increased accumulation of frazil ice by intercepting more ice and providing more nucleation surface upon which ice could form.

TABLE 7 FEASIBILITY CONSIDERATIONS FOR INCLINED RACK SYSTEM

ENGINEERING FEASIBILITY?	FEASIBLE
Material selection	Steel bar-rack system
Construction methods/techniques	New construction (in the wet)
Civil/structural issues	Assume bedrock is present for intake structure foundation; structural design for fully blinded racks due to increased potential for ice buildup
Operation and maintenance requirements	Additional cleaning and monitoring, increased debris load
Construction/installation concerns	Construction will likely need to be completed in the wet with a barge and divers
Acceptability of technology	Recommended by resource agencies
Biological considerations	1-inch spacing unlikely to prevent entrainment of juvenile resident fish species; increased through-rack velocities for trashracks less than or equal to 1-inch likely in increase number of fish impinged

TABLE 8 OPINION OF PROBABLE COSTS FOR INCLINED RACK SYSTEM

PROJECT	CONSTRUCTION COSTS	ANNUAL O & M COSTS*
Holcombe	$3,518,000	$66,000/yr.
Wissota	$5,851,000	$110,000/yr.
Dells	$3,680,000	$66,000/yr.
TOTAL	**$13,049,000**	**$242,000/yr.**

* Assumes that two operators have to spend an average of one additional hour per day every other day to clean the racks.

5.4 FLOATING BARRIER NET

This option involves installing a full-depth, heavy-duty netting system just upstream of the Holcombe, Cornell, Jim Falls and Wissota intakes. For these sites the barrier net would be L-shaped, extending from the spillway side of each powerhouse directly upstream to an anchor point in the existing forebay and then extending from the anchor point at a 90-degree angle over to the forebay wall or shoreline. The nets would be constructed of knotless, heavy-duty material (e.g., Dyneema)[4] with a small mesh opening (i.e., less than 1 inch). Although nets would be coated with a material that prevents bio-fouling, debris loading and cleaning could be considerable. Nets would be anchored to the bottom of the channel or canal bed and suspended from large floating booms. The nets probably would be installed seasonally during the period when freezing of the headpond was not a concern. Debris fouling could be a significant issue because the nets cannot be cleaned easily like trashracks. Xcel Energy would need to deploy divers regularly to clean the nets and annually to retrieve them to prevent damage due to ice or debris. The potential for the nets and anchoring system to fail under a heavy debris load may limit the feasibility of this option. The floating barrier net would reduce the ability of fish to swim through the intake volitionally or to be entrained. The layout of the net would be selected to provide enough area to limit approach velocities to be less than 1.0 fps to reduce entrainment and impingement. This option is infeasible at the Dells Project due to heavy debris loading in the impoundment.

Detailed sketches of the proposed layout of barrier nets at the Holcombe, Cornell, Jim Falls, and Wissota Projects are included in Appendix F. Table 9 summarizes our assessment of the operations and maintenance requirements, engineering feasibility, and biological feasibility of this option. Table 10 provides our opinion of probable construction costs and the estimated annual operation and maintenance costs. This estimate does not include additional indirect costs associated with owner's administration, finance, insurance, outages associated with installation, or other non-capital costs.

[4] Strong light fiber used in commercial fishing and aquaculture operations made from ultra-high molecular weight polyethylene.

TABLE 9 FEASIBILITY CONSIDERATIONS FOR FLOATING BARRIER NET

ENGINEERING FEASIBILITY?	FEASIBLE
Material selection	Dyneema or comparable netting, concrete anchors, floating booms
Operations and maintenance requirements/issues	Additional cleaning and debris loading; annual removal and installation to prevent damage from ice; dive inspections; replacement or mending of nets if damage from woody debris occurs
Construction methods/techniques	Cranes or boom-truck; divers required
Civil/structural issues	Loads on anchors for floating boom will be significant
Acceptability of technology	Has been used in the Mid-West in some situations
Biological considerations	Typically, effective for larger bodied fish, may cause impingement in nets, resulting in injury or mortality; may dissuade smaller fish from entering the intake areas

TABLE 10 OPINION OF PROBABLE COSTS FOR FLOATING BARRIER NET

PROJECT	CONSTRUCTION COSTS	ANNUAL O & M COSTS*
Holcombe	$1,072,000	$80,000/yr.
Cornell	$1,542,000	$90,000/yr.
Jim Falls	$1,158,000	$80,000/yr.
Wissota	$933,000	$60,000/yr.
TOTAL	**$4,705,000**	**$310,000/yr.**

* Assumes that a dive team will be on site for installation, removal, and cleaning twice per year (spring and fall).

5.5 WISSOTA FISH PROTECTION

No significant advances in downstream fish protection technology have been made since Xcel Energy completed the conceptual design study of fish protection alternatives at the Wissota Project in 1997. Therefore, we reviewed two options identified in the 1997 study (i.e., floating barrier net and an inclined intake structure with full-depth, narrowly spaced trashracks) and updated the costs to 2016 dollars. The cost for the floating barrier net was scaled using the historical cost index from RS Means. Since no cost was included in the 1997 study for a new inclined intake structure the cost was scaled from the angle bar rack structure for Jim Falls because the required length and incline were similar to what would be required for Wissota. Our opinion of probable construction costs and the estimated annual operation and maintenance costs for the floating barrier net and inclined intake structure are provided in Table 8 and Table 10.

6.0 HEAD LOSS ANALYSIS

Head loss values at each turbine were calculated for each project, except Chippewa Falls. As flow enters the turbine bays, the physical obstruction caused by the bars on the intake rack reduces the gross flow area, which results in increased water velocity through the rack (i.e., through-rack velocity). Greater velocities cause increased drag forces, represented as dynamic head losses. The primary obstruction for clean intake racks is due to the thickness of the vertical bars (typically 3/8 inch) and the clear spacing between them (varies); therefore, reducing the spacing between the vertical bars represents a direct increase (non-linear) in dynamic head loss. Debris that collects on the intake racks partially blocks the intake, effectively reducing the gross area. This "blinding" of the intake racks further increases water velocity through the remaining open areas, contributing to the dynamic head losses.

We examined head losses for the existing rack configurations and the alternatives selected for further review. Each site was analyzed for a range of trashrack blinding conditions as well as 1-inch bar spacing. Four percentages of trashrack blinding were examined: 0, 15, 25, and 50. Dimensions of the trashracks were obtained from historical project drawings and measurements taken during a site visit. Table 11 summarizes the alternatives analyzed for each site. Head loss is considered to be minimal for the floating barrier net alternatives.

TABLE 11 FISH PROTECTION ALTERNATIVES REVIEWED IN DETAIL

PROJECT	SELECTED ALTERNATIVES
Holcombe	- Replace existing trashracks with narrowly spaced bar racks - Inclined intake structure with full-depth narrowly spaced trashracks
Cornell	- Replace existing trashracks with narrowly spaced bar racks - Angled bar rack structure with full-depth narrowly spaced trashracks
Jim Falls	- Replace existing trashracks with narrowly spaced bar racks - Angled bar rack structure with full-depth narrowly spaced trashracks
Wissota	- Replace existing trashracks with narrowly spaced bar racks - Inclined intake structure with full-depth narrowly spaced trashracks
Dells	- Replace existing trashracks with narrowly spaced bar racks - Inclined intake structure with full-depth narrowly spaced trashracks

6.1 METHODS

For the inclined racks, the trashracks were assumed to be at an incline of approximately 15 to 45 degrees. The depth of rack in the water was increased to account for the incline in the bars. For the angled bar racks, the racks were assumed to have a slight incline of 15 degrees, so the depth of rack in the water was assumed to be equal to the difference between the headpond and invert elevations. Using the bar spacing, bar widths, and any supports attached to the bars, the total blocked area was calculated and subtracted from the gross area to obtain the net flow area through the trashracks.

The head losses through each rack were calculated using the formula $H_L = K*(V^2/2g)$, where:

H_L = head loss (feet)
K = loss coefficient
V = flow velocity through the rack (feet/second)
g = gravitational constant (feet/second squared)

The loss coefficient K was determined for each bar spacing option using the equation $K = 1.45 - 0.45R - R^2$ (Creager and Justin 1950), where R is the ratio of net rack flow area to gross rack area. The loss coefficient remains constant for all percentages of rack blinding because it represents the hydraulics associated with flow through the bars and their spacing in each rack.

Field observations at some of the intakes indicated a higher head loss than calculated. This may be attributed to partial blinding during the observation, hydraulic complexities such as cross-flow or end contractions, or higher flows through some units. Given these conditions, the observed head losses were assumed to be associated with the 15 percent blinded condition; incremental increases were added to those based on the calculated values. The incremental increase added to the projects was based on the reported observations and varied among the sites.

The through-rack velocity was calculated as part of the head loss calculations at each turbine intake. The through-rack velocities were then used in our analysis of the potential for impingement (Section 9.0). Table 12 summarizes the assumptions for the head loss calculations at each site, and the calculations are included in Appendix B.

TABLE 12 ASSUMPTIONS FOR HEAD LOSS ANALYSIS

	Holocombe Units 1-3		Cornell EC and NSTR		Cornell Units 1-4	Jim Falls Units 1 and 2[b]		Wissota EC and NSTR		Wissota Units 1-6	Dells EC and NSTR			Dells Inclined Racks and NSTR
	EC & NSTR	Inclined Racks & NSTR	Units 1-3	Minimum Flow Unit 4	Angled Bar Rack & NSTR	EC & NSTR	Angled Bar Rack & NSTR	Units 1 & 4	Units 2, 3, 5, & 6	Inclined Racks & NSTR	Unit 1	Units 2-4	Unit 5	Units 1-5
Total Rack Length (ft)	111	140	105	9.08	365	86	116.33	52	104	90	36	73	24	162
Rack Invert Elevation (ft)	997.5	997	982.2	977.5	982[a]	890.35	890.35	871	871	871	777	774.75	774.75	774.75
Normal Headpond Elevation (ft)	1,045	1045	1002	1,002	1002	953.2	952.2	898	898	898	795	795	795	795
Depth of Trashrack in Flow (ft)	47.50	48.00	19.80	24.50	20.00	46.34	46.34	27.95	27.95	67	18.70	20.95	20.95	31.00
Gross Area (ft^2)	1,757.5	6,720.0	693.0	222.5	7,300.0	1,992.6	5,390.7	726.7	726.7	6030	635.6	502.8	502.8	5,022.0
Total Flow Capacity (cfs)	10,800	10,800	11,250	400	11,650	13,500	13,500	3,700	5,760	9460	1,800	4,275	800	6,875
Incremental Loss Factor (ft)	0	0	0.25	0	0.25	1.0	1.0	0.0	0.0	0.0	0.3	0.5	0.2	1.0

[a] Invert of trashrack assumed to be at same elevation as Units 1-3.
[b] Head loss calculations do not include the minimum flow unit for Jim Falls.
EC = Existing conditions
NSTR = Narrowly spaced trashrack

6.2 Results

Table 13 summarizes the results of the analysis. Generally, head losses increase as the spacing between bars decreases because decreasing bar spacing results in decreased net flow area and increased flow velocities through the racks. The effect of blinding increases as the spacing between the bars decreases. For example, at Cornell, 25 percent blinding over the existing units would result in an incremental increase in head loss of 0.01 foot compared with clear racks. The same blinding comparison with 1.0-inch spacing results in an incremental increase in head loss of 0.4 foot.

Careful consideration of the increased rate of blinding that occurs with narrower rack spacing is warranted. Although the calculated head loss associated with reduced bar spacing is not significant, it results in smaller debris accumulating on the intake that would pass through under current conditions. The accumulation of smaller debris will increase the blinding rate quickly, which has a greater effect than the rack spacing. Narrower spacing has an identical effect on ice buildup. When blinding by debris or icing increases, increasing velocity through the racks increases end contractions, which effectively reduce the area of the racks through which flow passes. These compounding effects are difficult to account for with reasonable accuracy, and this analysis does not account for them specifically. Cleaning racks frequently is important to avoid rapidly increasing head losses with narrower bar spacing. Even with good raking equipment, blinding can require almost continuous cleaning of racks.

TABLE 13 CALCULATED HEAD LOSS (FEET)

	0% Blind	15% Blind	25% Blind	50% Blind
HOLCOMBE UNITS 1-3				
Existing conditions (5-inch bar spacing)	0.0	0.0	0.0	0.1
Replace existing trashracks with narrowly spaced racks	0.1	0.1	0.2	0.4
Inclined rack structure with full-depth, narrowly spaced racks	0.1	0.1	0.1	0.2
CORNELL UNITS 1-3				
Existing conditions (6-inch bar spacing)	0.4	0.4	0.4	0.7
Replace existing trashracks with narrowly spaced racks	0.9	1.1	1.3	2.7
CORNELL MINIMUM FLOW UNIT 4				
Existing conditions (3-inch bar spacing)	0.0	0.1	0.1	0.2
Replace existing trashracks with narrowly spaced racks	0.2	0.2	0.3	0.7
CORNELL UNITS 1-4				
Angled rack structure with full-depth, narrowly spaced racks	0.3	0.3	0.4	0.5
JIM FALLS UNITS 1 AND 2				
Existing conditions (5-inch bar spacing)	1.0	1.1	1.1	1.2
Replace existing trashracks with narrowly spaced racks	1.2	1.3	1.4	2.0
Angled rack structure with full-depth, narrowly spaced racks	1.1	1.1	1.1	1.2
WISSOTA UNITS 1 AND 4				
Existing conditions (3.75-inch bar spacing)	0.0	0.1	0.1	0.2
Replace existing trashracks with narrowly spaced racks	0.2	0.2	0.3	0.7
WISSOTA UNITS 2, 3, 5, AND 6				
Existing conditions (3.75-inch bar spacing)	0.0	0.0	0.0	0.1
Replace existing trashracks with narrowly spaced racks	0.1	0.1	0.2	0.4
WISSOTA UNITS 1-6				
Inclined rack structure with full-depth narrowly-spaced racks	0.1	0.1	0.1	0.2
DELLS UNIT 1				
Existing conditions (5-inch bar spacing)	0.3	0.3	0.3	0.4
Replace existing trashracks with narrowly spaced racks	0.4	0.4	0.5	0.7
DELLS UNITS 2-4				
Existing Conditions (5-inch bar spacing)	0.5	0.5	0.5	0.6
Replace existing trashracks with narrowly-spaced racks	0.6	0.7	0.7	1.0
DELLS UNIT 5				
Existing conditions (5-inch bar spacing)	0.2	0.2	0.2	0.2
Replace existing trashracks with narrowly spaced racks	0.2	0.2	0.3	0.3
DELLS UNITS 1-5				
Inclined rack structure with full-depth, narrowly spaced racks	1.0	1.0	1.0	1.1

7.0 POTENTIAL EFFECTS OF HEAD LOSS ON TURBINE OPERATIONS

Turbine water passages should provide adequate hydraulic capacity and steady-state flow paths under the full operating range, which is important for operating efficiently and ensuring that equipment remains in reliable condition. Flow accelerates 10-fold between the intake and the turbine, and adequate intake depth should be provided to prevent strong vortices from extending into the turbine. Vortices can cause excessive vibration that can damage equipment, and air entrained by strong vortices can reduce generating efficiency. Increases in head loss associated with narrower trashrack bar spacing or increased blinding can effectively reduce turbine submergence. A cursory review of turbine submergence at each project was performed to identify turbines susceptible to operational problems due to increased head loss.

7.1 METHODS

Where applicable, the predicted submergence requirement was calculated using an empirically derived equation, the Gordon formula (ASCE, 1995). This calculation of recommended minimum submergence is based on the depth of the intake, the velocity at the intake entrance, and a coefficient related to flow uniformity. The simplest application of the equation is for a well-defined horizontal intake, such as a penstock opening or an immediate transition from a vertical wall to a horizontal conveyance. A horizontal intake often is absent at hydro projects, especially those with intakes that are integral with powerhouses, like the Chippewa River projects; therefore, we considered multiple locations for each unique turbine and bay, particularly intake gate slots and places where intake geometry changes abruptly. This simplistic approach provides order-of-magnitude estimates. Where actual submergence is close to the calculated requirement, these estimates offer no assurance that exiting submergence is adequate to prevent problems.

Flows were reported by Xcel Energy personnel, and all dimensions and geometry information used in the analysis is as represented on drawings provided by Xcel Energy. The Chippewa Falls Hydro Project was excluded from this evaluation because its trashracks already have 1-inch clear spacing between the bars; the minimum flow unit at Jim Falls was excluded for the same reason.

7.2 RESULTS

Most turbines at most of the projects appear to have adequate submergence for the reported flows, such that head loss associated with installing racks with narrowly spaced bars would not be expected to affect turbine operation negatively. Submergence appears to be inadequate to accommodate significantly increased head loss at some units at the Cornell and Dells projects, as described in the following paragraphs.

The water passage for the three large units at Cornell appears to be defined by an inclined entrance directly below the radial gates; however, it is not clear whether the conveyance starts with a circular cross-section or a rectangular cross-section that transitions gradually to circular. Assuming a circular entrance produces a smaller entrance surface area than assuming a rectangular entrance and results in velocity such that the actual submergence (19.8 feet) is slightly below the calculated 21.4 feet of submergence recommended to accommodate the head loss expected with racks with narrowly spaced bars. This assumes a non-uniform flow, which would be expected with a sharp entrance that lacks a rounded or beveled edge. Given the potentially large head losses calculated for these units (i.e., 2.7 feet with 50-percent blinding; Table 14), the potential effects of reduced submergence are worthy of concern. When evaluated as a rectangular entrance with a gradual transition to round, the entrance velocity is much lower, flow is more uniform, and actual submergence appears to be adequate; nevertheless, the expected 2.7-foot head loss associated with 50 percent blinding of racks with narrowly spaced bars would account for more than half of the 5-foot margin between the calculated requirement and actual submergence.

TABLE 14 CALCULATED SUBMERGENCE REQUIREMENTS FOR CORNELL UNITS 1 – 3

ASSUMPTION OF ENTRANCE GEOMETRY	EXISTING SUBMERGENCE (ft)	CALCULATED SUBMERGENCE REQUIRED (ft)	CALCULATED SUBMERGENCE W/ NARROWLY SPACED RACKS, 50% BLINDED
Circular Entrance	19.8	21.4	17.1
Rectangular Entrance	19.8	14.1	17.1

The horizontal units at the Dells powerhouse have exposed gate cases in open flumes through which water is drawn when the wicket gates open. Such flumes are particularly susceptible to developing vortices and entraining air. Units 2, 3, and 4 were replaced within the past 10 years, but Unit 5 is original; all of the units have the same horizontal configuration. The newer, larger turbines were installed with increased hydraulic capacity and a higher shaft setting, resulting in slightly less submergence for these three units. Velocity through the gate casings at these three units is greater than at Unit 5, which results in an increased submergence requirement for the newer units. Although the submergence requirement for trashracks with narrowly spaced bars cannot be determined easily, comparing these conditions indicates that any issues with submergence would become apparent first with the three larger turbines. Assuming a potential 6-inch incremental increase in head loss with 50 percent blinding and the top of the gate case just 8 feet below the normal pond elevation, these turbines could be subject to submergence issues if racks with narrowly spaced bars were to be installed.

These findings do not indicate that the turbines at Cornell and Dells currently have, or will have, operational issues associated with inadequate submergence; however, this evaluation suggests the need for careful consideration of the potential for submergence issues before making any permanent changes at the intakes for these units. Hydraulic modeling is one means of evaluating the adequacy of these units' submergence more thoroughly, but it could be very costly. A less expensive alternative for evaluating the potential effects of blinding would be to monitor operations of these turbines under conditions where the racks are partially blinded, such as just prior to cleaning.

If any of these units currently have operational issues suspected to be associated with limited submergence, Kleinschmidt recommends carefully considering the potential effects of head loss of even a few inches associated with installing racks with narrowly spaced bars. The effect of blinding on head loss is greater than the effect of bar spacing, and the increased rate at which the racks with narrowly spaced bars would collect debris will result in rapidly worsening blinding; therefore, 50 percent blinding of trashracks with narrowly spaced bars should be considered in any decision-making process. Rack cleaning operations would need to increase in frequency to prevent excessive blinding and poor operational conditions.

8.0 ENERGY ANALYSIS

8.1 METHODS

Kleinschmidt uses a Microsoft Excel-based model to calculate the energy generated by a project daily. Flow data for use within the energy models for each project were obtained using gauge data from the upstream watershed. The three USGS gauges upstream of the Holcombe site (Gage No 05356500 – Chippewa River near Bruce, WI; Gage No 05360500 – Flambeau River near Bruce, WI; Gage No. 05362000 – Jump River at Sheldon, WI) were used to develop the modeled flows for Holcombe, Cornell, Jim Falls, and Wissota. The USGS gauge downstream of the Chippewa Falls dam and upstream of the Dells dam (Gage No. 05365500 – Chippewa River at Chippewa Falls, WI) was used to develop the modeled flows for the Dells Project. The mean daily flows from January 1996 through December 2015 were used for all the models. Using the flow data from the USGS gauge for each day of the noted period along with the number of turbines operated for each day, head losses through the machines and the peak efficiency for each type of turbine were used to compute the annual generation. Peak efficiency values were selected because Xcel Energy operates the turbines at best-gate settings, which maximizes generation. For projects with a minimum flow unit, the flow was allocated through that unit first, and then to the larger units.

8.2 RESULTS

8.2.1 BASE CASE – CALIBRATION

After developing the base model with the existing conditions, the results were compared with the historical monthly generation between 2009 and 2014. Generator efficiency was assumed to be static for each unit but ranged between 92 and 95 percent. The head loss through the turbine and draft tube was adjusted within a relatively narrow range to calibrate the modeled generation to match the historical values. Leakage through gates was assumed to occur at each site, depending on the number of gates. Each site's generation was calibrated to historical generation using the existing rack spacing and assuming 15 percent blinding, which is a typical average condition. Calibration was assumed to be reached when the modeled generation was within 5 percent of the historical generation (2009 through 2014). When necessary, the models were calibrated by adjusting the leakage, turbine or generator efficiency, and overall head loss.

8.2.2 ENERGY ANALYSIS FOR SELECTED ALTERNATIVES

Scenarios were run to predict the effect of replacing the intake trashracks with the options discussed in Section 5.0. The assumptions for each model remained the same as those for the calibrated model, except for the head loss associated with the trashracks.

Table 15 summarizes the modeled percent change in annual energy generation for the different intake rack options based on the last 19 years of recorded continuous flow (1996 through 2014). A negative percentage indicates a decrease in generation. Annual and monthly results of the energy model evaluation are included in Appendix C.

TABLE 15 CHANGE IN ANNUAL ENERGY GENERATION ESTIMATED FOR ALTERNATIVE CONFIGURATIONS AT XCEL ENERGY'S CHIPPEWA RIVER PROJECTS

	0% BLIND	15% BLIND	25% BLIND	50% BLIND
HOLCOMBE				
Replace existing trashracks with narrowly spaced racks	-0.1%	-0.2%	-0.3%	-0.6%
Inclined rack structure with full-depth, narrowly spaced trashracks	0.0%	0.0%	0.0%	0.0%
CORNELL				
Replace existing trashracks with narrowly spaced racks	-1.0%	-1.3%	-1.7%	-3.8%
Angled rack structure with full-depth, narrowly spaced trashracks	0.5%	0.6%	0.6%	1.0%
JIM FALLS				
Replace existing trashracks with narrowly spaced racks	-0.2%	-0.3%	-0.4%	-0.8%
Angled rack structure with full-depth, narrowly spaced trashracks	0.5%	0.5%	0.5%	0.5%
WISSOTA				
Replace existing trashracks with narrowly spaced racks	-0.1%	-0.2%	-0.3%	-0.6%
Inclined rack structure with full-depth narrowly spaced trashracks	0.0%	0.1%	0.1%	0.2%
DELLS				
Replace existing trashracks with narrowly spaced racks	-0.3%	-0.4%	-0.6%	-1.3%
Inclined rack structure with full-depth, narrowly spaced trashracks	-0.1%	-0.1%	0.0%	0.0%

Results of the energy modeling indicate that replacing trashracks with narrowly spaced racks (i.e., 1-inch clear spacing between the bars) would have minimal effects on generation, assuming clear racks. Without blinding (0 percent), the annual generation would decrease between 0.15 and 1.0 percent at each site. Replacing the trashracks with the angled or inclined rack structures with narrowly spaced trashracks would increase generation at Cornell, Jim Falls, and Wisotta, assuming no blinding. No noticeable change in generation is predicted at Holcombe, and a very small decrease in generation is predicted at Dells.

Narrower bar spacing will result in more rapid blinding of the racks, and blinding has a more significant effect on energy generation than does bar spacing. The energy model does not account for the rate of blinding, but that factor should be considered before selecting narrower bar spacing. For example, although reducing bar spacing to 1 inch is predicted to decrease generation at Cornell by only 1 percent without blinding (i.e., the worst case among the modeled conditions across the projects), average blinding conditions of 25 percent are expected to cause a nearly 2 percent loss in generation, and 50 percent blinding would cause a nearly 4 percent loss. In addition to causing head losses that reduce generation, significant blinding can require units to be shutdown to prevent damage due to rough operation or just to facilitate cleaning the intake trashracks. The energy analysis does not account for the potential reduced generation if units are taken offline due to blinding, which could be several percent if blinding occurs rapidly.

9.0 ANALYSIS OF BLADE STRIKE, ENTRAINMENT, AND IMPINGEMENT

Installing traditional fish screening measures such as trashracks with narrowly spaced vertical bars (i.e., 1-inch clear openings) has the potential to entrain small fishes that can fit between the bars. The resulting increase in water velocity that occurs in front of and through racks with narrowly spaced bars also has the potential to impinge larger fish on the face of the trashracks. The number of fish entrained is related to a variety of physical factors near the dams and powerhouses including powerhouse flow, forebay configuration, intake depth, plant operating mode, intake approach velocities, trashrack spacing, and proximity to fish feeding and rearing habitats (EPRI 1992; FERC 1995). Other factors include head, turbine size and design, runner speed, wicket gate openings and overhangs, number of runner blades, angle of runner blades, gap sizes, and the amount and direction of water passing through the turbines (Cada 1990; Odeh 1999; Cada and Rinehart 2000; Cada 2001). Biotic factors that affect the level of entrainment include diurnal and seasonal patterns of fish migration and dispersal, fish size and swimming speed, fish behavior, life history requirements, and density-dependent influences (e.g., resource availability) of fish populations in upstream habitats (EPRI 1992; FERC 1995; Cada et al. 1997).

Fish that pass through hydroelectric turbines can be injured or killed as a result of striking or colliding with structures within the turbine system (e.g., moving runner blades, fixed guide and stay vanes, flow-straightening walls in the draft tube) or of being drawn through gaps between fixed and moving structures in the turbine passageway. Several other mechanisms can lead to mortality as fish pass through a turbine, including pressure changes, cavitation, turbulence, and shear stress (Cada 1990; Cada et al. 1997; Cada 2001; Odeh 1999). Entrained fish are most likely to survive when turbines are operating near their peak efficiency, and smaller fish tend to suffer the least mortality (EPRI 1992). Outside the peak range of operating efficiency, increased mortality appears to be related mainly to the effects of cavitation, pressure changes, shear stresses, turbulence, and narrow clearances between wicket gates at low gate settings (EPRI 1992; Cada 2001). The sizes of clearances between wicket gates, and between the trailing edges of the wicket gates and the turbine blades, are especially important for the passage of larger fish at high runner speeds (EPRI 1992).

9.1 Blade Strike Assessment

9.1.1 Methods

Our analysis of turbine-related injury focused on estimating the probability of blade strike following the installation of full-depth, narrowly spaced vertical trashracks, angled racks, or inclined racks. The predictive equations we used consider only fish size; they do not differentiate between species. Fish size has been shown to influence turbine survival more than species (Franke et al. 1997). Several models have been developed to predict the survival rate of fish passing through hydroelectric turbines. These models consider fish size, turbine specifications, and station hydraulics to estimate the theoretical probability of blade strike and of survival of fish of specific sizes for a particular turbine configuration. Direct effects of turbine passage can be predicted as a probability because the variables (e.g., turbine diameter, number of blades) and values for those variables can be defined precisely. These models allow the user to manipulate parameters such as fish size or turbine characteristics to determine the relative effect on turbine passage survival.

Blade strike probability and turbine passage survival at the Holcombe, Cornell, Jim Falls, Wissota, and Dells projects were calculated using the Advanced Hydro Turbine model developed by Franke and colleagues (1997). Franke and colleagues (1997) revised an earlier model (Bell 1981) to consider the effect of tangential projection of the fish length on blade strike probability because most turbine passage mortality at low-head dams (<100 feet) is caused by fish striking a turbine blade or some other turbine structure. Appendix D provides a summary of the methods used to determine the probability of blade strike survival.

Blade strike probability and turbine passage survival were estimated for the seven target species (i.e., muskellunge, smallmouth bass, walleye, bluegill, black crappie, yellow perch, and lake sturgeon) based on the size ranges expected to become entrained through trashrack bars spaced at 1 inch, clear spacing (Table 16). Survival estimates are based on the composite total of all fish that could physically fit through 1-inch trashracks (Table 16). Fish greater than 1 inch in at least two dimensions (i.e., length and body width) would be physically excluded but may be impinged as a result of increases in the velocity at which water moves through the trashracks. In general, body width appears to be the limiting factor with regard to physical exclusion by trashracks. Table 16 also can be used to understand which species may not be susceptible to entrainment but may be subject to impingement if narrowly spaced trashracks were installed.

TABLE 16 SIZE OF FISH THAT MAY BE ENTRAINED THROUGH A 1-INCH TRASHRACK

Fish Length (inches)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Muskellunge	0.09	0.18	0.29	0.37	0.46	0.55	0.64	0.74	0.83	0.92	1.01	1.11	1.20	1.29	1.38	1.47	1.57	1.66	1.75	1.84	1.93	2.03	2.12	2.21	2.30
Walleye	0.12	0.24	0.36	0.48	0.60	0.73	0.85	0.97	1.09	1.21	1.33	1.45	1.57	1.69	1.81	1.93	2.06	2.18	2.30	2.42	2.54	2.66	2.78	2.90	3.02
Smallmouth bass	0.18	0.36	0.54	0.72	0.89	1.07	1.25	1.43	1.61	1.79	1.97	2.15	2.32	2.50	2.68	2.86	3.04								
Bluegill	0.15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.69	2.84	2.99	3.14				
Black crappie	0.15	0.30	0.44	0.59	0.74	0.89	1.04	1.18	1.33	1.48	1.63	1.78	1.92	2.07	2.22	2.37	2.51	2.66	2.81	2.96	3.11				
Yellow perch	0.19	0.38	0.57	0.76	0.95	1.14	1.33	1.52	1.71	1.90	2.09	2.29	2.48	2.67	2.86	3.05									
Lake sturgeon*	0.12	0.24	0.35	0.47	0.59	0.71	0.83	0.94	1.06	1.18	1.30	1.42	1.53	1.65	1.77	1.89	2.01	2.13	2.24	2.36	2.48	2.60	2.72	2.83	2.95

Values within the table are fish widths corresponding to the fish lengths identified at the top of the column.

Cells shaded in blue represent fish less than 1" in width that could pass through a 1-inch trashrack (i.e., would be entrained).

* Critical body width per fish size (inches) as converted from ratio of body width to girth derived using regression analysis for lake sturgeon collected in the Grasse River, New York (Appendix E).

Body morphology varies by species; therefore, body width was estimated relative to body length based on morphological characteristics of the target species provided by Smith (1985). Body width for lake sturgeon was estimated based on morphometric information collected during a recent radio-telemetry study of lake sturgeon habitat use in the Grasse River[5] conducted by Kleinschmidt. In total, researchers collected 170 sturgeon with complete body morphology information. The final equation used in this analysis for lake sturgeon width given length is:

$$\textbf{width} = \textbf{length}*\textbf{0.12}$$

Appendix E provides the methodology used to calculate lake sturgeon body girth so that we could identify the size of fish likely to be entrained at intakes with trashrack bars with 1-inch clear openings.

9.1.2 Results

Several dynamic parameters affect turbine survival estimates: turbine discharge (i.e., gate settings), turbine specifications (e.g., number of blades, RPM) operating head, the value of the correlation factor, and fish size. As such, there are many potential iterations of turbine survival estimates. The survival estimates provided in this section represent unweighted average values for the size groups representing target species. Although the model output is not species specific, data are presented by length ranges representing the sizes of the target fishes that would pass through a 1-inch trashrack. In general, survival rates are greater for small fish than for large fish; therefore, survival across all projects is expected to be greater for small species (e.g., bluegill, yellow perch, black crappie, and smallmouth bass) than for large species (e.g., walleye, muskellunge, and large sturgeon). In summary, the results of our analysis demonstrate that predicted average turbine passage survival of small resident fish species is greater than 90 percent for all seven species at the Holcombe, Cornell, Dells, Jim Falls, and Wissota hydroelectric projects (Table 17). Turbine passage survival for muskellunge and walleye is predicted to be the lowest at all projects; the lowest estimated turbine passage survival for muskellunge (75.9 percent) and for walleye (88 percent) is at the Cornell Project Unit 4 (Table 18). Average turbine passage survival for juvenile lake sturgeon ranged from 90.1 percent (Wissota Units 2, 3, 5, and 6) to 96.6 percent (Jim Falls Units 1 and 2) (Table 18).

[5] Tributary to the St. Lawrence River in eastern New York.

TABLE 17 SUMMARY OF PERCENT TURBINE PASSAGE SURVIVAL OF WALLEYE, MUSKELLUNGE, SMALLMOUTH BASS, BLUEGILL, YELLOW PERCH, BLACK CRAPPIE, AND LAKE STURGEON AT CHIPPEWA RIVER PROJECTS WITH NARROWLY SPACED TRASHRACKS

PROJECT AND UNIT(S)	MINIMUM SURVIVAL ESTIMATE (%)	MAXIMUM SURVIVAL ESTIMATE (%)	AVERAGE SURVIVAL ESTIMATE (%)
Holcombe Project (all units)	93.3	98.6	96.7
Cornell Project (Units 1, 2, and 3)	93.1	98.9	97.3
Cornell Project (Unit 4)	75.9	96.4	91.7
Dells Project (Unit 1)	91.7	98.6	96.6
Dells Project (Units 2, 3, and 4)	84.2	97.7	93.6
Dells Project (Unit 5)	84.9	97.7	93.6
Jim Falls Project (Unit 1 and 2)	94.1	99.9	97.4
Wissota Project (Unit 1 and 4)	89.2	96.9	94.0
Wissota Project (Units 2, 3, 5, 6)	84.3	95.8	91.8

Appendix D presents the model results for the numerous iterations for each target species based on 1-inch size increments for each of the different unit types at the Holcombe, Cornell, Jim Falls, Wissota, and Dells projects.

TABLE 18 PREDICTED TURBINE PASSAGE SURVIVAL FOR EACH TARGET FISH SPECIES AT XCEL ENERGY'S CHIPPEWA RIVER HYDROELECTRIC PROJECTS

	HOLCOMBE			CORNELL UNITS 1, 2 &3			CORNELL UNIT 4			DELLS UNIT 1			DELLS UNITS 2, 3, & 4			DELLS UNIT 5			JIM FALLS UNITS 1 & 2			WISSOTA UNITS 1 & 4			WISSOTA UNITS 2, 3, 5, & 6		
SPECIES	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max
Muskellunge	95.5	93.3	97.5	95.0	93.1	96.8	83.4	75.9	89.6	94.3	91.7	96.4	89.3	84.2	93.3	89.6	84.9	93.5	95.9	94.1	97.4	91.9	89.2	94.6	88.2	84.3	92.2
Walleye	96.3	94.4	97.9	97.5	96.5	98.4	91.7	88.0	94.8	95.7	93.8	97.3	92.0	88.1	95.0	92.2	88.7	95.1	96.4	94.8	97.7	93.3	91.0	95.5	91.0	87.9	94.0
Smallmouth Bass	97.4	96.1	98.6	98.3	97.6	98.9	94.2	91.6	96.4	97.9	97.1	98.6	96.2	94.5	97.7	96.4	94.7	97.7	98.4	97.7	99.0	95.3	93.7	96.9	93.7	91.6	95.8
Bluegill	97.0	95.5	98.4	98.0	97.2	98.7	93.4	90.4	95.8	97.7	96.7	98.6	95.7	93.7	97.3	95.9	93.9	97.4	98.2	97.7	99.9	94.6	92.8	96.4	92.8	90.4	95.2
Black Crappie	97.0	95.5	98.4	98.0	97.2	98.7	93.4	90.4	95.8	97.7	96.7	98.6	95.7	93.7	97.3	95.9	93.9	97.4	98.2	97.4	98.8	94.6	92.8	96.4	92.8	90.4	95.2
Yellow Perch	97.4	96.1	98.6	98.3	97.6	98.9	94.2	91.6	96.4	98.0	97.1	98.7	96.2	94.5	97.7	96.4	94.7	97.7	98.4	97.7	99.0	95.3	93.7	96.9	93.7	91.6	95.8
Lake Sturgeon	96.3	94.4	97.9	96.0	94.4	97.4	91.7	88.0	94.8	94.8	92.5	96.8	90.3	85.8	94.0	91.7	87.9	94.8	96.6	95.1	97.8	93.3	91.0	95.5	90.1	86.7	93.4

9.2 Swim Speed and Impingement Analysis

The formula typically used to estimate the size at which fish would be expected to avoid certain water velocities is (USFWS 1989):

Critical Fish Length (ft) = Water velocity (fps) /Minimum sustained speed (3 to 7 body lengths/sec)

Sustained swimming speed is the velocity that a fish can be expected to sustain indefinitely; burst speed is a velocity that a fish could sustain briefly to ambush prey, escape predation, or maneuver in current (Bell 1990). Using the USFWS criteria, swimming at a rate of 3 body lengths a second, a 12-inch fish would be capable of a sustained speed of 3 fps. Using a higher burst speed of 6 body lengths a second, a 12-inch fish would yield a swimming speed of 6 fps. Table 19 describes the swimming performance for both sustained swimming speeds (3 to 5 body lengths) and burst swimming speeds (6 to 7 body lengths) for each length frequency group using this equation. Based on the sustained swim speed criteria, which is a gait or swim speed that can be maintained indefinitely (Beamish 1978), fish measuring 6 inches or larger potentially would be able to swim away or escape a target approach velocity of 2.0 fps in front of the intake structures.

TABLE 19 SWIMMING SPEEDS OF FISH FOR EACH LENGTH FREQUENCY GROUP

	FISH LENGTH																			
Swim Speed (Body Length/s)	**1-inch**	**2-inch**	**3-inch**	**4-inch**	**5-inch**	**6-inch**	**7-inch**	**8-inch**	**9-inch**	**10-inch**	**11-inch**	**12-inch**	**13-inch**	**14-inch**	**15-inch**	**16-inch**	**17-inch**	**18-inch**	**19-inch**	**20-inch**
Sustained Swim Speeds	SWIMMING SPEEDS (fps)																			
3	0.24	0.48	0.75	0.99	1.26	1.5	1.8	2.1	2.25	2.49	2.76	3.0	3.3	3.27	3.75	3.99	4.23	4.5	4.74	4.98
4	0.32	0.64	1.0	1.32	1.68	2.0	2.4	2.8	3	3.32	3.68	4.0	4.4	4.36	5	5.32	5.64	6.0	6.32	6.64
5	0.4	0.8	1.25	1.65	2.1	2.5	3.0	3.5	3.75	4.15	4.6	5.0	5.5	5.45	6.25	6.65	7.05	7.5	7.9	8.3
Burst Swim Speeds																				
6	0.48	0.96	1.5	1.98	2.52	3.0	3.6	4.2	4.5	4.98	5.52	6.0	6.6	6.54	7.5	7.98	8.46	9.0	9.48	9.96
7	0.56	1.12	1.75	2.31	2.94	3.5	4.2	4.9	5.25	5.81	6.44	7.0	7.7	7.63	8.75	9.31	9.87	10.5	11.06	11.62

Installing narrowly spaced trash racks (i.e., 1-inch clear opening) would increase through-rack velocities by 0.40 fps to 3.67 fps over existing conditions at the Holcombe, Cornell, Jim Falls, Wissota, and Dells projects depending on unit and intake configuration (Appendix A). Through-rack velocities under existing conditions at these 5 sites range from 1.69 fps to 11.82 fps at 0 percent to 50 percent blinding, respectively. With narrowly spaced trashracks, through-rack velocities would range from 2.09 fps to 15.49 fps at 0 percent to 50 percent blinding, respectively (Table 20). Many of these velocities exceed the swim speeds of juvenile and adult fish and, therefore, are likely to result in increased impingement of large-bodied fish and entrainment of fish smaller than 3 inches. The calculated through-rack velocities for the 1-inch trashracks installed at the Chippewa Falls range from 2.47 fps to 4.95 fps (Table 20). These velocities exceed the sustained swim speed of fish smaller than 3 inches and the burst swim speed of an 8-inch fish. Depending on the size and species of fish, fish that are not entrained may not be able to avoid being involuntarily impinged at each of the hydroelectric projects due to the increase in through-rack velocities.

TABLE 20 EXPECTED THROUGH-RACK VELOCITIES AT THE CHIPPEWA RIVER PROJECTS WITH NARROWLY SPACED TRASHRACKS (0 AND 50 PERCENT BLINDING)

PROJECT / INTAKE AREA	EXISTING CONDITIONS (NO BLINDING)	EXISTING CONDITIONS (50 % BLINDING)	EXPECTED WATER VELOCITY (NO BLINDING)	EXPECTED WATER VELOCITY (50 % BLINDING)
Cornell Project (Units 1-3)	5.91 fps	11.82 fps	7.75 fps	15.49 fps
Cornell Project (Unit 4)	2.36 fps	4.73 fps	3.46 fps	6.92 fps
Dells Project (Unit 1)	2.84 fps	5.68 fps	3.51 fps	7.02 fps
Dells Project (Units 2-4)	3.01 fps	6.02 fps	3.72 fps	7.44 fps
Dells Project (Unit 5)	1.69 fps	3.38 fps	2.09 fps	4.17
Holcombe (all units)	2.19 fps	4.38 fps	2.92 fps	5.84 fps
Jim Falls (all units)	3.70 fps	7.40 fps	4.81 fps	9.78 fps
Wissota (Units 1-4)	2.98 fps	5.96 fps	3.88 fps	7.75 fps
Wissota (Units 2-3, 5-6)	2.32 fps	4.64 fps	3.02 fps	6.03 fps
Chippewa Falls (all units)	2.47 fps	4.95 fps	NA*	

* The Chippewa Project already has 1-inch trashrack bars in front of the turbines intakes.

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Appendix A

Calculations of Through-Rack Velocities

APPENDIX A CALCULATIONS OF THROUGH-RACK VELOCITIES

Chippewa River Fish Protection Study
Through Rack Velocity Summary Tables

Cornell

Units 1-3 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	5.91	6.95	7.88	11.82
Proposed 1" Spacing	7.75	9.11	10.33	15.49

Unit 4 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	2.36	2.78	3.15	4.73
Proposed 1" Spacing	3.46	4.07	4.61	6.92

Units 1-4 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Proposed Angled 1" Spacing	2.35	2.76	3.13	4.69

Dells

Unit 1 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	2.84	3.34	3.79	5.68
Proposed 1" Spacing	3.51	4.13	4.68	7.02

Units 2-4 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	3.01	3.54	4.01	6.02
Proposed 1" Spacing	3.72	4.37	4.96	7.44

Unit 5 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	1.69	1.99	2.25	3.38
Proposed 1" Spacing	2.09	2.46	2.78	4.17

Units 1-5 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Proposed Angled 1" Spacing	2.73	3.21	3.63	5.45
Proposed Inclined 1" Spacing	2.68	3.15	3.57	5.35

Holcombe

Units 1-3 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	2.24	2.63	2.98	4.47
Proposed 1" Spacing	3.01	3.54	4.01	6.01
Proposed Angled 1" Spacing	2.36	2.77	3.14	4.71

Jim Falls

Units 1-2 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	3.70	4.35	4.93	7.40
Proposed 1" Spacing	4.89	5.75	6.52	9.78
Proposed Inclined 1" Spacing	2.51	2.95	3.34	5.01

Wissota

Units 1 & 4 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	2.98	3.51	3.97	5.96
Proposed 1" Spacing	3.88	4.56	5.17	7.75

Units 2,3,5,6 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	2.32	2.73	3.09	4.64
Proposed 1" Spacing	3.02	3.55	4.02	6.03

Chippewa Falls

Units 1-6 Through Velocity Summary Table (Velocity in ft/s)

Scenario	0% Blind	15 % Blind	25% Blind	50% Blind
Existing Conditions	2.47	2.91	3.30	4.95

APPENDIX B

HEAD LOSS CALCULATIONS

Kleinschmidt

Units 1-3

Project No: 1126003.01
By: KDG Date: 3/25/2016
Checked: JSJ Date: 3/25/2016

TABLE B1 HOLCOMBE HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions			Trash Rack Base Dimensions		
Rack Total Length, L =	37	ft	Rack Total Length, L =	140	ft
Rack Invert Elevation =	997.5	ft	Rack Invert Elevation =	997	ft
Normal Headpond Elevation =	1045	ft	Normal Headpond Elevation =	1045	ft
Height of trash rack in flow =	47.50	ft	Height of trash rack in flow =	48.00	ft
			Slope of trash rack =	0.00	H:V
Gross Area, A_{gross} =	1757.50	ft^2	Gross Area, A_{gross} =	6720.00	ft^2
Flow Capacity, Q =	3600	cfs	Flow Capacity, Q =	10800	cfs
			Top of Rack =	1053	ft
5.0" Rack Spacing - Existing Conditions			**1.0" Rack Spacing - Angled rack**		
Vertical Bar Spacing =	5.0	in	Vertical Bar Spacing =	1.0	in
Vertical Bar Width, b_{bar} =	0.375	In	Vertical Bar Width, b_{bar} =	0.375	In
Vert. Bar Length in Flow, L_{bar} =	47.50	ft	Vert. Bar Length in Flow, L_{bar} =	48.00	ft
Number of Vertical Bars =	44		Number of Vertical Bars =	1221	
Horizontal Bar 1 Width =	0.75	in	Horizontal Bar 1 Width =	0.75	in
Horizontal Bar 1 Length =	35.8	ft	Horizontal Bar 1 Length =	140	ft
Number of Horizontal Bar 1 =	13		Number of Horizontal Bar 1 =	13	
Horizontal Bar 2 Width =	0.88	in	Horizontal Bar 2 Width =	0.88	in
Horizontal Bar 2 Length =	37.00	ft	Horizontal Bar 2 Length =	140.00	ft
Number of Horizontal Bar 2 =	8		Number of Horizontal Bar 2 =	8	
Horizontal Bar 3 Width =	0.75	in	Horizontal Bar 1 Width =	0.75	in
Horizontal Bar 3 Length =	37	ft	Horizontal Bar 1 Length =	140	ft
Number of Horizontal Bar 3 =	8		Number of Horizontal Bar 1 =	8	
Angle Bar Total Length =	12.1	ft	Angle Bar Total Length =	12.1	ft
Angle Bar width =	0.75	in	Angle Bar width =	0.75	in
Number of Angle bars in flow =	17.1		Number of Angle bars =	51.3	
Area of Bars, A_{bars} =	147.4	ft^2	Area of Bars, A_{bars} =	2135.7	ft^2
Net Open Area of Racks, A_{net} =	1610.1	ft^2	Net Open Area of Racks, A_{net} =	4584.3	ft^2
Ratio of Net to Gross Area, R =	0.92		Ratio of Net to Gross Area, R =	0.68	
Loss Coefficient, K =	0.198		Loss Coefficient, K =	0.678	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	1610.08	ft^2	Net Open Area of Racks =	4584.29	ft^2
Flow Velocity, V =	2.24	ft/s	Flow Velocity, V =	2.36	ft/s
Trash Rack Head Loss, H_L =	0.015	ft	Trash Rack Head Loss, H_L =	0.058	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	1368.57	ft^2	Net Open Area of Racks =	3896.64	ft^2
Flow Velocity, V =	2.63	ft/s	Flow Velocity, V =	2.77	ft/s
Trash Rack Head Loss, H_L =	0.021	ft	Trash Rack Head Loss, H_L =	0.081	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	1207.56	ft^2	Net Open Area of Racks =	3438.22	ft^2
Flow Velocity =	2.98	ft/s	Flow Velocity =	3.14	ft/s
Trash Rack Head Loss =	0.027	ft	Trash Rack Head Loss =	0.104	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	805.04	ft^2	Net Open Area of Racks =	2292.14	ft^2
Flow Velocity =	4.47	ft/s	Flow Velocity =	4.71	ft/s
Trash Rack Head Loss =	0.062	ft	Trash Rack Head Loss =	0.234	ft

TABLE B2 CORNELL HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions			Trash Rack Base Dimensions - Angled Rack		
Rack Total Length, L =	35	ft	Rack Total Length, L =	365	ft
Rack Invert Elevation =	982.2	ft	Rack Invert Elevation =	982	ft
Normal Headpond Elevation =	1002	ft	Normal Headpond Elevation =	1002	ft
Height of trash rack in flow =	19.80	ft	Height of trash rack in flow =	20.00	ft
Gross Area, A_{gross} =	693.00	ft^2	Gross Area, A_{gross} =	7300.00	ft^2
Flow Capacity, Q =	3750	cfs	Flow Capacity, Q =	11650	cfs
			Top of Rack =	1008	ft
Calibration Factor	0.25	ft			
6.0" Rack Spacing - Existing Conditions			**1.0" Rack Spacing - Angled Bar Rack**		
Vertical Bar Spacing =	6.0	in	Vertical Bar Spacing =	1	in
Vertical Bar 1 Width, b_{bar} =	0.5	In	Vertical Bar Width, b_{bar} =	0.375	In
Vert. Bar 1 Length in Flow, L_{bar} =	19.80	ft	Vert. Bar Length in Flow, L_{bar} =	20.00	ft
Number of Vertical Bar 1 =	2		Number of Vertical Bars =	3185	
Vertical Bar 2 Width, b_{bar} =	0.5	In			
Vert. Bar 2 Length in Flow, L_{bar} =	19.80	ft			
Number of Vertical Bar 2 =	2				
Vertical Bar 3 Width, b_{bar} =	0.625	In			
Vert. Bar 3 Length in Flow, L_{bar} =	19.80	ft			
Number of Vertical Bar 3 =	34				
Plate Area =	50	in^2			
Number of plates in flow =	6				
Horizontal Bar 1 Width =	0.625	in	Horizontal Bar 1 Width =	0.625	in
Horizontal Bar 1 Length =	19.08	ft	Horizontal Bar 1 Length =	365	ft
Number of Horiz. Bar 1 in flow =	3		Number of Horiz. Bar 1 in flow =	3	
Horizontal Bar 2 Width =	0.5	in	Horizontal Bar 2 Width =	0.5	in
Horizontal Bar 2 Length =	19.08	ft	Horizontal Bar 2 Length =	365	ft
Number of Horiz Bar 2 in flow =	7		Number of Horiz Bar 2 in flow =	7	
Horizontal Bar 3 Width =	3.00	in	Horizontal Bar 3 Width =	3.00	in
Horizontal Bar 3 Length =	19.08	ft	Horizontal Bar 3 Length =	365.00	ft
Number of Horiz Bar 3 in flow=	2		Number of Horiz Bar 3 in flow=	2	
Area of Bars, A_{bars} =	58.5	ft^2	Area of Bars, A_{bars} =	2336.6	ft^2
Net Open Area of Racks, A_{net} =	634.5	ft^2	Net Open Area of Racks, A_{net} =	4963.4	ft^2
Ratio of Net to Gross Area, R =	0.92		Ratio of Net to Gross Area, R =	0.68	
Loss Coefficient, K =	0.200		Loss Coefficient, K =	0.682	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	634.47	ft^2	Net Open Area of Racks =	4963.39	ft^2
Flow Velocity, V =	5.91	ft/s	Flow Velocity, V =	2.35	ft/s
Trash Rack Head Loss, H_L =	0.358	ft	Trash Rack Head Loss, H_L =	0.308	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	539.30	ft^2	Net Open Area of Racks =	4218.88	ft^2
Flow Velocity, V =	6.95	ft/s	Flow Velocity, V =	2.76	ft/s
Trash Rack Head Loss, H_L =	0.400	ft	Trash Rack Head Loss, H_L =	0.331	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	475.85	ft^2	Net Open Area of Racks =	3722.54	ft^2
Flow Velocity =	7.88	ft/s	Flow Velocity =	3.13	ft/s
Trash Rack Head Loss =	0.443	ft	Trash Rack Head Loss =	0.354	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	317.23	ft^2	Net Open Area of Racks =	2481.69	ft^2
Flow Velocity =	11.82	ft/s	Flow Velocity =	4.69	ft/s
Trash Rack Head Loss =	0.684	ft	Trash Rack Head Loss =	0.483	ft

TABLE B2 CORNELL HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	9.08	ft
Rack Invert Elevation =	977.5	ft
Normal Headpond Elevation =	1002	ft
Height of trash rack in flow =	24.50	ft
Gross Area, A_{gross} =	222.54	ft^2
Flow Capacity, Q =	400	cfs

3.0" Rack Spacing - Existing Conditions			1.0" Rack Spacing		
Vertical Bar Spacing =	3.0	in	Vertical Bar Spacing =	1	in
Vertical Bar 1 Width =	0.625	In	Vertical Bar Width, b_{bar} =	0.375	In
Vert. Bar 1 Length in Flow =	24.50	ft	Vert. Bar Length in Flow, L_{bar} =	24.50	ft
Number of Vertical Bar 1 =	33		Number of Vertical Bars =	79	
Vertical Bar 2 Width (MK2-2) =	0.5	In			
Vert. Bar 2 (MK2-2) Length in Flow, =	2.92	ft			
Number of Vertical Bar 2 (MK2-2) =	2				
Vertical Bar 3 Width (MK2-1) =	0.625	In			
Vert. Bar 3 Length in Flow (MK2-1) =	9.42	ft			
Number of Vertical Bar 3 (MK2-1) =	2				
Vertical Bar 3 Width (MK2-2) =	0.625	In			
Vert. Bar 3 Length in Flow (MK2-2) =	12.00	ft			
Number of Vertical Bar 3 (MK2-2) =	2				
Vertical Bar 4 Width (MK2-2) =	0.5	In			
Vert. Bar 4 Length in Flow (MK2-2) =	24.50	ft			
Number of Vertical Bar 4 (MK2-2) =	2				
Plate Area =	50	in^2	Plate Area =	50	in^2
Number of plates in flow =	6		Number of plates in flow =	6	
Horizontal Bar 1 Width =	0.625	in	Horizontal Bar 1 Width =	0.75	in
Horizontal Bar 1 Length =	9.5	ft	Horizontal Bar 1 Length =	19.33	ft
Number of Horizontal Bar 1 =	7		Number of Horizontal Bar 1 =	25	
Horizontal Bar 2 Width =	0.50	in	Horizontal Bar 2 Width =	0.88	in
Horizontal Bar 2 Length =	9.50	ft	Horizontal Bar 2 Length =	19.33	ft
Number of Horizontal Bar 2 =	3		Number of Horizontal Bar 2 =	10	
Area of Bars, A_{bars} =	53.4	ft^2	Area of Bars, A_{bars} =	106.9	ft^2
Net Open Area of Racks, A_{net} =	169.2	ft^2	Net Open Area of Racks, A_{net} =	115.7	ft^2
Ratio of Net to Gross Area, R =	0.76		Ratio of Net to Gross Area, R =	0.52	
Loss Coefficient, K =	0.530		Loss Coefficient, K =	0.946	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	169.18	ft^2	Net Open Area of Racks =	115.68	ft^2
Flow Velocity, V =	2.36	ft/s	Flow Velocity, V =	3.46	ft/s
Trash Rack Head Loss, H_L =	0.046	ft	Trash Rack Head Loss, H_L =	0.176	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	143.80	ft^2	Net Open Area of Racks =	98.32	ft^2
Flow Velocity, V =	2.78	ft/s	Flow Velocity, V =	4.07	ft/s
Trash Rack Head Loss, H_L =	0.064	ft	Trash Rack Head Loss, H_L =	0.243	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	126.89	ft^2	Net Open Area of Racks =	86.76	ft^2
Flow Velocity =	3.15	ft/s	Flow Velocity =	4.61	ft/s
Trash Rack Head Loss =	0.082	ft	Trash Rack Head Loss =	0.312	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	84.59	ft^2	Net Open Area of Racks =	57.84	ft^2
Flow Velocity =	4.73	ft/s	Flow Velocity =	6.92	ft/s
Trash Rack Head Loss =	0.184	ft	Trash Rack Head Loss =	0.703	ft

TABLE B3 JIM FALLS HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions			**Trash Rack Base Dimensions - Angled Rack**		
Rack Total Length, L =	43	ft	Rack Total Length, L =	150	ft
Rack Invert Elevation =	890.35	ft	Rack Invert Elevation =	890	ft
Normal Headpond Elevation =	953.2	ft	Normal Headpond Elevation =	952.2	ft
Height of trash rack in flow* =	46.34	ft	Height of trash rack in flow* =	50.00	ft
Gross Area, A_{gross} =	1992.62	ft^2	Gross Area, A_{gross} =	7500.00	ft^2
Flow Capacity, Q =	6750	cfs	Flow Capacity, Q =	13500	cfs
*Existing rack is angled					
Calibration Factor	1	ft			
5.0" Rack Spacing - Existing Conditions			**1.0" Rack Spacing**		
Vertical Bar Spacing =	5.0	in	Vertical Bar Spacing =	1.0	in
Vertical Bar 1 Width, b_{bar} =	0.75	In	Vertical Bar Width, b_{bar} =	0.375	In
Vert. Bar 1 Length in Flow, L_{bar} =	46.34	ft	Vert. Bar Length in Flow, L_{bar} =	50.00	ft
Number of Vertical Bar 1 =	42		Number of Vertical Bars =	1309	
Plate Area =	14	in^2	Plate Area =	14	in^2
Number of plates in flow =	96		Number of plates in flow =	96	
Horizontal Bar 1 Width =	0.75	in	Horizontal Bar 1 Width =	0.75	in
Horizontal Bar 1 Length =	2.85	ft	Horizontal Bar 1 Length =	19.33	ft
Number of Horizontal Bar 1 =	128		Number of Horizontal Bar 1 =	25	
Horizontal Bar 2 Width =	0.75	in	Horizontal Bar 1 Width =	0.75	in
Horizontal Bar 2 Length =	2.08	ft	Horizontal Bar 1 Length =	19.33	ft
Number of Horizontal Bar 1 =	112		Number of Horizontal Bar 1 =	25	
Area of Bars, A_{bars} =	168.2	ft^2	Area of Bars, A_{bars} =	2114.9	ft^2
Net Open Area of Racks, A_{net} =	1824.5	ft^2	Net Open Area of Racks, A_{net} =	5385.1	ft^2
Ratio of Net to Gross Area, R =	0.92		Ratio of Net to Gross Area, R =	0.72	
Loss Coefficient, K =	0.200		Loss Coefficient, K =	0.611	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	1824.45	ft^2	Net Open Area of Racks =	5385.11	ft^2
Flow Velocity, V =	3.70	ft/s	Flow Velocity, V =	2.51	ft/s
Trash Rack Head Loss, H_L =	1.042	ft	Trash Rack Head Loss, H_L =	1.060	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	1550.78	ft^2	Net Open Area of Racks =	4577.35	ft^2
Flow Velocity, V =	4.35	ft/s	Flow Velocity, V =	2.95	ft/s
Trash Rack Head Loss, H_L =	1.059	ft	Trash Rack Head Loss, H_L =	1.083	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	1368.34	ft^2	Net Open Area of Racks =	4038.84	ft^2
Flow Velocity =	4.93	ft/s	Flow Velocity =	3.34	ft/s
Trash Rack Head Loss =	1.075	ft	Trash Rack Head Loss =	1.106	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	912.23	ft^2	Net Open Area of Racks =	2692.56	ft^2
Flow Velocity =	7.40	ft/s	Flow Velocity =	5.01	ft/s
Trash Rack Head Loss =	1.170	ft	Trash Rack Head Loss =	1.239	ft

TABLE B4 WISSOTA HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	26	ft
Rack Invert Elevation =	871	ft
Normal Headpond Elevation =	898	ft
Height of trash rack in flow =	27.95	ft
Gross Area, A_{gross} =	726.70	ft^2
Flow Capacity, Q =	1440	cfs

3.75" Rack Spacing - Existing Conditions			1.0" Rack Spacing		
Vertical Bar Spacing =	3.8	in	Vertical Bar Spacing =	1.0	in
Vertical Bar Width, b_{bar} =	0.3125	In	Vertical Bar Width, b_{bar} =	0.375	In
Vert. Bar Length in Flow, L_{bar} =	27.95	ft	Vert. Bar Length in Flow, L_{bar} =	27.95	ft
Number of Vertical Bar =	74		Number of Vertical Bar =	226	
Horizontal Bar Width =	3	in	Horizontal Bar Width =	3	in
Horizontal Bar Length =	26	ft	Horizontal Bar Length =	26	ft
Number of Horizontal Bars =	8		Number of Horizontal Bars =	8	
Area of Bars, A_{bars} =	105.9	ft^2	Area of Bars, A_{bars} =	249.4	ft^2
Net Open Area of Racks, A_{net} =	620.8	ft^2	Net Open Area of Racks, A_{net} =	477.3	ft^2
Ratio of Net to Gross Area, R =	0.85		Ratio of Net to Gross Area, R =	0.66	
Loss Coefficient, K =	0.336		Loss Coefficient, K =	0.723	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	620.84	ft^2	Net Open Area of Racks =	477.30	ft^2
Flow Velocity, V =	2.32	ft/s	Flow Velocity, V =	3.02	ft/s
Trash Rack Head Loss, H_L =	0.028	ft	Trash Rack Head Loss, H_L =	0.102	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	527.71	ft^2	Net Open Area of Racks =	405.71	ft^2
Flow Velocity, V =	2.73	ft/s	Flow Velocity, V =	3.55	ft/s
Trash Rack Head Loss, H_L =	0.039	ft	Trash Rack Head Loss, H_L =	0.141	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	465.63	ft^2	Net Open Area of Racks =	357.98	ft^2
Flow Velocity =	3.09	ft/s	Flow Velocity =	4.02	ft/s
Trash Rack Head Loss =	0.050	ft	Trash Rack Head Loss =	0.182	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	310.42	ft^2	Net Open Area of Racks =	238.65	ft^2
Flow Velocity =	4.64	ft/s	Flow Velocity =	6.03	ft/s
Trash Rack Head Loss =	0.112	ft	Trash Rack Head Loss =	0.409	ft

TABLE B4 WISSOTA HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	26	ft
Rack Invert Elevation =	871	ft
Normal Headpond Elevation =	898	ft
Height of trash rack in flow =	27.95	ft
Gross Area, A_{gross} =	726.70	ft^2
Flow Capacity, Q =	1850	cfs

3.75" Rack Spacing - Existing Conditions			1.0" Rack Spacing		
Vertical Bar Spacing =	3.8	in	Vertical Bar Spacing =	1.0	in
Vertical Bar Width, b_{bar} =	0.3125	In	Vertical Bar Width, b_{bar} =	0.375	In
Vert. Bar Length in Flow, L_{bar} =	27.95	ft	Vert. Bar Length in Flow, L_{bar} =	27.95	ft
Number of Vertical Bar =	74		Number of Vertical Bar =	226	
Horizontal Bar Width =	3	in	Horizontal Bar Width =	3	in
Horizontal Bar Length =	26	ft	Horizontal Bar Length =	26	ft
Number of Horizontal Bars =	8		Number of Horizontal Bars =	8	
Area of Bars, A_{bars} =	105.9	ft^2	Area of Bars, A_{bars} =	249.4	ft^2
Net Open Area of Racks, A_{net} =	620.8	ft^2	Net Open Area of Racks, A_{net} =	477.3	ft^2
Ratio of Net to Gross Area, R =	0.85		Ratio of Net to Gross Area, R =	0.66	
Loss Coefficient, K =	0.336		Loss Coefficient, K =	0.723	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	620.84	ft^2	Net Open Area of Racks =	477.30	ft^2
Flow Velocity, V =	2.98	ft/s	Flow Velocity, V =	3.88	ft/s
Trash Rack Head Loss, H_L =	0.046	ft	Trash Rack Head Loss, H_L =	0.169	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	527.71	ft^2	Net Open Area of Racks =	405.71	ft^2
Flow Velocity, V =	3.51	ft/s	Flow Velocity, V =	4.56	ft/s
Trash Rack Head Loss, H_L =	0.064	ft	Trash Rack Head Loss, H_L =	0.233	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	465.63	ft^2	Net Open Area of Racks =	357.98	ft^2
Flow Velocity =	3.97	ft/s	Flow Velocity =	5.17	ft/s
Trash Rack Head Loss =	0.082	ft	Trash Rack Head Loss =	0.300	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	310.42	ft^2	Net Open Area of Racks =	238.65	ft^2
Flow Velocity =	5.96	ft/s	Flow Velocity =	7.75	ft/s
Trash Rack Head Loss =	0.185	ft	Trash Rack Head Loss =	0.675	ft

TABLE B4 WISSOTA HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	90	ft
Rack Invert Elevation =	871	ft
Normal Headpond Elevation =	898	ft
Height of trash rack in flow =	67.00	ft
Gross Area, A_{gross} =	6030.00	ft^2
Flow Capacity, Q =	9460	cfs
1.0" Rack Spacing - Inclined		
Vertical Bar Spacing =	1.0	in
Vertical Bar Width, b_{bar} =	0.375	In
Vert. Bar Length in Flow, L_{bar} =	67.00	ft
Number of Vertical Bar =	785	
Horizontal Bar Width =	3	in
Horizontal Bar Length =	90	ft
Number of Horizontal Bars =	8	
Area of Bars, A_{bars} =	1823.6	ft^2
Net Open Area of Racks, A_{net} =	4206.4	ft^2
Ratio of Net to Gross Area, R =	0.70	
Loss Coefficient, K =	0.649	
Gravitational Constant, g =	32.20	ft/s^2
0% Blinding		
Percent Blinding =	0%	
Net Open Area of Racks =	4206.41	ft^2
Flow Velocity, V =	2.25	ft/s
Trash Rack Head Loss, H_L =	0.051	ft
15% Blinding		
Percent Blinding =	15%	
Net Open Area of Racks =	3575.45	ft^2
Flow Velocity, V =	2.65	ft/s
Trash Rack Head Loss, H_L =	0.071	ft
25% Blinding		
Percent Blinding =	25%	
Net Open Area of Racks =	3154.80	ft^2
Flow Velocity =	3.00	ft/s
Trash Rack Head Loss =	0.091	ft
50% Blinding		
Percent Blinding =	50%	
Net Open Area of Racks =	2103.20	ft^2
Flow Velocity =	4.50	ft/s
Trash Rack Head Loss =	0.204	ft

TABLE B5 DELLS HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	36	ft
Rack Invert Elevation =	777	ft
Normal Headpond Elevation =	795	ft
Height of trash rack in flow* =	18.70	ft
Gross Area, A_{gross} =	673.20	ft^2
Flow Capacity, Q =	1800	cfs
*Angled rack measured from drawing		
Calibration Factor	0.3	ft

5" O.C. Rack Spacing - Existing Conditions			1.0" Rack Spacing		
Vertical Bar Spacing =	5.0	in	Vertical Bar Spacing =	1.0	in
Vertical Bar 1 Width, b_{bar} =	0.3125	In	Vertical Bar Width, b_{bar} =	0.3125	In
Vert. Bar 1 Length in Flow, L_{bar} =	18.70	ft	Vert. Bar Length in Flow, L_{bar} =	18.70	ft
Number of Vertical Bar =	81		Number of Vertical Bar =	329	
Area of Bars, A_{bars} =	39.4	ft^2	Area of Bars, A_{bars} =	160.2	ft^2
Net Open Area of Racks, A_{net} =	633.8	ft^2	Net Open Area of Racks, A_{net} =	513.0	ft^2
Ratio of Net to Gross Area, R =	0.94		Ratio of Net to Gross Area, R =	0.76	
Loss Coefficient, K =	0.140		Loss Coefficient, K =	0.526	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	633.75	ft^2	Net Open Area of Racks =	512.98	ft^2
Flow Velocity, V =	2.84	ft/s	Flow Velocity, V =	3.51	ft/s
Trash Rack Head Loss, H_L =	0.318	ft	Trash Rack Head Loss, H_L =	0.401	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	538.69	ft^2	Net Open Area of Racks =	436.04	ft^2
Flow Velocity, V =	3.34	ft/s	Flow Velocity, V =	4.13	ft/s
Trash Rack Head Loss, H_L =	0.324	ft	Trash Rack Head Loss, H_L =	0.439	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	475.32	ft^2	Net Open Area of Racks =	384.74	ft^2
Flow Velocity =	3.79	ft/s	Flow Velocity =	4.68	ft/s
Trash Rack Head Loss =	0.331	ft	Trash Rack Head Loss =	0.479	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	316.88	ft^2	Net Open Area of Racks =	256.49	ft^2
Flow Velocity =	5.68	ft/s	Flow Velocity =	7.02	ft/s
Trash Rack Head Loss =	0.370	ft	Trash Rack Head Loss =	0.703	ft

TABLE B5 DELLS HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	24	ft
Rack Invert Elevation =	774.75	ft
Normal Headpond Elevation =	795	ft
Height of trash rack in flow* =	20.95	ft
Gross Area, A_{gross} =	502.80	ft^2
Flow Capacity, Q =	1425	cfs
*Angled rack measured from drawing		
Calibration Factor (ft)	0.5	

5" O.C. Rack Spacing - Existing Conditions			1.0" Rack Spacing		
Vertical Bar Spacing =	5.0	in	Vertical Bar Spacing =	1.0	in
Vertical Bar 1 Width, b_{bar} =	0.3125	In	Vertical Bar Width, b_{bar} =	0.3125	In
Vert. Bar 1 Length in Flow, L_{bar} =	20.95	ft	Vert. Bar Length in Flow, L_{bar} =	20.95	ft
Number of Vertical Bar =	54		Number of Vertical Bar =	219	
Area of Bars, A_{bars} =	29.5	ft^2	Area of Bars, A_{bars} =	119.5	ft^2
Net Open Area of Racks, A_{net} =	473.3	ft^2	Net Open Area of Racks, A_{net} =	383.3	ft^2
Ratio of Net to Gross Area, R =	0.94		Ratio of Net to Gross Area, R =	0.76	
Loss Coefficient, K =	0.140		Loss Coefficient, K =	0.526	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	473.34	ft^2	Net Open Area of Racks =	383.32	ft^2
Flow Velocity, V =	3.01	ft/s	Flow Velocity, V =	3.72	ft/s
Trash Rack Head Loss, H_L =	0.520	ft	Trash Rack Head Loss, H_L =	0.613	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	402.34	ft^2	Net Open Area of Racks =	325.82	ft^2
Flow Velocity, V =	3.54	ft/s	Flow Velocity, V =	4.37	ft/s
Trash Rack Head Loss, H_L =	0.527	ft	Trash Rack Head Loss, H_L =	0.656	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	355.00	ft^2	Net Open Area of Racks =	287.49	ft^2
Flow Velocity =	4.01	ft/s	Flow Velocity =	4.96	ft/s
Trash Rack Head Loss =	0.535	ft	Trash Rack Head Loss =	0.701	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	236.67	ft^2	Net Open Area of Racks =	191.66	ft^2
Flow Velocity =	6.02	ft/s	Flow Velocity =	7.44	ft/s
Trash Rack Head Loss =	0.579	ft	Trash Rack Head Loss =	0.951	ft

TABLE B5 DELLS HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	24	ft
Rack Invert Elevation =	774.75	ft
Normal Headpond Elevation =	795	ft
Height of trash rack in flow* =	20.95	ft
Gross Area, A_{gross} =	502.80	ft^2
Flow Capacity, Q =	800	cfs
*Angled rack measured from drawing		
Calibration Factor (ft)	0.2	

5" O.C. Rack Spacing - Existing Conditions			1.0" Rack Spacing		
Vertical Bar Spacing =	5.0	in	Vertical Bar Spacing =	1.0	in
Vertical Bar 1 Width, b_{bar} =	0.3125	In	Vertical Bar Width, b_{bar} =	0.3125	In
Vert. Bar 1 Length in Flow, L_{bar} =	20.95	ft	Vert. Bar Length in Flow, L_{bar} =	20.95	ft
Number of Vertical Bar =	54		Number of Vertical Bar =	219	
Area of Bars, A_{bars} =	29.5	ft^2	Area of Bars, A_{bars} =	119.5	ft^2
Net Open Area of Racks, A_{net} =	473.3	ft^2	Net Open Area of Racks, A_{net} =	383.3	ft^2
Ratio of Net to Gross Area, R =	0.94		Ratio of Net to Gross Area, R =	0.76	
Loss Coefficient, K =	0.140		Loss Coefficient, K =	0.526	
Gravitational Constant, g =	32.20	ft/s^2	Gravitational Constant, g =	32.20	ft/s^2
0% Blinding			**0% Blinding**		
Percent Blinding =	0%		Percent Blinding =	0%	
Net Open Area of Racks =	473.34	ft^2	Net Open Area of Racks =	383.32	ft^2
Flow Velocity, V =	1.69	ft/s	Flow Velocity, V =	2.09	ft/s
Trash Rack Head Loss, H_L =	0.206	ft	Trash Rack Head Loss, H_L =	0.236	ft
15% Blinding			**15% Blinding**		
Percent Blinding =	15%		Percent Blinding =	15%	
Net Open Area of Racks =	402.34	ft^2	Net Open Area of Racks =	325.82	ft^2
Flow Velocity, V =	1.99	ft/s	Flow Velocity, V =	2.46	ft/s
Trash Rack Head Loss, H_L =	0.209	ft	Trash Rack Head Loss, H_L =	0.249	ft
25% Blinding			**25% Blinding**		
Percent Blinding =	25%		Percent Blinding =	25%	
Net Open Area of Racks =	355.00	ft^2	Net Open Area of Racks =	287.49	ft^2
Flow Velocity =	2.25	ft/s	Flow Velocity =	2.78	ft/s
Trash Rack Head Loss =	0.211	ft	Trash Rack Head Loss =	0.263	ft
50% Blinding			**50% Blinding**		
Percent Blinding =	50%		Percent Blinding =	50%	
Net Open Area of Racks =	236.67	ft^2	Net Open Area of Racks =	191.66	ft^2
Flow Velocity =	3.38	ft/s	Flow Velocity =	4.17	ft/s
Trash Rack Head Loss =	0.225	ft	Trash Rack Head Loss =	0.342	ft

TABLE B5 DELLS HEAD LOSS CALCULATIONS

Trash Rack Base Dimensions		
Rack Total Length, L =	162	ft
Rack Invert Elevation =	774.75	ft
Normal Headpond Elevation =	795	ft
Height of trash rack in flow =	31.00	ft
Gross Area, A_{gross} =	5022.00	ft^2
Flow Capacity, Q =	6875	cfs
Top of Rack =	802.5	ft
Caibration Factor	1	ft
1.0" Rack Spacing - Inclined rack		
Vertical Bar Spacing =	1.0	in
Vertical Bar 1 Width, b_{bar} =	0.3125	In
Vert. Bar 1 Length in Flow, L_{bar} =	31.00	ft
Number of Vertical Bar =	1481	
Area of Bars, A_{bars} =	1195.6	ft^2
Net Open Area of Racks, A_{net} =	3826.4	ft^2
Ratio of Net to Gross Area, R =	0.76	
Loss Coefficient, K =	0.527	
Gravitational Constant, g =	32.20	ft/s^2
0% Blinding		
Percent Blinding	0%	
Net Open Area of Racks =	3826.40	ft^2
Flow Velocity, V =	1.80	ft/s
Trash Rack Head Loss, H_L =	1.026	ft
15% Blinding		
Percent Blinding	15%	
Net Open Area of Racks =	3252.44	ft^2
Flow Velocity, V =	2.11	ft/s
Trash Rack Head Loss, H_L =	1.037	ft
25% Blinding		
Percent Blinding	25%	
Net Open Area of Racks =	2869.80	ft^2
Flow Velocity =	2.40	ft/s
Trash Rack Head Loss =	1.047	ft
50% Blinding		
Percent Blinding	50%	
Net Open Area of Racks =	1913.20	ft^2
Flow Velocity =	3.59	ft/s
Trash Rack Head Loss =	1.106	ft

Appendix C

Monthly Results of the Energy Model Evaluation

TABLE C1 MONTHLY GENERATION – HOLCOMBE EXISTING CONDITIONS

Existing	0% Blind	15% Blind	25% Blind	50% Blind
JAN	4,574.0	4,573.7	4,573.4	4,571.6
FEB	4,388.0	4,387.7	4,387.4	4,385.6
MAR	7,651.1	7,650.2	7,649.4	7,644.7
APR	14,041.7	14,039.8	14,037.9	14,027.0
MAY	12,201.5	12,200.0	12,198.4	12,189.5
JUN	9,379.1	9,378.0	9,376.8	9,370.4
JUL	6,511.6	6,510.9	6,510.3	6,506.7
AUG	5,884.8	5,884.3	5,883.8	5,880.7
SEP	5,394.3	5,393.8	5,393.4	5,390.6
OCT	6,920.9	6,920.3	6,919.5	6,915.5
NOV	6,537.2	6,536.6	6,535.9	6,532.3
DEC	5,465.5	5,465.0	5,464.6	5,461.9
ANN	88,949.7	88,940.3	88,930.7	88,876.5

TABLE C2 MONTHLY GENERATION – HOLCOMBE PROPOSED NARROWLY-SPACED RACKS CONDITIONS

1"	0% Blind	15% Blind	25% Blind	50% Blind
JAN	4,569.8	4,567.9	4,566.0	4,554.9
FEB	4,383.8	4,381.9	4,380.0	4,369.0
MAR	7,640.1	7,635.1	7,630.0	7,601.1
APR	14,016.3	14,004.6	13,992.6	13,925.2
MAY	12,180.7	12,171.1	12,161.4	12,106.1
JUN	9,364.1	9,357.3	9,350.3	9,310.7
JUL	6,503.1	6,499.2	6,495.2	6,472.8
AUG	5,877.6	5,874.3	5,870.9	5,851.8
SEP	5,387.9	5,385.0	5,381.9	5,364.9
OCT	6,911.6	6,907.3	6,902.9	6,878.0
NOV	6,528.7	6,524.8	6,520.7	6,498.1
DEC	5,459.4	5,456.6	5,453.7	5,437.6
ANN	88,823.1	88,765.1	88,705.6	88,370.0

TABLE C3 MONTHLY GENERATION – HOLCOMBE PROPOSED NARROWLY-SPACED INCLINED RACKS CONDITIONS

1"-Inclined	0% Blind	15% Blind	25% Blind	50% Blind
JAN	4,573.8	4,573.4	4,573.0	4,570.8
FEB	4,387.8	4,387.4	4,387.0	4,384.7
MAR	7,650.5	7,649.5	7,648.4	7,642.5
APR	14,040.4	14,038.0	14,035.6	14,021.8
MAY	12,200.5	12,198.5	12,196.5	12,185.2
JUN	9,378.3	9,376.9	9,375.5	9,367.4
JUL	6,511.1	6,510.3	6,509.5	6,504.9
AUG	5,884.5	5,883.8	5,883.1	5,879.2
SEP	5,394.0	5,393.4	5,392.8	5,389.3
OCT	6,920.5	6,919.6	6,918.7	6,913.6
NOV	6,536.8	6,536.0	6,535.2	6,530.5
DEC	5,465.2	5,464.6	5,464.0	5,460.7
ANN	88,943.3	88,931.4	88,919.3	88,850.8

TABLE C4 MONTHLY GENERATION – CORNELL EXISTING CONDITIONS

Existing	0% Blind	15% Blind	25% Blind	50% Blind
JAN	4,050.9	4,049.0	4,047.0	4,035.9
FEB	3,897.1	3,895.1	3,893.1	3,881.8
MAR	6,848.2	6,842.8	6,837.2	6,805.8
APR	12,826.4	12,812.6	12,798.4	12,718.4
MAY	11,037.1	11,025.9	11,014.4	10,949.9
JUN	8,390.1	8,382.4	8,374.5	8,329.7
JUL	5,791.7	5,787.5	5,783.1	5,758.8
AUG	5,241.6	5,238.0	5,234.4	5,213.6
SEP	4,806.9	4,803.5	4,800.1	4,780.9
OCT	6,163.0	6,158.1	6,153.1	6,124.9
NOV	5,821.9	5,817.6	5,813.2	5,788.6
DEC	4,849.0	4,846.0	4,842.9	4,825.3
ANN	79,723.9	79,658.5	79,591.6	79,213.5

TABLE C5 MONTHLY GENERATION – CORNELL PROPOSED NARROWLY-SPACED RACKS CONDITIONS

1"	0% Blind	15% Blind	25% Blind	50% Blind
JAN	4,029.5	4,019.4	4,009.0	3,950.4
FEB	3,875.1	3,864.7	3,854.0	3,793.8
MAR	6,785.0	6,755.3	6,724.8	6,552.8
APR	12,663.3	12,586.8	12,508.4	12,065.8
MAY	10,905.7	10,844.0	10,780.9	10,424.3
JUN	8,299.4	8,256.9	8,213.2	7,967.0
JUL	5,743.0	5,720.0	5,696.5	5,563.9
AUG	5,200.4	5,180.9	5,161.0	5,048.7
SEP	4,768.7	4,750.7	4,732.3	4,628.3
OCT	6,106.3	6,079.6	6,052.3	5,898.0
NOV	5,772.5	5,749.2	5,725.4	5,590.9
DEC	4,814.3	4,797.9	4,781.1	4,686.4
ANN	78,963.1	78,605.5	78,239.0	76,170.3

TABLE C6 MONTHLY GENERATION – HOLCOMBE PROPOSED NARROWLY-SPACED ANGLED RACKS CONDITIONS

1"-Angled	0% Blind	15% Blind	25% Blind	50% Blind
JAN	4,061.5	4,061.2	4,060.9	4,059.2
FEB	3,908.1	3,907.8	3,907.5	3,905.7
MAR	6,880.8	6,879.9	6,879.0	6,873.8
APR	12,911.3	12,909.0	12,906.5	12,892.9
MAY	11,105.3	11,103.4	11,101.4	11,090.5
JUN	8,437.1	8,435.8	8,434.4	8,426.9
JUL	5,816.6	5,815.9	5,815.2	5,811.2
AUG	5,262.6	5,262.1	5,261.5	5,258.1
SEP	4,826.3	4,825.8	4,825.2	4,822.1
OCT	6,192.1	6,191.3	6,190.5	6,185.8
NOV	5,847.2	5,846.5	5,845.8	5,841.7
DEC	4,866.7	4,866.2	4,865.7	4,862.9
ANN	80,115.6	80,104.8	80,093.6	80,030.8

TABLE C7 MONTHLY GENERATION – JIM FALLS EXISTING CONDITIONS

Existing	0% Blind	15% Blind	25% Blind	50% Blind
JAN	6,241.9	6,241.6	6,241.4	6,239.9
FEB	5,999.4	5,999.0	5,998.7	5,996.7
MAR	10,499.5	10,498.0	10,496.5	10,487.6
APR	19,730.1	19,724.9	19,719.6	19,689.5
MAY	16,926.1	16,922.2	16,918.3	16,895.9
JUN	12,789.1	12,786.7	12,784.3	12,770.7
JUL	8,883.3	8,882.2	8,881.1	8,875.1
AUG	8,045.4	8,044.5	8,043.5	8,038.2
SEP	7,375.2	7,374.2	7,373.2	7,367.7
OCT	9,415.3	9,413.9	9,412.4	9,404.1
NOV	8,918.5	8,917.4	8,916.2	8,909.7
DEC	7,454.1	7,453.4	7,452.7	7,448.7
ANN	122,277.9	122,258.2	122,237.9	122,123.8

TABLE C8 MONTHLY GENERATION – JIM FALLS PROPOSED NARROWLY-SPACED RACKS CONDITIONS

1"	0% Blind	15% Blind	25% Blind	50% Blind
JAN	6,238.7	6,237.2	6,235.7	6,227.0
FEB	5,995.2	5,993.3	5,991.3	5,980.0
MAR	10,480.6	10,471.8	10,462.8	10,411.9
APR	19,665.5	19,635.5	19,604.8	19,431.1
MAY	16,878.1	16,855.7	16,832.8	16,703.7
JUN	12,759.8	12,746.3	12,732.3	12,653.8
JUL	8,870.3	8,864.3	8,858.1	8,823.3
AUG	8,033.9	8,028.6	8,023.1	7,992.2
SEP	7,363.3	7,357.7	7,352.0	7,319.9
OCT	9,397.5	9,389.3	9,380.8	9,333.0
NOV	8,904.6	8,898.2	8,891.5	8,854.3
DEC	7,445.5	7,441.4	7,437.3	7,414.0
ANN	122,033.0	121,919.2	121,802.6	121,144.2

TABLE C9 MONTHLY GENERATION – JIM FALLS PROPOSED NARROWLY-SPACED ANGLED RACKS CONDITIONS

1"-Angled	0% Blind	15% Blind	25% Blind	50% Blind
JAN	6,250.0	6,249.9	6,249.7	6,248.6
FEB	6,010.0	6,009.7	6,009.5	6,008.1
MAR	10,547.5	10,546.5	10,545.4	10,539.2
APR	19,893.8	19,890.2	19,886.4	19,865.3
MAY	17,047.9	17,045.2	17,042.4	17,026.6
JUN	12,863.1	12,861.4	12,859.7	12,850.2
JUL	8,916.0	8,915.3	8,914.6	8,910.3
AUG	8,074.5	8,073.9	8,073.2	8,069.4
SEP	7,405.5	7,404.8	7,404.1	7,400.2
OCT	9,460.4	9,459.4	9,458.4	9,452.6
NOV	8,953.6	8,952.8	8,952.0	8,947.5
DEC	7,476.1	7,475.6	7,475.1	7,472.3
ANN	122,898.5	122,884.6	122,870.4	122,790.2

TABLE C10 MONTHLY GENERATION – WISSOTA EXISTING CONDITIONS

Existing	0% Blind	15% Blind	25% Blind	50% Blind
JAN	7,209.3	7,208.1	7,206.9	7,200.0
FEB	6,856.7	6,855.5	6,854.4	6,847.8
MAR	11,438.8	11,436.3	11,433.7	11,419.1
APR	18,672.6	18,668.0	18,663.3	18,636.9
MAY	16,980.7	16,976.7	16,972.5	16,949.3
JUN	13,778.0	13,774.8	13,771.6	13,753.4
JUL	9,969.4	9,967.4	9,965.3	9,953.5
AUG	8,906.0	8,904.3	8,902.5	8,892.7
SEP	8,085.4	8,084.0	8,082.5	8,074.2
OCT	10,408.9	10,406.8	10,404.7	10,392.8
NOV	10,000.3	9,998.3	9,996.2	9,984.6
DEC	8,475.0	8,473.5	8,472.0	8,463.2
ANN	130,781.0	130,753.7	130,725.7	130,567.6

TABLE C11 MONTHLY GENERATION – WISSOTA PROPOSED NARROWLY-SPACED RACKS CONDITIONS

1"	0% Blind	15% Blind	25% Blind	50% Blind
JAN	7,201.1	7,196.7	7,192.3	7,167.1
FEB	6,848.9	6,844.7	6,840.5	6,816.6
MAR	11,421.4	11,412.3	11,402.8	11,349.7
APR	18,641.1	18,624.5	18,607.4	18,511.1
MAY	16,953.0	16,938.4	16,923.4	16,838.8
JUN	13,756.3	13,744.8	13,733.1	13,666.7
JUL	9,955.4	9,948.0	9,940.4	9,897.5
AUG	8,894.2	8,888.0	8,881.6	8,845.7
SEP	8,075.5	8,070.3	8,065.0	8,034.8
OCT	10,394.7	10,387.2	10,379.6	10,336.2
NOV	9,986.5	9,979.2	9,971.7	9,929.5
DEC	8,464.6	8,459.1	8,453.5	8,421.6
ANN	130,592.9	130,493.3	130,391.3	129,815.1

TABLE C12 MONTHLY GENERATION – WISSOTA PROPOSED NARROWLY-SPACED INCLINED RACKS CONDITIONS

1"	0% Blind	15% Blind	25% Blind	50% Blind
JAN	7,211.7	7,211.4	7,211.1	7,209.5
FEB	6,858.9	6,858.6	6,858.3	6,856.7
MAR	11,443.5	11,442.8	11,442.0	11,437.8
APR	18,680.2	18,678.5	18,676.9	18,667.4
MAY	16,987.6	16,986.2	16,984.8	16,976.9
JUN	13,783.6	13,782.6	13,781.6	13,776.0
JUL	9,973.3	9,972.7	9,972.2	9,969.0
AUG	8,909.2	8,908.7	8,908.2	8,905.4
SEP	8,088.0	8,087.6	8,087.2	8,084.8
OCT	10,412.6	10,412.0	10,411.4	10,407.9
NOV	10,004.0	10,003.5	10,002.9	9,999.7
DEC	8,477.9	8,477.5	8,477.1	8,474.8
ANN	130,830.6	130,822.3	130,813.8	130,765.9

TABLE C13 MONTHLY GENERATION – DELLS EXISTING CONDITIONS

Existing	0% Blind	15% Blind	25% Blind	50% Blind
JAN	3,172.9	3,172.3	3,171.7	3,168.0
FEB	2,933.6	2,933.0	2,932.4	2,928.7
MAR	4,621.3	4,620.1	4,618.9	4,611.9
APR	5,704.0	5,702.2	5,700.3	5,689.6
MAY	5,608.8	5,607.2	5,605.5	5,596.0
JUN	5,120.9	5,119.5	5,118.1	5,110.0
JUL	4,061.9	4,061.0	4,060.0	4,054.6
AUG	3,504.3	3,503.6	3,502.7	3,498.2
SEP	3,197.6	3,196.9	3,196.1	3,191.8
OCT	3,946.4	3,945.4	3,944.4	3,938.7
NOV	4,079.8	4,078.8	4,077.8	4,072.2
DEC	3,516.3	3,515.5	3,514.7	3,510.1
ANN	49,468.0	49,455.4	49,442.5	49,369.6

TABLE C14 MONTHLY GENERATION – DELLS PROPOSED NARROWLY-SPACED RACKS CONDITIONS

Narrowly-Spaced	0% Blind	15% Blind	25% Blind	50% Blind
JAN	3,165.1	3,161.5	3,157.8	3,136.8
FEB	2,925.8	2,922.1	2,918.4	2,897.2
MAR	4,606.5	4,599.6	4,592.5	4,552.6
APR	5,681.3	5,670.7	5,659.8	5,598.6
MAY	5,588.6	5,579.2	5,569.6	5,515.3
JUN	5,103.7	5,095.7	5,087.6	5,041.3
JUL	4,050.3	4,044.9	4,039.4	4,008.1
AUG	3,494.7	3,490.2	3,485.6	3,459.6
SEP	3,188.4	3,184.1	3,179.8	3,155.1
OCT	3,934.3	3,928.7	3,922.9	3,890.3
NOV	4,067.8	4,062.2	4,056.4	4,024.0
DEC	3,506.5	3,501.9	3,497.2	3,470.8
ANN	49,313.0	49,240.9	49,166.9	48,749.6

TABLE C15 MONTHLY GENERATION – DELLS PROPOSED NARROWLY-SPACED INCLINED RACKS CONDITIONS

Inclined	0% Blind	15% Blind	25% Blind	50% Blind
JAN	3,175.3	3,175.0	3,174.7	3,173.0
FEB	2,935.0	2,934.6	2,934.3	2,932.5
MAR	4,617.0	4,616.3	4,615.6	4,611.3
APR	5,692.2	5,691.0	5,689.7	5,682.5
MAY	5,599.8	5,598.7	5,597.6	5,591.4
JUN	5,114.2	5,113.3	5,112.4	5,107.2
JUL	4,060.2	4,059.7	4,059.2	4,056.0
AUG	3,504.0	3,503.6	3,503.2	3,500.7
SEP	3,196.9	3,196.5	3,196.1	3,193.7
OCT	3,944.2	3,943.6	3,943.0	3,939.7
NOV	4,078.4	4,077.8	4,077.2	4,074.0
DEC	3,516.7	3,516.2	3,515.8	3,513.4
ANN	49,433.9	49,426.4	49,418.7	49,375.3

APPENDIX D

METHODS AND RESULTS OF PROBABILITY OF BLADE STRIKE SURVIVAL

Model iterations for the target species were prepared using three correlation factors for all units and three r values for the Kaplan units. The r value refers to the point along the runner radius where fish enter the turbine. The passage routes (i.e., r values) included the edge of hub, midpoint between the turbine hub and the discharge ring, and at the blade tip. The Advanced Hydro Turbine model uses a correlation factor to adjust the model results to correspond with empirical results from field studies because the contact of a fish with a turbine component does not always result in injury or mortality (Bell 1981; Cada 1998). The correlation factor is used to adjust predicted turbine strike results to more closely match empirical results. Based on a number of recent test results obtained from studies conducted with salmonids on the west coast, Franke and colleagues (1997) recommend setting the correlation factor between 0.10 and 0.20. In this study, we used correlation factors of 0.10, 0.15, and 0.20.

The probability of blade strike was calculated for each Kaplan and Francis turbine (including axial flow) using the following formulas:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\cos\alpha_a}{8 \cdot Q_{wd}} + \frac{\sin\alpha_a}{\pi \cdot \frac{r}{R}} \right]$$

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\sin\alpha_l \left[\frac{B}{D_1} \right]}{2Q_{ed}} + \frac{\cos\alpha_l}{\pi} \right]$$

In each formula the input parameters are defined as:

P	=	Predicted strike probability
N	=	Number of turbine blades
L	=	Length of fish
D	=	Diameter of runner
D_1	=	Diameter of runner at inlet
B	=	Runner height at inlet

λ = Strike mortality correlation factor (lambda)

R = Radius of runner = (D/2)

r = Location along radius that a given fish enters the turbine (i.e., edge of hub, midpoint between the turbine hub and the discharge ring, and at the blade tip)

η = Turbine efficiency

$E_{\omega d}$ = Head Coefficient or energy coefficient

$$= \frac{gH}{(\omega D)^2}$$

α_a = Angle to axial of absolute flow upstream of runner

$$= \tan\alpha_a = \frac{\pi \cdot E_{wd} \cdot \eta}{2 \cdot Q_{wd} \cdot \frac{r}{R}}$$

g = Acceleration of gravity

H = Turbine net head

ω = Rotational speed

$$= RPM \cdot \frac{2\pi}{60}$$

RPM = Revolutions per minute

Q = Turbine discharge

Q_{opt} = Turbine discharge at best efficiency

$Q_{\omega d}$ = Discharge Coefficient

$$= \frac{Q}{\omega D^3}$$

$$\tan\beta = \frac{0.707 \cdot \frac{\pi}{8}}{\xi \cdot Q_{\omega d}\, opt \left(\frac{D_1}{D_2}\right)^3}$$

ξ = Ratio between Q with no exit swirl and Q_{opt}

Survival was calculated by subtracting the predicted strike estimate from 100.

TABLES D1.1 THROUGH D1.7

HOLCOMBE PROJECT – RESULTS OF BLADE STRIKE CALCULATIONS

TABLE D1.1 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE HOLCOMBE PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.93%	1.39%	1.86%
3	1.39%	2.09%	2.79%
4	1.86%	2.79%	3.72%
5	2.32%	3.49%	4.65%
6	2.79%	4.18%	5.58%
7	3.25%	4.88%	6.51%
8	3.72%	5.58%	7.44%
9	4.18%	6.28%	8.37%
10	4.65%	6.97%	9.30%
Average	**2.8%**	**4.2%**	**5.6%**
	97.2%	95.8%	94.4%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.84%	1.25%	1.67%
3	1.25%	1.88%	2.51%
4	1.67%	2.51%	3.34%
5	2.09%	3.13%	4.18%
6	2.51%	3.76%	5.01%
7	2.92%	4.38%	5.85%
8	3.34%	5.01%	6.68%
9	3.76%	5.64%	7.52%
10	4.18%	6.26%	8.35%
Average	**2.5%**	**3.8%**	**5.0%**
	97.5%	96.2%	95.0%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.82%	1.24%	1.65%
3	1.24%	1.85%	2.47%
4	1.65%	2.47%	3.29%
5	2.06%	3.09%	4.12%
6	2.47%	3.71%	4.94%
7	2.88%	4.32%	5.77%
8	3.29%	4.94%	6.59%
9	3.71%	5.56%	7.41%
10	4.12%	6.18%	8.24%
Average	**2.5%**	**3.7%**	**4.9%**
	97.5%	96.3%	95.1%

TABLE D1.2: RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE HOLCOMBE PROJECT – WALLEYE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.93%	1.39%	1.86%
3	1.39%	2.09%	2.79%
4	1.86%	2.79%	3.72%
5	2.32%	3.49%	4.65%
6	2.79%	4.18%	5.58%
7	3.25%	4.88%	6.51%
8	3.72%	5.58%	7.44%
Average	**2.3%**	**3.5%**	**4.6%**
	97.7%	96.5%	95.4%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.84%	1.25%	1.67%
3	1.25%	1.88%	2.51%
4	1.67%	2.51%	3.34%
5	2.09%	3.13%	4.18%
6	2.51%	3.76%	5.01%
7	2.92%	4.38%	5.85%
8	3.34%	5.01%	6.68%
Average	**2.1%**	**3.1%**	**4.2%**
	97.9%	96.9%	95.8%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.82%	1.24%	1.65%
3	1.24%	1.85%	2.47%
4	1.65%	2.47%	3.29%
5	2.06%	3.09%	4.12%
6	2.47%	3.71%	4.94%
7	2.88%	4.32%	5.77%
8	3.29%	4.94%	6.59%
Average	**2.1%**	**3.1%**	**4.1%**
	97.9%	96.9%	95.9%

Table D1.3 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Units 1-3 at the Holcombe Project – Smallmouth Bass.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.93%	1.39%	1.86%		**2**	0.84%	1.25%	1.67%		**2**	0.82%	1.24%	1.65%
3	1.39%	2.09%	2.79%		**3**	1.25%	1.88%	2.51%		**3**	1.24%	1.85%	2.47%
4	1.86%	2.79%	3.72%		**4**	1.67%	2.51%	3.34%		**4**	1.65%	2.47%	3.29%
5	2.32%	3.49%	4.65%		**5**	2.09%	3.13%	4.18%		**5**	2.06%	3.09%	4.12%
Average	**1.6%**	**2.4%**	**3.3%**		**Average**	**1.5%**	**2.2%**	**2.9%**		**Average**	**1.4%**	**2.2%**	**2.9%**
	98.4%	97.6%	96.7%			98.5%	97.8%	97.1%			98.6%	97.8%	97.1%

Table D1.4 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Units 1-3 at the Holcombe Project – Bluegill.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.93%	1.39%	1.86%		**2**	0.84%	1.25%	1.67%		**2**	0.82%	1.24%	1.65%
3	1.39%	2.09%	2.79%		**3**	1.25%	1.88%	2.51%		**3**	1.24%	1.85%	2.47%
4	1.86%	2.79%	3.72%		**4**	1.67%	2.51%	3.34%		**4**	1.65%	2.47%	3.29%
5	2.32%	3.49%	4.65%		**5**	2.09%	3.13%	4.18%		**5**	2.06%	3.09%	4.12%
6	2.79%	4.18%	5.58%		**6**	2.51%	3.76%	5.01%		**6**	2.47%	3.71%	4.94%
Average	**1.9%**	**2.8%**	**3.7%**		**Average**	**1.7%**	**2.5%**	**3.3%**		**Average**	**1.6%**	**2.5%**	**3.3%**
	98.1%	97.2%	96.3%			98.3%	97.5%	96.7%			98.4%	97.5%	96.7%

TABLE D1.5 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE HOLCOMBE PROJECT – BLACK CRAPPIE.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.93%	1.39%	1.86%		**2**	0.84%	1.25%	1.67%		**2**	0.82%	1.24%	1.65%
3	1.39%	2.09%	2.79%		**3**	1.25%	1.88%	2.51%		**3**	1.24%	1.85%	2.47%
4	1.86%	2.79%	3.72%		**4**	1.67%	2.51%	3.34%		**4**	1.65%	2.47%	3.29%
5	2.32%	3.49%	4.65%		**5**	2.09%	3.13%	4.18%		**5**	2.06%	3.09%	4.12%
6	2.79%	4.18%	5.58%		**6**	2.51%	3.76%	5.01%		**6**	2.47%	3.71%	4.94%
Average	**1.9%**	**2.8%**	**3.7%**		**Average**	**1.7%**	**2.5%**	**3.3%**		**Average**	**1.6%**	**2.5%**	**3.3%**
	98.1%	97.2%	96.3%			98.3%	97.5%	96.7%			98.4%	97.5%	96.7%

TABLE D1.6 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE HOLCOMBE PROJECT – YELLOW PERCH.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.93%	1.39%	1.86%		**2**	0.84%	1.25%	1.67%		**2**	0.82%	1.24%	1.65%
3	1.39%	2.09%	2.79%		**3**	1.25%	1.88%	2.51%		**3**	1.24%	1.85%	2.47%
4	1.86%	2.79%	3.72%		**4**	1.67%	2.51%	3.34%		**4**	1.65%	2.47%	3.29%
5	2.32%	3.49%	4.65%		**5**	2.09%	3.13%	4.18%		**5**	2.06%	3.09%	4.12%
Average	**1.6%**	**2.4%**	**3.3%**		**Average**	**1.5%**	**2.2%**	**2.9%**		**Average**	**1.4%**	**2.2%**	**2.9%**
	98.4%	97.6%	96.7%			98.5%	97.8%	97.1%			98.6%	97.8%	97.1%

TABLE D1.7 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE HOLCOMBE PROJECT – LAKE STURGEON.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.93%	1.39%	1.86%		**2**	0.84%	1.25%	1.67%		**2**	0.82%	1.24%	1.65%
3	1.39%	2.09%	2.79%		**3**	1.25%	1.88%	2.51%		**3**	1.24%	1.85%	2.47%
4	1.86%	2.79%	3.72%		**4**	1.67%	2.51%	3.34%		**4**	1.65%	2.47%	3.29%
5	2.32%	3.49%	4.65%		**5**	2.09%	3.13%	4.18%		**5**	2.06%	3.09%	4.12%
6	2.79%	4.18%	5.58%		**6**	2.51%	3.76%	5.01%		**6**	2.47%	3.71%	4.94%
7	3.25%	4.88%	6.51%		**7**	2.92%	4.38%	5.85%		**7**	2.88%	4.32%	5.77%
8	3.72%	5.58%	7.44%		**8**	3.34%	5.01%	6.68%		**8**	3.29%	4.94%	6.59%
Average	**2.3%**	**3.5%**	**4.6%**		**Average**	**2.1%**	**3.1%**	**4.2%**		**Average**	**2.1%**	**3.1%**	**4.1%**
	97.7%	96.5%	95.4%			97.9%	96.9%	95.8%			97.9%	96.9%	95.9%

TABLES D2.1 THROUGH D2.14

CORNELL PROJECT – RESULTS OF BLADE STRIKE CALCULATIONS

TABLE D2.1 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE CORNELL PROJECT - MUSKELLUNGE.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.69%	1.04%	1.39%		**2**	0.65%	0.97%	1.30%		**2**	0.64%	0.97%	1.29%
3	1.04%	1.56%	2.08%		**3**	0.97%	1.46%	1.94%		**3**	0.97%	1.45%	1.93%
4	1.39%	2.08%	2.78%		**4**	1.30%	1.94%	2.59%		**4**	1.29%	1.93%	2.58%
5	1.74%	2.60%	3.47%		**5**	1.62%	2.43%	3.24%		**5**	1.61%	2.42%	3.22%
6	2.08%	3.12%	4.16%		**6**	1.94%	2.91%	3.89%		**6**	1.93%	2.90%	3.87%
7	2.43%	3.64%	4.86%		**7**	2.27%	3.40%	4.53%		**7**	2.25%	3.38%	4.51%
8	2.78%	4.16%	5.55%		**8**	2.59%	3.89%	5.18%		**8**	2.58%	3.87%	5.15%
9	3.12%	4.69%	6.25%		**9**	2.91%	4.37%	5.83%		**9**	2.90%	4.35%	5.80%
10	3.47%	5.21%	6.94%		**10**	3.24%	4.86%	6.48%		**10**	3.22%	4.83%	6.44%
Average	**3.5%**	**5.2%**	**6.9%**		**Average**	**3.2%**	**4.9%**	**6.5%**		**Average**	**3.2%**	**4.8%**	**6.4%**
	96.5%	94.8%	93.1%			96.8%	95.1%	93.5%			96.8%	95.2%	93.6%

TABLE D2.2 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE CORNELL PROJECT - WALLEYE.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.69%	1.04%	1.39%		**2**	0.65%	0.97%	1.30%		**2**	0.64%	0.97%	1.29%
3	1.04%	1.56%	2.08%		**3**	0.97%	1.46%	1.94%		**3**	0.97%	1.45%	1.93%
4	1.39%	2.08%	2.78%		**4**	1.30%	1.94%	2.59%		**4**	1.29%	1.93%	2.58%
5	1.74%	2.60%	3.47%		**5**	1.62%	2.43%	3.24%		**5**	1.61%	2.42%	3.22%
6	2.08%	3.12%	4.16%		**6**	1.94%	2.91%	3.89%		**6**	1.93%	2.90%	3.87%
7	2.43%	3.64%	4.86%		**7**	2.27%	3.40%	4.53%		**7**	2.25%	3.38%	4.51%
8	2.78%	4.16%	5.55%		**8**	2.59%	3.89%	5.18%		**8**	2.58%	3.87%	5.15%
Average	**1.7%**	**2.6%**	**3.5%**		**Average**	**1.6%**	**2.4%**	**3.2%**		**Average**	**1.6%**	**2.4%**	**3.2%**
	98.3%	97.4%	96.5%			98.4%	97.6%	96.8%			98.4%	97.6%	96.8%

TABLE D2.3 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE CORNELL PROJECT – SMALLMOUTH BASS.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.69%	1.04%	1.39%		**2**	0.65%	0.97%	1.30%		**2**	0.64%	0.97%	1.29%
3	1.04%	1.56%	2.08%		**3**	0.97%	1.46%	1.94%		**3**	0.97%	1.45%	1.93%
4	1.39%	2.08%	2.78%		**4**	1.30%	1.94%	2.59%		**4**	1.29%	1.93%	2.58%
5	1.74%	2.60%	3.47%		**5**	1.62%	2.43%	3.24%		**5**	1.61%	2.42%	3.22%
Average	**1.2%**	**1.8%**	**2.4%**		**Average**	**1.1%**	**1.7%**	**2.3%**		**Average**	**1.1%**	**1.7%**	**2.3%**
	98.8%	98.2%	97.6%			98.9%	98.3%	97.7%			98.9%	98.3%	97.7%

TABLE D2.4 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE CORNELL PROJECT – BLUEGILL.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.69%	1.04%	1.39%		**2**	0.65%	0.97%	1.30%		**2**	0.64%	0.97%	1.29%
3	1.04%	1.56%	2.08%		**3**	0.97%	1.46%	1.94%		**3**	0.97%	1.45%	1.93%
4	1.39%	2.08%	2.78%		**4**	1.30%	1.94%	2.59%		**4**	1.29%	1.93%	2.58%
5	1.74%	2.60%	3.47%		**5**	1.62%	2.43%	3.24%		**5**	1.61%	2.42%	3.22%
6	2.08%	3.12%	4.16%		**6**	1.94%	2.91%	3.89%		**6**	1.93%	2.90%	3.87%
Average	**1.4%**	**2.1%**	**2.8%**		**Average**	**1.3%**	**1.9%**	**2.6%**		**Average**	**1.3%**	**1.9%**	**2.6%**
	98.6%	97.9%	97.2%			98.7%	98.1%	97.4%			98.7%	98.1%	97.4%

TABLE D2.5 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE CORNELL PROJECT – BLACK CRAPPIE.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.69%	1.04%	1.39%		**2**	0.65%	0.97%	1.30%		**2**	0.64%	0.97%	1.29%
3	1.04%	1.56%	2.08%		**3**	0.97%	1.46%	1.94%		**3**	0.97%	1.45%	1.93%
4	1.39%	2.08%	2.78%		**4**	1.30%	1.94%	2.59%		**4**	1.29%	1.93%	2.58%
5	1.74%	2.60%	3.47%		**5**	1.62%	2.43%	3.24%		**5**	1.61%	2.42%	3.22%
6	2.08%	3.12%	4.16%		**6**	1.94%	2.91%	3.89%		**6**	1.93%	2.90%	3.87%
Average	**1.4%**	**2.1%**	**2.8%**		**Average**	**1.3%**	**1.9%**	**2.6%**		**Average**	**1.3%**	**1.9%**	**2.6%**
	98.6%	97.9%	97.2%			98.7%	98.1%	97.4%			98.7%	98.1%	97.4%

TABLE D2.6 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE CORNELL PROJECT – YELLOW PERCH.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.69%	1.04%	1.39%		**2**	0.65%	0.97%	1.30%		**2**	0.64%	0.97%	1.29%
3	1.04%	1.56%	2.08%		**3**	0.97%	1.46%	1.94%		**3**	0.97%	1.45%	1.93%
4	1.39%	2.08%	2.78%		**4**	1.30%	1.94%	2.59%		**4**	1.29%	1.93%	2.58%
5	1.74%	2.60%	3.47%		**5**	1.62%	2.43%	3.24%		**5**	1.61%	2.42%	3.22%
Average	**1.2%**	**1.8%**	**2.4%**		**Average**	**1.1%**	**1.7%**	**2.3%**		**Average**	**1.1%**	**1.7%**	**2.3%**
	98.8%	98.2%	97.6%			98.9%	98.3%	97.7%			98.9%	98.3%	97.7%

TABLE D2.7 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1-3 AT THE CORNELL PROJECT – LAKE STURGEON.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.69%	1.04%	1.39%		**2**	0.65%	0.97%	1.30%		**2**	0.64%	0.97%	1.29%
3	1.04%	1.56%	2.08%		**3**	0.97%	1.46%	1.94%		**3**	0.97%	1.45%	1.93%
4	1.39%	2.08%	2.78%		**4**	1.30%	1.94%	2.59%		**4**	1.29%	1.93%	2.58%
5	1.74%	2.60%	3.47%		**5**	1.62%	2.43%	3.24%		**5**	1.61%	2.42%	3.22%
6	2.08%	3.12%	4.16%		**6**	1.94%	2.91%	3.89%		**6**	1.93%	2.90%	3.87%
7	2.43%	3.64%	4.86%		**7**	2.27%	3.40%	4.53%		**7**	2.25%	3.38%	4.51%
8	2.78%	4.16%	5.55%		**8**	2.59%	3.89%	5.18%		**8**	2.58%	3.87%	5.15%
Average	**2.8%**	**4.2%**	**5.6%**		**Average**	**2.6%**	**3.9%**	**5.2%**		**Average**	**2.6%**	**3.9%**	**5.2%**
	97.2%	95.8%	94.4%			97.4%	96.1%	94.8%			97.4%	96.1%	94.8%

TABLE D2.8 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 4 AT THE CORNELL PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	2.41%	3.61%	4.82%		**2**	2.15%	3.22%	4.30%		**2**	2.08%	3.12%	4.16%
3	3.61%	5.42%	7.23%		**3**	3.22%	4.84%	6.45%		**3**	3.12%	4.68%	6.24%
4	4.82%	7.23%	9.63%		**4**	4.30%	6.45%	8.60%		**4**	4.16%	6.24%	8.32%
5	6.02%	9.03%	12.04%		**5**	5.37%	8.06%	10.75%		**5**	5.20%	7.80%	10.41%
6	7.23%	10.84%	14.45%		**6**	6.45%	9.67%	12.90%		**6**	6.24%	9.37%	12.49%
7	8.43%	12.65%	16.86%		**7**	7.52%	11.28%	15.05%		**7**	7.28%	10.93%	14.57%
8	9.63%	14.45%	19.27%		**8**	8.60%	12.90%	17.19%		**8**	8.32%	12.49%	16.65%
9	10.84%	16.26%	21.68%		**9**	9.67%	14.51%	19.34%		**9**	9.37%	14.05%	18.73%
10	12.04%	18.06%	24.09%		**10**	10.75%	16.12%	21.49%		**10**	10.41%	15.61%	20.81%
Average	**12.0%**	**18.1%**	**24.1%**		**Average**	**10.7%**	**16.1%**	**21.5%**		**Average**	**10.4%**	**15.6%**	**20.8%**
	88.0%	81.9%	75.9%			89.3%	83.9%	78.5%			89.6%	84.4%	79.2%

TABLE D2.9 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 4 AT THE CORNELL PROJECT – WALLEYE.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	2.41%	3.61%	4.82%		**2**	2.15%	3.22%	4.30%		**2**	2.08%	3.12%	4.16%
3	3.61%	5.42%	7.23%		**3**	3.22%	4.84%	6.45%		**3**	3.12%	4.68%	6.24%
4	4.82%	7.23%	9.63%		**4**	4.30%	6.45%	8.60%		**4**	4.16%	6.24%	8.32%
5	6.02%	9.03%	12.04%		**5**	5.37%	8.06%	10.75%		**5**	5.20%	7.80%	10.41%
6	7.23%	10.84%	14.45%		**6**	6.45%	9.67%	12.90%		**6**	6.24%	9.37%	12.49%
7	8.43%	12.65%	16.86%		**7**	7.52%	11.28%	15.05%		**7**	7.28%	10.93%	14.57%
8	9.63%	14.45%	19.27%		**8**	8.60%	12.90%	17.19%		**8**	8.32%	12.49%	16.65%
Average	**6.0%**	**9.0%**	**12.0%**		**Average**	**5.4%**	**8.1%**	**10.7%**		**Average**	**5.2%**	**7.8%**	**10.4%**
	94.0%	91.0%	88.0%			94.6%	91.9%	89.3%			94.8%	92.2%	89.6%

TABLE D2.10 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 4 AT THE CORNELL PROJECT – SMALLMOUTH BASS.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	2.41%	3.61%	4.82%		**2**	2.15%	3.22%	4.30%		**2**	2.08%	3.12%	4.16%
3	3.61%	5.42%	7.23%		**3**	3.22%	4.84%	6.45%		**3**	3.12%	4.68%	6.24%
4	4.82%	7.23%	9.63%		**4**	4.30%	6.45%	8.60%		**4**	4.16%	6.24%	8.32%
5	6.02%	9.03%	12.04%		**5**	5.37%	8.06%	10.75%		**5**	5.20%	7.80%	10.41%
Average	**4.2%**	**6.3%**	**8.4%**		**Average**	**3.8%**	**5.6%**	**7.5%**		**Average**	**3.6%**	**5.5%**	**7.3%**
	95.8%	93.7%	91.6%			96.2%	94.4%	92.5%			96.4%	94.5%	92.7%

TABLE D2.11 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 4 AT THE CORNELL PROJECT – BLUEGILL.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	2.41%	3.61%	4.82%		**2**	2.15%	3.22%	4.30%		**2**	2.08%	3.12%	4.16%
3	3.61%	5.42%	7.23%		**3**	3.22%	4.84%	6.45%		**3**	3.12%	4.68%	6.24%
4	4.82%	7.23%	9.63%		**4**	4.30%	6.45%	8.60%		**4**	4.16%	6.24%	8.32%
5	6.02%	9.03%	12.04%		**5**	5.37%	8.06%	10.75%		**5**	5.20%	7.80%	10.41%
6	7.23%	10.84%	14.45%		**6**	6.45%	9.67%	12.90%		**6**	6.24%	9.37%	12.49%
Average	**4.8%**	**7.2%**	**9.6%**		**Average**	**4.3%**	**6.4%**	**8.6%**		**Average**	**4.2%**	**6.2%**	**8.3%**
	95.2%	92.8%	90.4%			95.7%	93.6%	91.4%			95.8%	93.8%	91.7%

Table D2.12 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Unit 4 at the Cornell Project – Black Crappie.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	2.41%	3.61%	4.82%		**2**	2.15%	3.22%	4.30%		**2**	2.08%	3.12%	4.16%
3	3.61%	5.42%	7.23%		**3**	3.22%	4.84%	6.45%		**3**	3.12%	4.68%	6.24%
4	4.82%	7.23%	9.63%		**4**	4.30%	6.45%	8.60%		**4**	4.16%	6.24%	8.32%
5	6.02%	9.03%	12.04%		**5**	5.37%	8.06%	10.75%		**5**	5.20%	7.80%	10.41%
6	7.23%	10.84%	14.45%		**6**	6.45%	9.67%	12.90%		**6**	6.24%	9.37%	12.49%
Average	**4.8%**	**7.2%**	**9.6%**		**Average**	**4.3%**	**6.4%**	**8.6%**		**Average**	**4.2%**	**6.2%**	**8.3%**
	95.2%	92.8%	90.4%			95.7%	93.6%	91.4%			95.8%	93.8%	91.7%

Table D2.13 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Unit 4 at the Cornell Project – Yellow Perch.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	2.41%	3.61%	4.82%		**2**	2.15%	3.22%	4.30%		**2**	2.08%	3.12%	4.16%
3	3.61%	5.42%	7.23%		**3**	3.22%	4.84%	6.45%		**3**	3.12%	4.68%	6.24%
4	4.82%	7.23%	9.63%		**4**	4.30%	6.45%	8.60%		**4**	4.16%	6.24%	8.32%
5	6.02%	9.03%	12.04%		**5**	5.37%	8.06%	10.75%		**5**	5.20%	7.80%	10.41%
Average	**4.2%**	**6.3%**	**8.4%**		**Average**	**3.8%**	**5.6%**	**7.5%**		**Average**	**3.6%**	**5.5%**	**7.3%**
	95.8%	93.7%	91.6%			96.2%	94.4%	92.5%			96.4%	94.5%	92.7%

TABLE D2.14 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 4 AT THE CORNELL PROJECT – LAKE STURGEON.

	CORRELATION FACTOR				CORRELATION FACTOR				CORRELATION FACTOR		
	0.10	0.15	0.20		0.10	0.15	0.20		0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	2.41%	3.61%	4.82%	**2**	2.15%	3.22%	4.30%	**2**	2.08%	3.12%	4.16%
3	3.61%	5.42%	7.23%	**3**	3.22%	4.84%	6.45%	**3**	3.12%	4.68%	6.24%
4	4.82%	7.23%	9.63%	**4**	4.30%	6.45%	8.60%	**4**	4.16%	6.24%	8.32%
5	6.02%	9.03%	12.04%	**5**	5.37%	8.06%	10.75%	**5**	5.20%	7.80%	10.41%
6	7.23%	10.84%	14.45%	**6**	6.45%	9.67%	12.90%	**6**	6.24%	9.37%	12.49%
7	8.43%	12.65%	16.86%	**7**	7.52%	11.28%	15.05%	**7**	7.28%	10.93%	14.57%
8	9.63%	14.45%	19.27%	**8**	8.60%	12.90%	17.19%	**8**	8.32%	12.49%	16.65%
Average	**6.0%**	**9.0%**	**12.0%**	**Average**	**5.4%**	**8.1%**	**10.7%**	**Average**	**5.2%**	**7.8%**	**10.4%**
	94.0%	91.0%	88.0%		94.6%	91.9%	89.3%		94.8%	92.2%	89.6%

TABLES D3.1 THROUGH D3.21

DELLS PROJECT – RESULTS OF BLADE STRIKE CALCULATIONS

TABLE D3.1 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 1 AT THE DELLS PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR				**CORRELATION FACTOR**				**CORRELATION FACTOR**		
	0.10	0.15	0.20		0.10	0.15	0.20		0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.83%	1.24%	1.66%	**2**	0.74%	1.11%	1.48%	**2**	0.72%	1.08%	1.44%
3	1.24%	1.86%	2.49%	**3**	1.11%	1.67%	2.22%	**3**	1.08%	1.62%	2.17%
4	1.66%	2.49%	3.31%	**4**	1.48%	2.22%	2.96%	**4**	1.44%	2.17%	2.89%
5	2.07%	3.11%	4.14%	**5**	1.85%	2.78%	3.70%	**5**	1.80%	2.71%	3.61%
6	2.49%	3.73%	4.97%	**6**	2.22%	3.33%	4.44%	**6**	2.17%	3.25%	4.33%
7	2.90%	4.35%	5.80%	**7**	2.59%	3.89%	5.18%	**7**	2.53%	3.79%	5.05%
8	3.31%	4.97%	6.63%	**8**	2.96%	4.44%	5.93%	**8**	2.89%	4.33%	5.77%
9	3.73%	5.59%	7.46%	**9**	3.33%	5.00%	6.67%	**9**	3.25%	4.87%	6.50%
10	4.14%	6.21%	8.29%	**10**	3.70%	5.56%	7.41%	**10**	3.61%	5.41%	7.22%
Average	**4.1%**	**6.2%**	**8.3%**	**Average**	**3.7%**	**5.6%**	**7.4%**	**Average**	**3.6%**	**5.4%**	**7.2%**
	95.9%	93.8%	91.7%		96.3%	94.4%	92.6%		96.4%	94.6%	92.8%

TABLE D3.2 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 1 AT THE DELLS PROJECT – WALLEYE.

	CORRELATION FACTOR				**CORRELATION FACTOR**				**CORRELATION FACTOR**		
	0.10	0.15	0.20		0.10	0.15	0.20		0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.83%	1.24%	1.66%	**2**	0.74%	1.11%	1.48%	**2**	0.72%	1.08%	1.44%
3	1.24%	1.86%	2.49%	**3**	1.11%	1.67%	2.22%	**3**	1.08%	1.62%	2.17%
4	1.66%	2.49%	3.31%	**4**	1.48%	2.22%	2.96%	**4**	1.44%	2.17%	2.89%
5	2.07%	3.11%	4.14%	**5**	1.85%	2.78%	3.70%	**5**	1.80%	2.71%	3.61%
6	2.49%	3.73%	4.97%	**6**	2.22%	3.33%	4.44%	**6**	2.17%	3.25%	4.33%
7	2.90%	4.35%	5.80%	**7**	2.59%	3.89%	5.18%	**7**	2.53%	3.79%	5.05%
8	3.31%	4.97%	6.63%	**8**	2.96%	4.44%	5.93%	**8**	2.89%	4.33%	5.77%
Average	**3.1%**	**4.7%**	**6.2%**	**Average**	**2.8%**	**4.2%**	**5.6%**	**Average**	**2.7%**	**4.1%**	**5.4%**
	96.9%	95.3%	93.8%		97.2%	95.8%	94.4%		97.3%	95.9%	94.6%

TABLE D3.3 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 1 AT THE DELLS PROJECT – SMALLMOUTH BASS.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.83%	1.24%	1.66%
3	1.24%	1.86%	2.49%
4	1.66%	2.49%	3.31%
5	2.07%	3.11%	4.14%
Average	**1.5%**	**2.2%**	**2.9%**
	98.5%	97.8%	97.1%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.74%	1.11%	1.48%
3	1.11%	1.67%	2.22%
4	1.48%	2.22%	2.96%
6	2.22%	3.33%	4.44%
Average	**1.4%**	**2.1%**	**2.8%**
	98.6%	97.9%	97.2%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.72%	1.08%	1.44%
3	1.08%	1.62%	2.17%
4	1.44%	2.17%	2.89%
6	2.17%	3.25%	4.33%
Average	**1.4%**	**2.0%**	**2.7%**
	98.6%	98.0%	97.3%

TABLE D3.4 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 1 AT THE DELLS PROJECT – BLUEGILL.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.83%	1.24%	1.66%
3	1.24%	1.86%	2.49%
4	1.66%	2.49%	3.31%
5	2.07%	3.11%	4.14%
6	2.49%	3.73%	4.97%
Average	**1.7%**	**2.5%**	**3.3%**
	98.3%	97.5%	96.7%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.74%	1.11%	1.48%
3	1.11%	1.67%	2.22%
4	1.48%	2.22%	2.96%
5	1.85%	2.78%	3.70%
6	2.22%	3.33%	4.44%
Average	**1.5%**	**2.2%**	**3.0%**
	98.5%	97.8%	97.0%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.72%	1.08%	1.44%
3	1.08%	1.62%	2.17%
4	1.44%	2.17%	2.89%
5	1.80%	2.71%	3.61%
6	2.17%	3.25%	4.33%
Average	**1.4%**	**2.2%**	**2.9%**
	98.6%	97.8%	97.1%

TABLE D3.5 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 1 AT THE DELLS PROJECT – BLACK CRAPPIE.

	CORRELATION FACTOR				CORRELATION FACTOR				CORRELATION FACTOR		
	0.10	0.15	0.20		0.10	0.15	0.20		0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.83%	1.24%	1.66%	**2**	0.74%	1.11%	1.48%	**2**	0.72%	1.08%	1.44%
3	1.24%	1.86%	2.49%	**3**	1.11%	1.67%	2.22%	**3**	1.08%	1.62%	2.17%
4	1.66%	2.49%	3.31%	**4**	1.48%	2.22%	2.96%	**4**	1.44%	2.17%	2.89%
5	2.07%	3.11%	4.14%	**5**	1.85%	2.78%	3.70%	**5**	1.80%	2.71%	3.61%
6	2.49%	3.73%	4.97%	**6**	2.22%	3.33%	4.44%	**6**	2.17%	3.25%	4.33%
Average	**1.7%**	**2.5%**	**3.3%**	**Average**	**1.5%**	**2.2%**	**3.0%**	**Average**	**1.4%**	**2.2%**	**2.9%**
	98.3%	97.5%	96.7%		98.5%	97.8%	97.0%		98.6%	97.8%	97.1%

TABLE D3.6 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 1 AT THE DELLS PROJECT – YELLOW PERCH.

	CORRELATION FACTOR				CORRELATION FACTOR				CORRELATION FACTOR		
	0.10	0.15	0.20		0.10	0.15	0.20		0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.83%	1.24%	1.66%	**2**	0.74%	1.11%	1.48%	**2**	0.72%	1.08%	1.44%
3	1.24%	1.86%	2.49%	**3**	1.11%	1.67%	2.22%	**3**	1.08%	1.62%	2.17%
4	1.66%	2.49%	3.31%	**4**	1.48%	2.22%	2.96%	**4**	1.44%	2.17%	2.89%
5	2.07%	3.11%	4.14%	**5**	1.85%	2.78%	3.70%	**5**	1.80%	2.71%	3.61%
Average	**1.5%**	**2.2%**	**2.9%**	**Average**	**1.3%**	**1.9%**	**2.6%**	**Average**	**1.3%**	**1.9%**	**2.5%**
	98.5%	97.8%	97.1%		98.7%	98.1%	97.4%		98.7%	98.1%	97.5%

TABLE D3.7 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 1 AT THE DELLS PROJECT – LAKE STURGEON.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.83%	1.24%	1.66%		**2**	0.74%	1.11%	1.48%		**2**	0.72%	1.08%	1.44%
3	1.24%	1.86%	2.49%		**3**	1.11%	1.67%	2.22%		**3**	1.08%	1.62%	2.17%
4	1.66%	2.49%	3.31%		**4**	1.48%	2.22%	2.96%		**4**	1.44%	2.17%	2.89%
5	2.07%	3.11%	4.14%		**5**	1.85%	2.78%	3.70%		**5**	1.80%	2.71%	3.61%
6	2.49%	3.73%	4.97%		**6**	2.22%	3.33%	4.44%		**6**	2.17%	3.25%	4.33%
7	2.90%	4.35%	5.80%		**7**	2.59%	3.89%	5.18%		**7**	2.53%	3.79%	5.05%
8	3.31%	4.97%	6.63%		**8**	2.96%	4.44%	5.93%		**8**	2.89%	4.33%	5.77%
9	3.73%	5.59%	7.46%		**9**	3.33%	5.00%	6.67%		**9**	3.25%	4.87%	6.50%
Average	**3.7%**	**5.6%**	**7.5%**		**Average**	**3.3%**	**5.0%**	**6.7%**		**Average**	**3.2%**	**4.9%**	**6.5%**
	96.3%	94.4%	92.5%			96.7%	95.0%	93.3%			96.8%	95.1%	93.5%

TABLE D3.8 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2-4 AT THE DELLS PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.58%	2.37%	3.16%		**2**	1.37%	2.06%	2.75%		**2**	1.33%	2.00%	2.67%
3	2.37%	3.56%	4.74%		**3**	2.06%	3.09%	4.12%		**3**	2.00%	3.00%	4.00%
4	3.16%	4.74%	6.33%		**4**	2.75%	4.12%	5.50%		**4**	2.67%	4.00%	5.34%
5	3.95%	5.93%	7.91%		**5**	3.43%	5.15%	6.87%		**5**	3.34%	5.01%	6.67%
6	4.74%	7.12%	9.49%		**6**	4.12%	6.18%	8.24%		**6**	4.00%	6.01%	8.01%
7	5.53%	8.30%	11.07%		**7**	4.81%	7.21%	9.62%		**7**	4.67%	7.01%	9.34%
8	6.33%	9.49%	12.65%		**8**	5.50%	8.24%	10.99%		**8**	5.34%	8.01%	10.68%
9	7.12%	10.67%	14.23%		**9**	6.18%	9.27%	12.36%		**9**	6.01%	9.01%	12.01%
10	7.91%	11.86%	15.81%		**10**	6.87%	10.30%	13.74%		**10**	6.67%	10.01%	13.35%
Average	**7.9%**	**11.9%**	**15.8%**		**Average**	**6.9%**	**10.3%**	**13.7%**		**Average**	**6.7%**	**10.0%**	**13.3%**
	92.1%	88.1%	84.2%			93.1%	89.7%	86.3%			93.3%	90.0%	86.7%

TABLE D3.9 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2-4 AT THE DELLS PROJECT –WALLEYE.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.58%	2.37%	3.16%		**2**	1.37%	2.06%	2.75%		**2**	1.33%	2.00%	2.67%
3	2.37%	3.56%	4.74%		**3**	2.06%	3.09%	4.12%		**3**	2.00%	3.00%	4.00%
4	3.16%	4.74%	6.33%		**4**	2.75%	4.12%	5.50%		**4**	2.67%	4.00%	5.34%
5	3.95%	5.93%	7.91%		**5**	3.43%	5.15%	6.87%		**5**	3.34%	5.01%	6.67%
6	4.74%	7.12%	9.49%		**6**	4.12%	6.18%	8.24%		**6**	4.00%	6.01%	8.01%
7	5.53%	8.30%	11.07%		**7**	4.81%	7.21%	9.62%		**7**	4.67%	7.01%	9.34%
8	6.33%	9.49%	12.65%		**8**	5.50%	8.24%	10.99%		**8**	5.34%	8.01%	10.68%
Average	**5.9%**	**8.9%**	**11.9%**		**Average**	**5.2%**	**7.7%**	**10.3%**		**Average**	**5.0%**	**7.5%**	**10.0%**
	94.1%	91.1%	88.1%			94.8%	92.3%	89.7%			95.0%	92.5%	90.0%

TABLE D3.10 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2-4 AT THE DELLS PROJECT – SMALLMOUTH BASS.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.58%	2.37%	3.16%		**2**	1.37%	2.06%	2.75%		**2**	1.33%	2.00%	2.67%
3	2.37%	3.56%	4.74%		**3**	2.06%	3.09%	4.12%		**3**	2.00%	3.00%	4.00%
4	3.16%	4.74%	6.33%		**4**	2.75%	4.12%	5.50%		**4**	2.67%	4.00%	5.34%
5	3.95%	5.93%	7.91%		**5**	3.43%	5.15%	6.87%		**5**	3.34%	5.01%	6.67%
Average	**2.8%**	**4.2%**	**5.5%**		**Average**	**2.4%**	**3.6%**	**4.8%**		**Average**	**2.3%**	**3.5%**	**4.7%**
	97.2%	95.8%	94.5%			97.6%	96.4%	95.2%			97.7%	96.5%	95.3%

TABLE D3.11 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2-4 AT THE DELLS PROJECT – BLUEGILL.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.58%	2.37%	3.16%		**2**	1.37%	2.06%	2.75%		**2**	1.33%	2.00%	2.67%
3	2.37%	3.56%	4.74%		**3**	2.06%	3.09%	4.12%		**3**	2.00%	3.00%	4.00%
4	3.16%	4.74%	6.33%		**4**	2.75%	4.12%	5.50%		**4**	2.67%	4.00%	5.34%
5	3.95%	5.93%	7.91%		**5**	3.43%	5.15%	6.87%		**5**	3.34%	5.01%	6.67%
6	4.74%	7.12%	9.49%		**6**	4.12%	6.18%	8.24%		**6**	4.00%	6.01%	8.01%
Average	**3.2%**	**4.7%**	**6.3%**		**Average**	**2.7%**	**4.1%**	**5.5%**		**Average**	**2.7%**	**4.0%**	**5.3%**
	96.8%	95.3%	93.7%			97.3%	95.9%	94.5%			97.3%	96.0%	94.7%

TABLE D3.12 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2-4 AT THE DELLS PROJECT – BLACK CRAPPIE.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.58%	2.37%	3.16%		**2**	1.37%	2.06%	2.75%		**2**	1.33%	2.00%	2.67%
3	2.37%	3.56%	4.74%		**3**	2.06%	3.09%	4.12%		**3**	2.00%	3.00%	4.00%
4	3.16%	4.74%	6.33%		**4**	2.75%	4.12%	5.50%		**4**	2.67%	4.00%	5.34%
5	3.95%	5.93%	7.91%		**5**	3.43%	5.15%	6.87%		**5**	3.34%	5.01%	6.67%
6	4.74%	7.12%	9.49%		**6**	4.12%	6.18%	8.24%		**6**	4.00%	6.01%	8.01%
Average	**3.2%**	**4.7%**	**6.3%**		**Average**	**2.7%**	**4.1%**	**5.5%**		**Average**	**2.7%**	**4.0%**	**5.3%**
	96.8%	95.3%	93.7%			97.3%	95.9%	94.5%			97.3%	96.0%	94.7%

TABLE D3.13 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2-4 AT THE DELLS PROJECT –YELLOW PERCH.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.58%	2.37%	3.16%		**2**	1.37%	2.06%	2.75%		**2**	1.33%	2.00%	2.67%
3	2.37%	3.56%	4.74%		**3**	2.06%	3.09%	4.12%		**3**	2.00%	3.00%	4.00%
4	3.16%	4.74%	6.33%		**4**	2.75%	4.12%	5.50%		**4**	2.67%	4.00%	5.34%
5	3.95%	5.93%	7.91%		**5**	3.43%	5.15%	6.87%		**5**	3.34%	5.01%	6.67%
Average	**2.8%**	**4.2%**	**5.5%**		**Average**	**2.4%**	**3.6%**	**4.8%**		**Average**	**2.3%**	**3.5%**	**4.7%**
	97.2%	95.8%	94.5%			97.6%	96.4%	95.2%			97.7%	96.5%	95.3%

TABLE D3.14 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2-4 AT THE DELLS PROJECT – LAKE STURGEON.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.58%	2.37%	3.16%		**2**	1.37%	2.06%	2.75%		**2**	1.33%	2.00%	2.67%
3	2.37%	3.56%	4.74%		**3**	2.06%	3.09%	4.12%		**3**	2.00%	3.00%	4.00%
4	3.16%	4.74%	6.33%		**4**	2.75%	4.12%	5.50%		**4**	2.67%	4.00%	5.34%
5	3.95%	5.93%	7.91%		**5**	3.43%	5.15%	6.87%		**5**	3.34%	5.01%	6.67%
6	4.74%	7.12%	9.49%		**6**	4.12%	6.18%	8.24%		**6**	4.00%	6.01%	8.01%
7	5.53%	8.30%	11.07%		**7**	4.81%	7.21%	9.62%		**7**	4.67%	7.01%	9.34%
8	6.33%	9.49%	12.65%		**8**	5.50%	8.24%	10.99%		**8**	5.34%	8.01%	10.68%
9	7.12%	10.67%	14.23%		**9**	6.18%	9.27%	12.36%		**9**	6.01%	9.01%	12.01%
Average	**7.1%**	**10.7%**	**14.2%**		**Average**	**6.2%**	**9.3%**	**12.4%**		**Average**	**6.0%**	**9.0%**	**12.0%**
	92.9%	89.3%	85.8%			93.8%	90.7%	87.6%			94.0%	91.0%	88.0%

TABLE D3.15 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 5 AT THE DELLS PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.51%	2.27%	3.03%		**2**	1.33%	1.99%	2.66%		**2**	1.30%	1.95%	2.60%
3	2.27%	3.40%	4.54%		**3**	1.99%	2.99%	3.99%		**3**	1.95%	2.93%	3.90%
4	3.03%	4.54%	6.05%		**4**	2.66%	3.99%	5.32%		**4**	2.60%	3.90%	5.21%
5	3.78%	5.67%	7.57%		**5**	3.32%	4.98%	6.65%		**5**	3.25%	4.88%	6.51%
6	4.54%	6.81%	9.08%		**6**	3.99%	5.98%	7.97%		**6**	3.90%	5.86%	7.81%
7	5.30%	7.94%	10.59%		**7**	4.65%	6.98%	9.30%		**7**	4.56%	6.83%	9.11%
8	6.05%	9.08%	12.11%		**8**	5.32%	7.97%	10.63%		**8**	5.21%	7.81%	10.41%
9	6.81%	10.21%	13.62%		**9**	5.98%	8.97%	11.96%		**9**	5.86%	8.79%	11.71%
10	7.57%	11.35%	15.13%		**10**	6.65%	9.97%	13.29%		**10**	6.51%	9.76%	13.02%
Average	**7.6%**	**11.3%**	**15.1%**		**Average**	**6.6%**	**10.0%**	**13.3%**		**Average**	**6.5%**	**9.8%**	**13.0%**
	92.4%	88.7%	84.9%			93.4%	90.0%	86.7%			93.5%	90.2%	87.0%

TABLE D3.16 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 5 AT THE DELLS PROJECT – WALLEYE.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.51%	2.27%	3.03%		**2**	1.33%	1.99%	2.66%		**2**	1.30%	1.95%	2.60%
3	2.27%	3.40%	4.54%		**3**	1.99%	2.99%	3.99%		**3**	1.95%	2.93%	3.90%
4	3.03%	4.54%	6.05%		**4**	2.66%	3.99%	5.32%		**4**	2.60%	3.90%	5.21%
5	3.78%	5.67%	7.57%		**5**	3.32%	4.98%	6.65%		**5**	3.25%	4.88%	6.51%
6	4.54%	6.81%	9.08%		**6**	3.99%	5.98%	7.97%		**6**	3.90%	5.86%	7.81%
7	5.30%	7.94%	10.59%		**7**	4.65%	6.98%	9.30%		**7**	4.56%	6.83%	9.11%
8	6.05%	9.08%	12.11%		**8**	5.32%	7.97%	10.63%		**8**	5.21%	7.81%	10.41%
Average	**5.7%**	**8.5%**	**11.3%**		**Average**	**5.0%**	**7.5%**	**10.0%**		**Average**	**4.9%**	**7.3%**	**9.8%**
	94.3%	91.5%	88.7%			95.0%	92.5%	90.0%			95.1%	92.7%	90.2%

Table D3.17 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Unit 5 at the Dells Project – Smallmouth Bass.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.51%	2.27%	3.03%		**2**	1.33%	1.99%	2.66%		**2**	1.30%	1.95%	2.60%
3	2.27%	3.40%	4.54%		**3**	1.99%	2.99%	3.99%		**3**	1.95%	2.93%	3.90%
4	3.03%	4.54%	6.05%		**4**	2.66%	3.99%	5.32%		**4**	2.60%	3.90%	5.21%
5	3.78%	5.67%	7.57%		**5**	3.32%	4.98%	6.65%		**5**	3.25%	4.88%	6.51%
Average	**2.6%**	**4.0%**	**5.3%**		**Average**	**2.3%**	**3.5%**	**4.7%**		**Average**	**2.3%**	**3.4%**	**4.6%**
	97.4%	96.0%	94.7%			97.7%	96.5%	95.3%			97.7%	96.6%	95.4%

Table D3.18 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Unit 5 at the Dells Project – Bluegill.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.51%	2.27%	3.03%		**2**	1.33%	1.99%	2.66%		**2**	1.30%	1.95%	2.60%
3	2.27%	3.40%	4.54%		**3**	1.99%	2.99%	3.99%		**3**	1.95%	2.93%	3.90%
4	3.03%	4.54%	6.05%		**4**	2.66%	3.99%	5.32%		**4**	2.60%	3.90%	5.21%
5	3.78%	5.67%	7.57%		**5**	3.32%	4.98%	6.65%		**5**	3.25%	4.88%	6.51%
6	4.54%	6.81%	9.08%		**6**	3.99%	5.98%	7.97%		**6**	3.90%	5.86%	7.81%
Average	**3.0%**	**4.5%**	**6.1%**		**Average**	**2.7%**	**4.0%**	**5.3%**		**Average**	**2.6%**	**3.9%**	**5.2%**
	97.0%	95.5%	93.9%			97.3%	96.0%	94.7%			97.4%	96.1%	94.8%

Table D3.19 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Unit 5 at the Dells Project – Black Crappie.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.51%	2.27%	3.03%		**2**	1.33%	1.99%	2.66%		**2**	1.30%	1.95%	2.60%
3	2.27%	3.40%	4.54%		**3**	1.99%	2.99%	3.99%		**3**	1.95%	2.93%	3.90%
4	3.03%	4.54%	6.05%		**4**	2.66%	3.99%	5.32%		**4**	2.60%	3.90%	5.21%
5	3.78%	5.67%	7.57%		**5**	3.32%	4.98%	6.65%		**5**	3.25%	4.88%	6.51%
6	4.54%	6.81%	9.08%		**6**	3.99%	5.98%	7.97%		**6**	3.90%	5.86%	7.81%
Average	**3.0%**	**4.5%**	**6.1%**		**Average**	**2.7%**	**4.0%**	**5.3%**		**Average**	**2.6%**	**3.9%**	**5.2%**
	97.0%	95.5%	93.9%			97.3%	96.0%	94.7%			97.4%	96.1%	94.8%

Table D3.20 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Unit 5 at the Dells Project – Yellow Perch.

	Correlation Factor					Correlation Factor					Correlation Factor		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.51%	2.27%	3.03%		**2**	1.33%	1.99%	2.66%		**2**	1.30%	1.95%	2.60%
3	2.27%	3.40%	4.54%		**3**	1.99%	2.99%	3.99%		**3**	1.95%	2.93%	3.90%
4	3.03%	4.54%	6.05%		**4**	2.66%	3.99%	5.32%		**4**	2.60%	3.90%	5.21%
5	3.78%	5.67%	7.57%		**5**	3.32%	4.98%	6.65%		**5**	3.25%	4.88%	6.51%
Average	**2.6%**	**4.0%**	**5.3%**		**Average**	**2.3%**	**3.5%**	**4.7%**		**Average**	**2.3%**	**3.4%**	**4.6%**
	97.4%	96.0%	94.7%			97.7%	96.5%	95.3%			97.7%	96.6%	95.4%

TABLE D3.21 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNIT 5 AT THE DELLS PROJECT – LAKE STURGEON.

	CORRELATION FACTOR				**CORRELATION FACTOR**				**CORRELATION FACTOR**		
	0.10	0.15	0.20		0.10	0.15	0.20		0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**	**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	1.51%	2.27%	3.03%	**2**	1.33%	1.99%	2.66%	**2**	1.30%	1.95%	2.60%
3	2.27%	3.40%	4.54%	**3**	1.99%	2.99%	3.99%	**3**	1.95%	2.93%	3.90%
4	3.03%	4.54%	6.05%	**4**	2.66%	3.99%	5.32%	**4**	2.60%	3.90%	5.21%
5	3.78%	5.67%	7.57%	**5**	3.32%	4.98%	6.65%	**5**	3.25%	4.88%	6.51%
6	4.54%	6.81%	9.08%	**6**	3.99%	5.98%	7.97%	**6**	3.90%	5.86%	7.81%
7	5.30%	7.94%	10.59%	**7**	4.65%	6.98%	9.30%	**7**	4.56%	6.83%	9.11%
8	6.05%	9.08%	12.11%	**8**	5.32%	7.97%	10.63%	**8**	5.21%	7.81%	10.41%
Average	**6.1%**	**9.1%**	**12.1%**	**Average**	**5.3%**	**8.0%**	**10.6%**	**Average**	**5.2%**	**7.8%**	**10.4%**
	93.9%	90.9%	87.9%		94.7%	92.0%	89.4%		94.8%	92.2%	89.6%

TABLES D4.1 THROUGH D4.7

JIM FALLS PROJECT – RESULTS OF BLADE STRIKE CALCULATIONS

TABLE D4.1 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 2 AT THE JIM FALLS PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.65%	0.98%	1.30%		**2**	0.59%	0.89%	1.18%		**2**	0.58%	0.87%	1.16%
3	0.98%	1.46%	1.95%		**3**	0.89%	1.33%	1.77%		**3**	0.87%	1.30%	1.74%
4	1.30%	1.95%	2.60%		**4**	1.18%	1.77%	2.36%		**4**	1.16%	1.74%	2.32%
5	1.63%	2.44%	3.25%		**5**	1.48%	2.22%	2.96%		**5**	1.45%	2.17%	2.89%
6	1.95%	2.93%	3.90%		**6**	1.77%	2.66%	3.55%		**6**	1.74%	2.60%	3.47%
7	2.28%	3.41%	4.55%		**7**	2.07%	3.10%	4.14%		**7**	2.03%	3.04%	4.05%
8	2.60%	3.90%	5.20%		**8**	2.36%	3.55%	4.73%		**8**	2.32%	3.47%	4.63%
9	2.93%	4.39%	5.85%		**9**	2.66%	3.99%	5.32%		**9**	2.60%	3.91%	5.21%
10	3.25%	4.88%	6.50%		**10**	2.96%	4.43%	5.91%		**10**	2.89%	4.34%	5.79%
Average	**2.9%**	**4.4%**	**5.9%**		**Average**	**2.7%**	**4.0%**	**5.3%**		**Average**	**2.6%**	**3.9%**	**5.2%**
	97.1%	95.6%	94.1%			97.3%	96.0%	94.7%			97.4%	96.1%	94.8%

TABLE D4.2 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 2 AT THE JIM FALLS PROJECT –WALLEYE.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.65%	0.98%	1.30%		**2**	0.59%	0.89%	1.18%		**2**	0.58%	0.87%	1.16%
3	0.98%	1.46%	1.95%		**3**	0.89%	1.33%	1.77%		**3**	0.87%	1.30%	1.74%
4	1.30%	1.95%	2.60%		**4**	1.18%	1.77%	2.36%		**4**	1.16%	1.74%	2.32%
5	1.63%	2.44%	3.25%		**5**	1.48%	2.22%	2.96%		**5**	1.45%	2.17%	2.89%
6	1.95%	2.93%	3.90%		**6**	1.77%	2.66%	3.55%		**6**	1.74%	2.60%	3.47%
7	2.28%	3.41%	4.55%		**7**	2.07%	3.10%	4.14%		**7**	2.03%	3.04%	4.05%
8	2.60%	3.90%	5.20%		**8**	2.36%	3.55%	4.73%		**8**	2.32%	3.47%	4.63%
Average	**2.6%**	**3.9%**	**5.2%**		**Average**	**2.4%**	**3.5%**	**4.7%**		**Average**	**2.3%**	**3.5%**	**4.6%**
	97.4%	96.1%	94.8%			97.6%	96.5%	95.3%			97.7%	96.5%	95.4%

TABLE D4.3 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 2 AT THE JIM FALLS PROJECT – SMALLMOUTH BASS.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.65%	0.98%	1.30%		**2**	0.59%	0.89%	1.18%		**2**	0.58%	0.87%	1.16%
3	0.98%	1.46%	1.95%		**3**	0.89%	1.33%	1.77%		**3**	0.87%	1.30%	1.74%
4	1.30%	1.95%	2.60%		**4**	1.18%	1.77%	2.36%		**4**	1.16%	1.74%	2.32%
5	1.63%	2.44%	3.25%		**5**	1.48%	2.22%	2.96%		**5**	1.45%	2.17%	2.89%
Average	**1.1%**	**1.7%**	**2.3%**		**Average**	**1.0%**	**1.6%**	**2.1%**		**Average**	**1.0%**	**1.5%**	**2.0%**
	98.9%	98.3%	97.7%			99.0%	98.4%	97.9%			99.0%	98.5%	98.0%

TABLE D4.4 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 2 AT THE JIM FALLS PROJECT – BLUEGILL.

	CORRELATION FACTOR					CORRELATION FACTOR					CORRELATION FACTOR		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.65%	0.98%	1.30%		**2**	0.59%	0.89%	1.18%		**2**	0.58%	0.87%	1.16%
3	0.98%	1.46%	1.95%		**3**	0.89%	1.33%	1.77%		**3**	0.87%	1.30%	1.74%
4	1.30%	1.95%	2.60%		**4**	1.18%	1.77%	2.36%		**4**	1.16%	1.74%	2.32%
5	1.63%	2.44%	3.25%		**5**	1.48%	2.22%	2.96%		**5**	1.45%	2.17%	2.89%
6	1.95%	2.93%	3.90%		**6**	1.77%	2.66%	3.55%		**6**	1.74%	2.60%	3.47%
Average	**1.3%**	**2.0%**	**2.6%**		**Average**	**1.2%**	**1.8%**	**2.4%**		**Average**	**1.2%**	**1.7%**	**2.3%**
	98.7%	98.0%	97.4%			98.8%	98.2%	97.6%			98.8%	98.3%	97.7%

TABLE D4.5 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 2 AT THE JIM FALLS PROJECT – BLACK CRAPPIE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.65%	0.98%	1.30%
3	0.98%	1.46%	1.95%
4	1.30%	1.95%	2.60%
5	1.63%	2.44%	3.25%
6	1.95%	2.93%	3.90%
Average	**1.3%**	**2.0%**	**2.6%**
	98.7%	98.0%	97.4%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.59%	0.89%	1.18%
3	0.89%	1.33%	1.77%
4	1.18%	1.77%	2.36%
5	1.48%	2.22%	2.96%
6	1.77%	2.66%	3.55%
Average	**1.2%**	**1.8%**	**2.4%**
	98.8%	98.2%	97.6%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.58%	0.87%	1.16%
3	0.87%	1.30%	1.74%
4	1.16%	1.74%	2.32%
5	1.45%	2.17%	2.89%
6	1.74%	2.60%	3.47%
Average	**1.2%**	**1.7%**	**2.3%**
	98.8%	98.3%	97.7%

TABLE D4.6 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 2 AT THE JIM FALLS PROJECT – YELLOW PERCH.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.65%	0.98%	1.30%
3	0.98%	1.46%	1.95%
4	1.30%	1.95%	2.60%
5	1.63%	2.44%	3.25%
Average	**1.1%**	**1.7%**	**2.3%**
	98.9%	98.3%	97.7%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.59%	0.89%	1.18%
3	0.89%	1.33%	1.77%
4	1.18%	1.77%	2.36%
5	1.48%	2.22%	2.96%
Average	**1.0%**	**1.6%**	**2.1%**
	99.0%	98.4%	97.9%

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	0.58%	0.87%	1.16%
3	0.87%	1.30%	1.74%
4	1.16%	1.74%	2.32%
5	1.45%	2.17%	2.89%
Average	**1.0%**	**1.5%**	**2.0%**
	99.0%	98.5%	98.0%

TABLE D4.7 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 2 AT THE JIM FALLS PROJECT – LAKE STURGEON.

	CORRELATION FACTOR					**CORRELATION FACTOR**					**CORRELATION FACTOR**		
	0.10	0.15	0.20			0.10	0.15	0.20			0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**		**L (in)**	**P (%)**	**P (%)**	**P (%)**
2	0.65%	0.98%	1.30%		**2**	0.59%	0.89%	1.18%		**2**	0.58%	0.87%	1.16%
3	0.98%	1.46%	1.95%		**3**	0.89%	1.33%	1.77%		**3**	0.87%	1.30%	1.74%
4	1.30%	1.95%	2.60%		**4**	1.18%	1.77%	2.36%		**4**	1.16%	1.74%	2.32%
5	1.63%	2.44%	3.25%		**5**	1.48%	2.22%	2.96%		**5**	1.45%	2.17%	2.89%
6	1.95%	2.93%	3.90%		**6**	1.77%	2.66%	3.55%		**6**	1.74%	2.60%	3.47%
7	2.28%	3.41%	4.55%		**7**	2.07%	3.10%	4.14%		**7**	2.03%	3.04%	4.05%
8	2.60%	3.90%	5.20%		**8**	2.36%	3.55%	4.73%		**8**	2.32%	3.47%	4.63%
Average	**2.4%**	**3.7%**	**4.9%**		**Average**	**2.2%**	**3.3%**	**4.4%**		**Average**	**2.2%**	**3.3%**	**4.3%**
	97.6%	96.3%	95.1%			97.8%	96.7%	95.6%			97.8%	96.7%	95.7%

TABLES D5.1 THROUGH D5.14

WISSOTA PROJECT – RESULTS OF BLADE STRIKE CALCULATIONS

TABLE D5.1 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 4 AT THE WISSOTA PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	1.8%	2.7%	3.6%
3	2.7%	4.0%	5.4%
4	3.6%	5.4%	7.2%
5	4.5%	6.7%	9.0%
6	5.4%	8.1%	10.8%
7	6.3%	9.4%	12.6%
8	7.2%	10.8%	14.4%
9	8.1%	12.1%	16.2%
10	9.0%	13.5%	18.0%
Average	**5.4%**	**8.1%**	**10.8%**
	94.6%	91.9%	89.2%

TABLE D5.2 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 4 AT THE WISSOTA PROJECT –WALLEYE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	1.8%	2.7%	3.6%
3	2.7%	4.0%	5.4%
4	3.6%	5.4%	7.2%
5	4.5%	6.7%	9.0%
6	5.4%	8.1%	10.8%
7	6.3%	9.4%	12.6%
8	7.2%	10.8%	14.4%
Average	**4.5%**	**6.7%**	**9.0%**
	95.5%	93.3%	91.0%

TABLE D5.3 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 4 AT THE WISSOTA PROJECT – SMALLMOUTH BASS.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	1.8%	2.7%	3.6%
3	2.7%	4.0%	5.4%
4	3.6%	5.4%	7.2%
5	4.5%	6.7%	9.0%
Average	**3.1%**	**4.7%**	**6.3%**
	96.9%	95.3%	93.7%

TABLE D5.4 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 4 AT THE WISSOTA PROJECT – BLUEGILL.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	1.8%	2.7%	3.6%
3	2.7%	4.0%	5.4%
4	3.6%	5.4%	7.2%
5	4.5%	6.7%	9.0%
6	5.4%	8.1%	10.8%
Average	**3.6%**	**5.4%**	**7.2%**
	96.4%	94.6%	92.8%

TABLE D5.5 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 4 AT THE WISSOTA PROJECT – BLACK CRAPPIE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	1.8%	2.7%	3.6%
3	2.7%	4.0%	5.4%
4	3.6%	5.4%	7.2%
5	4.5%	6.7%	9.0%
6	5.4%	8.1%	10.8%
Average	**3.6%**	**5.4%**	**7.2%**
	96.4%	94.6%	92.8%

TABLE D5.6 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 4 AT THE WISSOTA PROJECT –YELLOW PERCH.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	1.8%	2.7%	3.6%
3	2.7%	4.0%	5.4%
4	3.6%	5.4%	7.2%
5	4.5%	6.7%	9.0%
Average	**3.1%**	**4.7%**	**6.3%**
	96.9%	95.3%	93.7%

TABLE D5.7 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 1 & 4 AT THE WISSOTA PROJECT – LAKE STURGEON.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	1.8%	2.7%	3.6%
3	2.7%	4.0%	5.4%
4	3.6%	5.4%	7.2%
5	4.5%	6.7%	9.0%
6	5.4%	8.1%	10.8%
7	6.3%	9.4%	12.6%
8	7.2%	10.8%	14.4%
Average	**4.5%**	**6.7%**	**9.0%**
	95.5%	93.3%	91.0%

TABLE D5.8 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2, 3, 5 & 6 AT THE WISSOTA PROJECT – MUSKELLUNGE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	2.4%	3.6%	4.8%
3	3.6%	5.4%	7.2%
4	4.8%	7.2%	9.6%
5	6.0%	9.0%	12.1%
6	7.2%	10.9%	14.5%
7	8.4%	12.7%	16.9%
8	9.6%	14.5%	19.3%
9	10.9%	16.3%	21.7%
10	12.1%	18.1%	24.1%
Average	**7.8%**	**11.8%**	**15.7%**
	92.2%	88.2%	84.3%

Table D5.9 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Units 2, 3, 5 & 6 at the Wissota Project – Walleye.

	Correlation Factor		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	2.4%	3.6%	4.8%
3	3.6%	5.4%	7.2%
4	4.8%	7.2%	9.6%
5	6.0%	9.0%	12.1%
6	7.2%	10.9%	14.5%
7	8.4%	12.7%	16.9%
8	9.6%	14.5%	19.3%
Average	**6.0%**	**9.0%**	**12.1%**
	94.0%	91.0%	87.9%

Table D5.10 Results of Blade Strike Calculations Based on the Formulas Provided in Franke et al (1997) for Units 2, 3, 5 & 6 at the Wissota Project – Smallmouth Bass.

	Correlation Factor		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	2.4%	3.6%	4.8%
3	3.6%	5.4%	7.2%
4	4.8%	7.2%	9.6%
5	6.0%	9.0%	12.1%
Average	**4.2%**	**6.3%**	**8.4%**

TABLE D5.11 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2, 3, 5 & 6 AT THE WISSOTA PROJECT – BLUEGILL.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	2.4%	3.6%	4.8%
3	3.6%	5.4%	7.2%
4	4.8%	7.2%	9.6%
5	6.0%	9.0%	12.1%
6	7.2%	10.9%	14.5%
Average	**4.8%**	**7.2%**	**9.6%**
	95.2%	92.8%	90.4%

TABLE D5.12 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2, 3, 5 & 6 AT THE WISSOTA PROJECT – BLACK CRAPPIE.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	2.4%	3.6%	4.8%
3	3.6%	5.4%	7.2%
4	4.8%	7.2%	9.6%
5	6.0%	9.0%	12.1%
6	7.2%	10.9%	14.5%
Average	**4.8%**	**7.2%**	**9.6%**
	95.2%	92.8%	90.4%

TABLE D5.13 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2, 3, 5 & 6 AT THE WISSOTA PROJECT – YELLOW PERCH.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	2.4%	3.6%	4.8%
3	3.6%	5.4%	7.2%
4	4.8%	7.2%	9.6%
5	6.0%	9.0%	12.1%
Average	**4.2%**	**6.3%**	**8.4%**
	95.8%	93.7%	91.6%

TABLE D5.14 RESULTS OF BLADE STRIKE CALCULATIONS BASED ON THE FORMULAS PROVIDED IN FRANKE ET AL (1997) FOR UNITS 2, 3, 5 & 6 AT THE WISSOTA PROJECT – LAKE STURGEON.

	CORRELATION FACTOR		
	0.10	0.15	0.20
L (in)	**P (%)**	**P (%)**	**P (%)**
2	2.4%	3.6%	4.8%
3	3.6%	5.4%	7.2%
4	4.8%	7.2%	9.6%
5	6.0%	9.0%	12.1%
6	7.2%	10.9%	14.5%
7	8.4%	12.7%	16.9%
8	9.6%	14.5%	19.3%
Average	**6.6%**	**9.9%**	**13.3%**
	93.4%	90.1%	86.7%

APPENDIX E

LAKE STURGEON MORPHOLOGY ANALYSIS

Morphometric information including measurements of length and girth was collected from more than 100 sturgeon. Although width was not measured specifically, a simplifying assumption regarding a sturgeon's body shape allowed us to estimate width from the available data. We assumed that a sturgeon's body is cylindrical and that girth was measured at the widest point (pectoral fins); therefore, width was estimated using the equation for the circumference of a circle (i.e. $C = \pi d$), where C is the circumference of a circle and is assumed to be equal to the girth of a fish, and d is the diameter and is assumed to be equal to the width of a fish.

To create an entrainment exclusion function for lake sturgeon, Kleinschmidt performed a simple linear ordinary least squares regression on the calculated widths given measured lengths using the data analysis extension within Microsoft Excel. In total, Kleinschmidt collected 170 sturgeon with complete information. An examination of the mean and median total length and calculated width show little skew (Table 1). Figures 1 and 2 are frequency distributions for length and width.

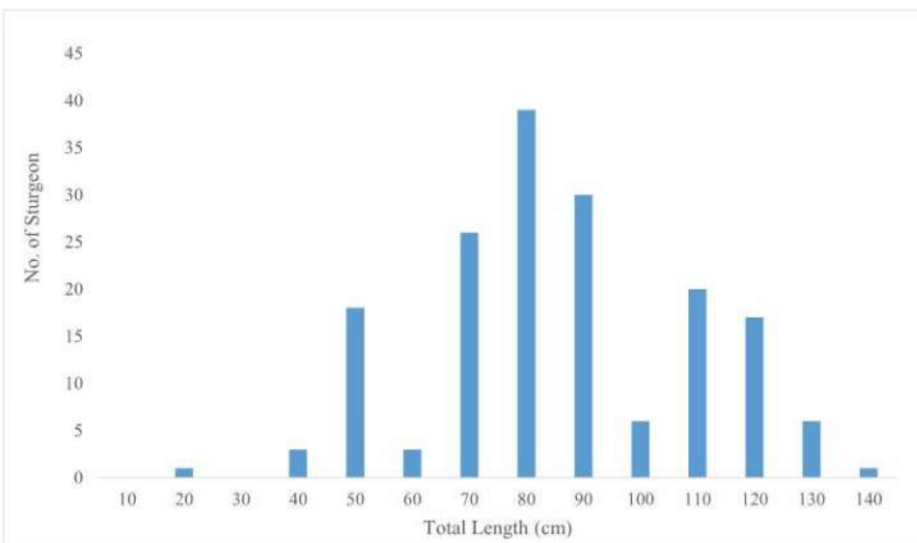


FIGURE 1 **LENGTH-FREQUENCY PLOT OF LAKE STURGEON TOTAL LENGTH, GRASSE RIVER, NEW YORK.**

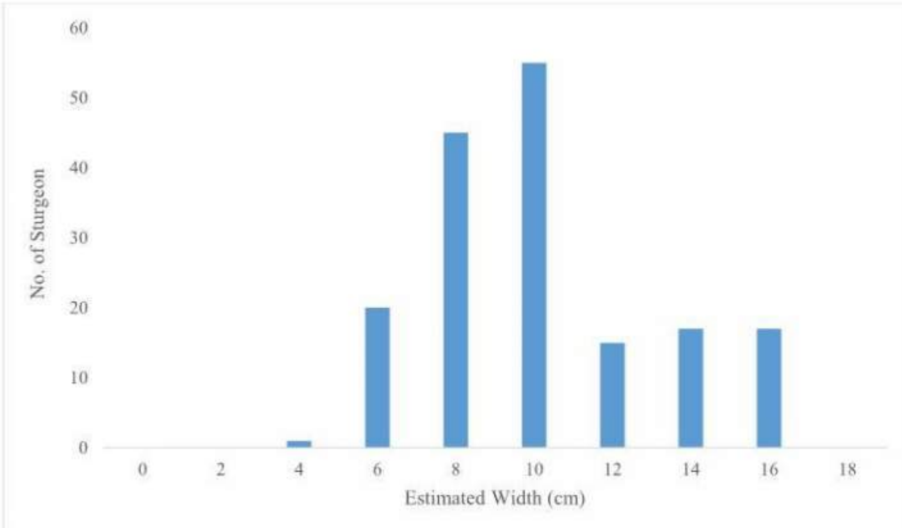


FIGURE 1 **LENGTH-FREQUENCY PLOT OF LAKE STURGEON WIDTH, GRASSE RIVER, NEW YORK.**

An examination of the mean and median total length and calculated width show little skew (Table 1).

TABLE 1 **LAKE STURGEON LENGTH AND WEIGHT STATISTICS USED IN ANALYSIS**

PARAMETER	MEAN	MEDIAN	ST DEV	MIN	MAX	N
Length (cm)	81.6	79.3	23	19	138	170
Width (cm)	9.2	8.4	2.8	3.7	15.9	170

The normal probability plot resulting from the ordinary least squares regression appears acceptable (Figure 3). One observation that appears to be influential was not removed from the analysis, and residual error increases with length (Figure 4). The regression was highly significant ($F = 1609.065$, $p < 0.001$, $R^2 = 0.91$), as was the slope (0.12 (+/- 0.0058), $p < 0.001$); however, the intercept was not (-0.42 (+/- 0.49), $p = 0.10$). Therefore, the final equation for lake sturgeon width given length is:

$$W = 0.12(L)$$

Where W is the width of a sturgeon and L is the total length of the sturgeon, both measured in centimeters (cm).

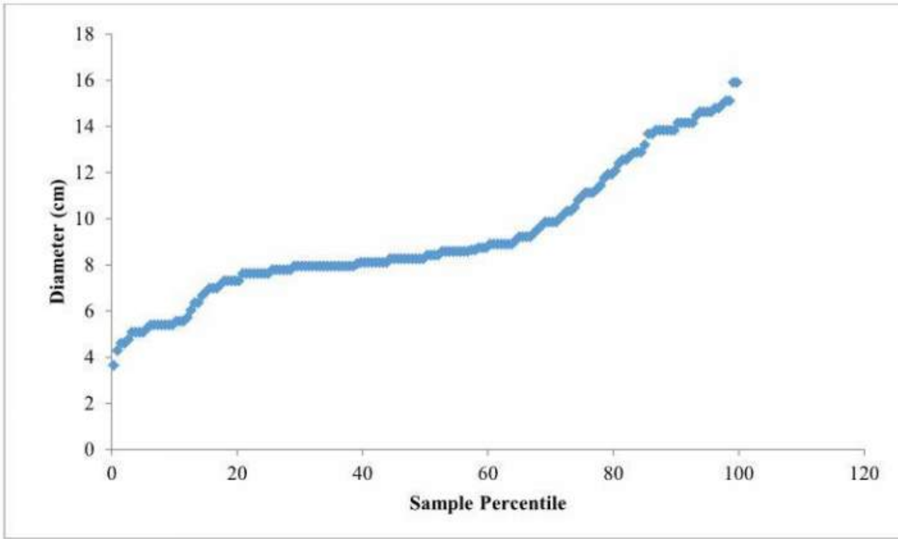


FIGURE 3 **NORMAL PROBABILITY PLOT OF LAKE STURGEON DIAMETER, GRASSE RIVER, NEW YORK**

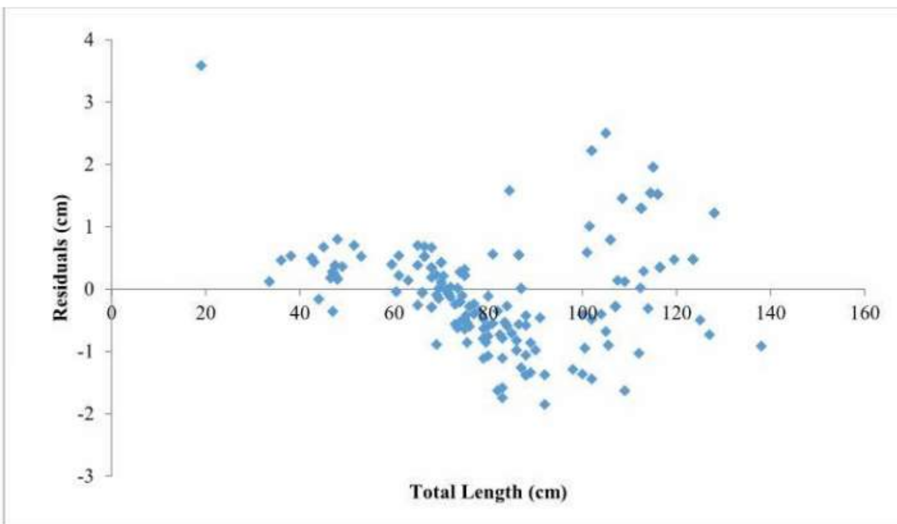


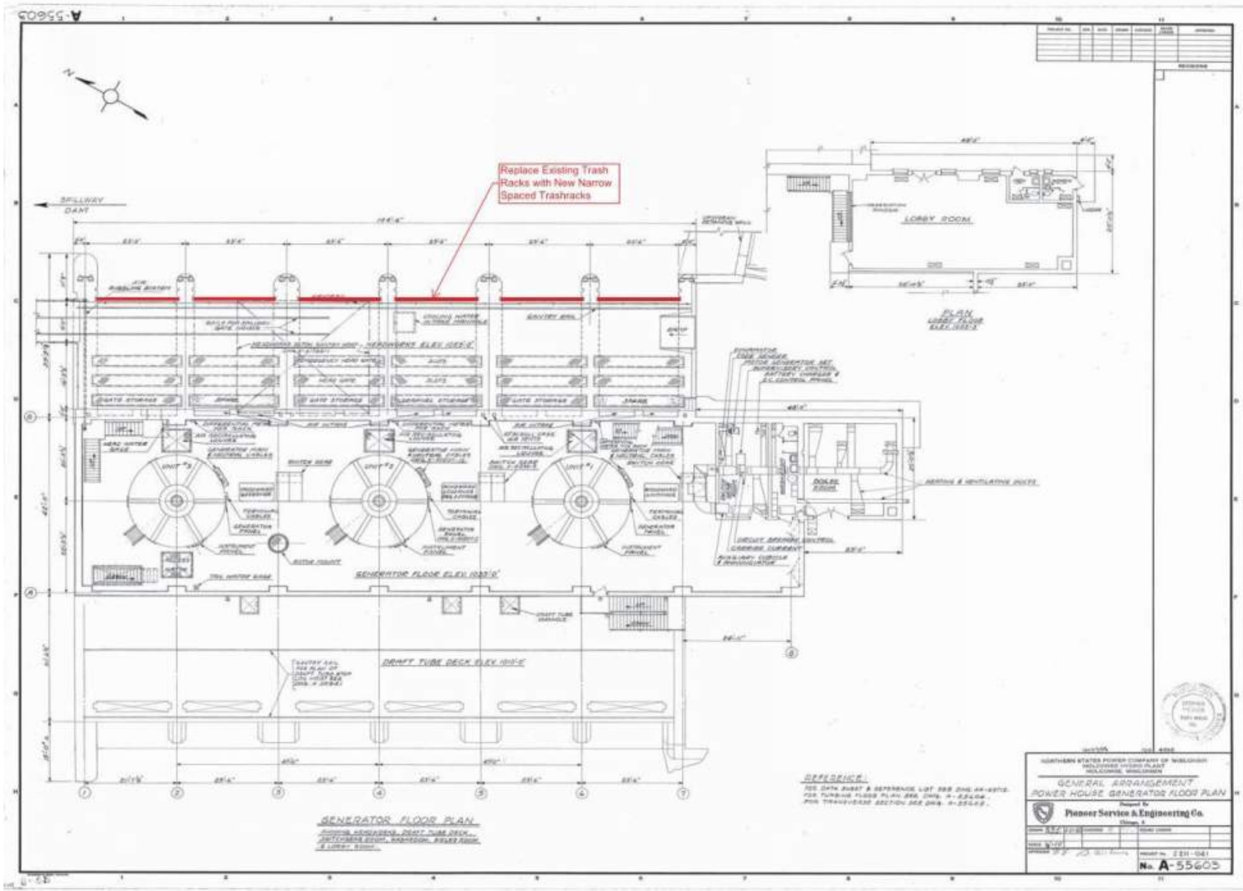
FIGURE 4 **REGRESSION RESIDUAL PLOT FOR LAKE STURGEON, GRASSE RIVER, NEW YORK**

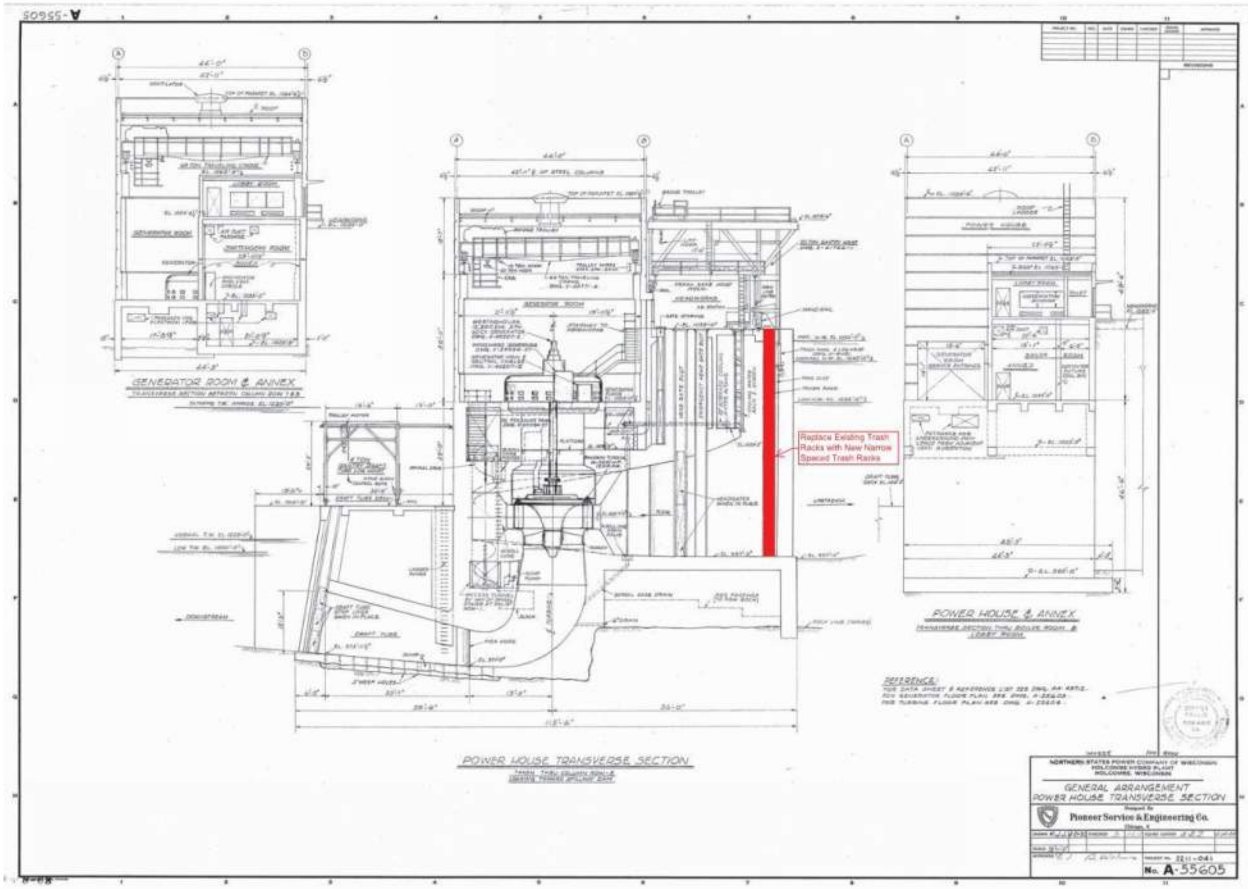
APPENDIX F

SKETCHES OF FISH PROTECTION ALTERNATIVES

HOLCOMBE

REPLACE EXISTING TRASHRACKS WITH NEW NARROWLY SPACED TRASHRACKS

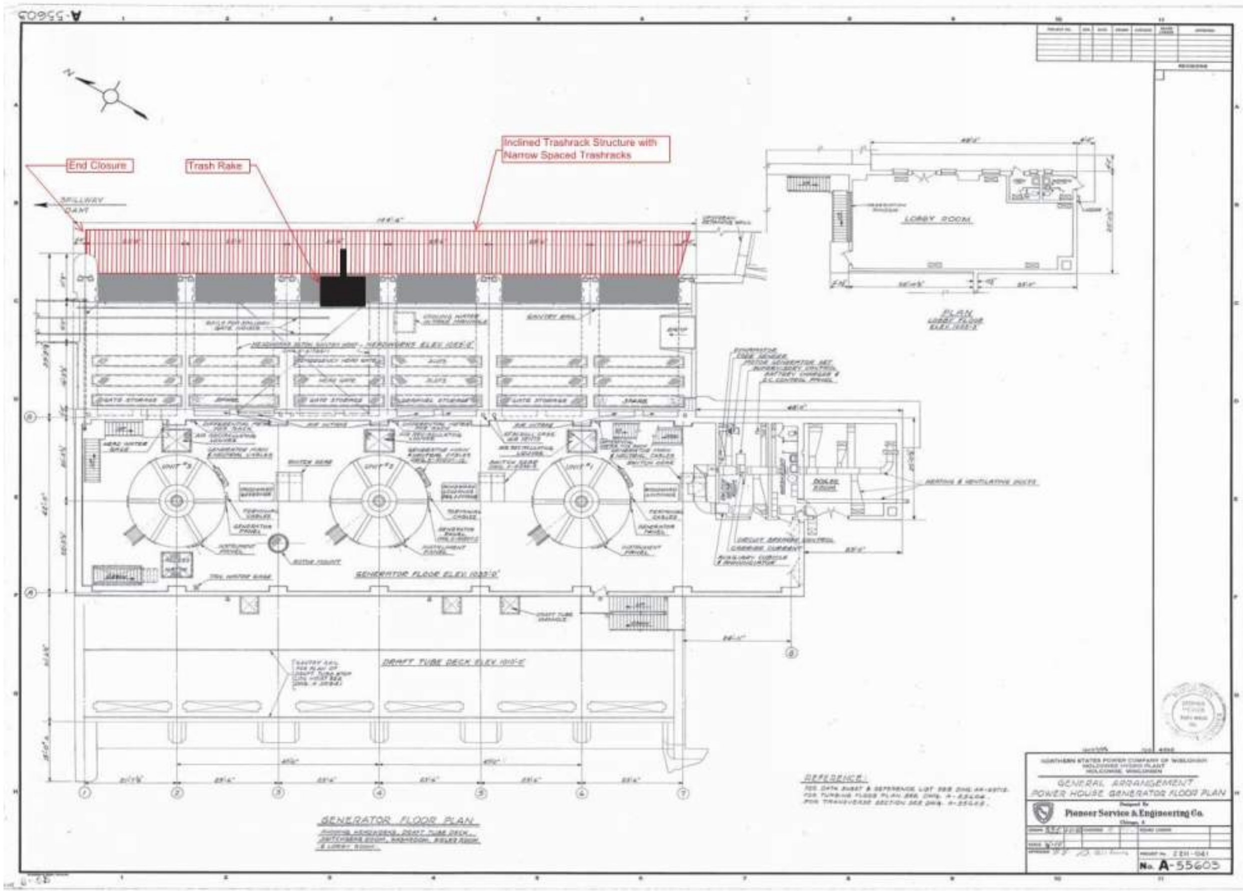

A-55603
Replace Existing Trash
Racks with New Narrow
Spaced Trashracks
SPILLWAY
DAM
LOBBY ROOM
PLAN
GENERATOR FLOOR ELEV. 1025'-0"
DRAFT TUBE DECK ELEV. 1010'-0"
DIESEL ROOM
REFERENCE:
GENERATOR FLOOR PLAN
GENERAL ARRANGEMENT
POWER HOUSE GENERATOR FLOOR PLAN
Pioneer Service & Engineering Co.
No. A-55603



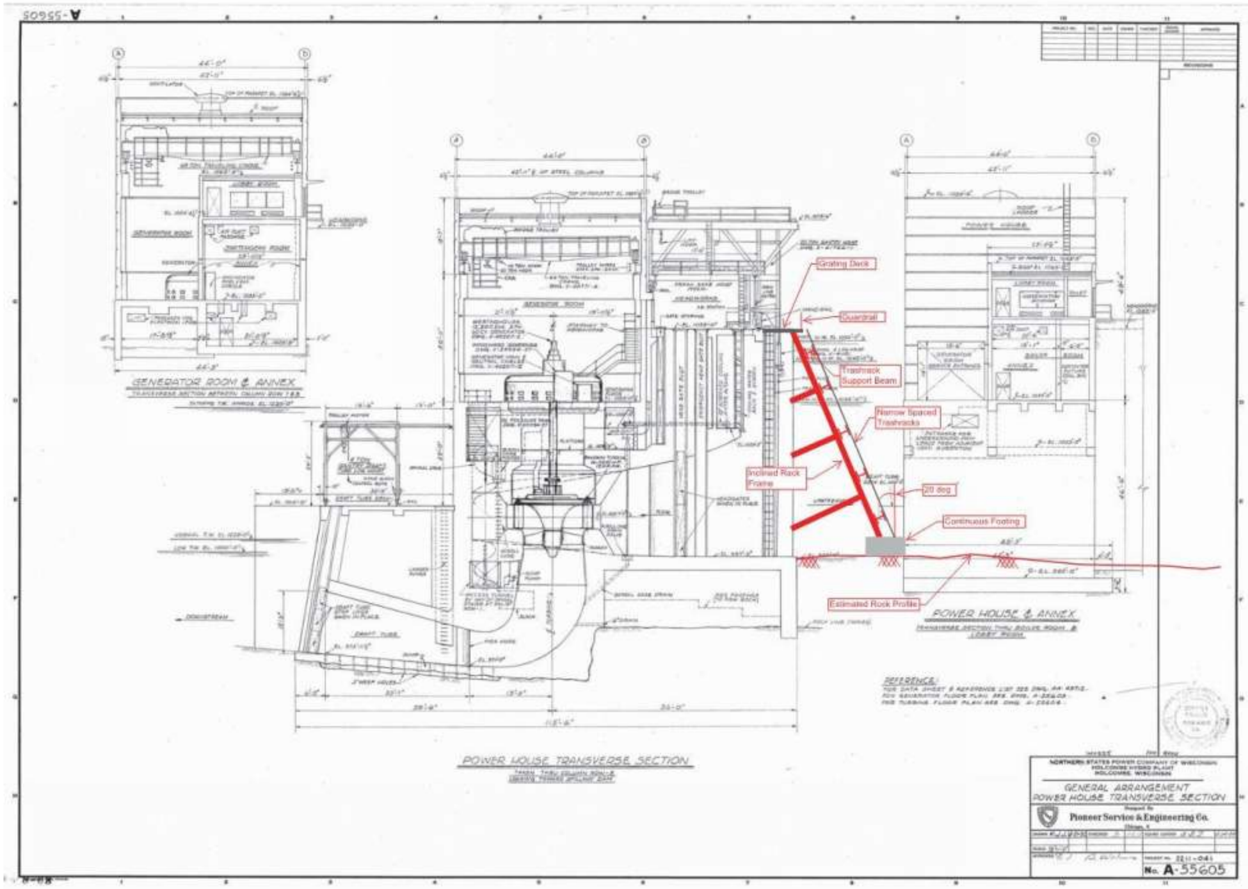
GENERATOR ROOM & ANNEX
POWER HOUSE TRANSVERSE SECTION
POWER HOUSE & ANNEX
Replace Existing Trash Racks with New Narrow Spaced Trash Racks
REFERENCE:
NORTHERN STATES POWER COMPANY OF WISCONSIN
HOLCOMBE HYDRO PLANT
HOLCOMBE, WISCONSIN
GENERAL ARRANGEMENT
POWER HOUSE TRANSVERSE SECTION
Pioneer Service & Engineering Co.
No. A-55605

HOLCOMBE

INCLINED BAR RACK WITH NARROWLY SPACED BARS

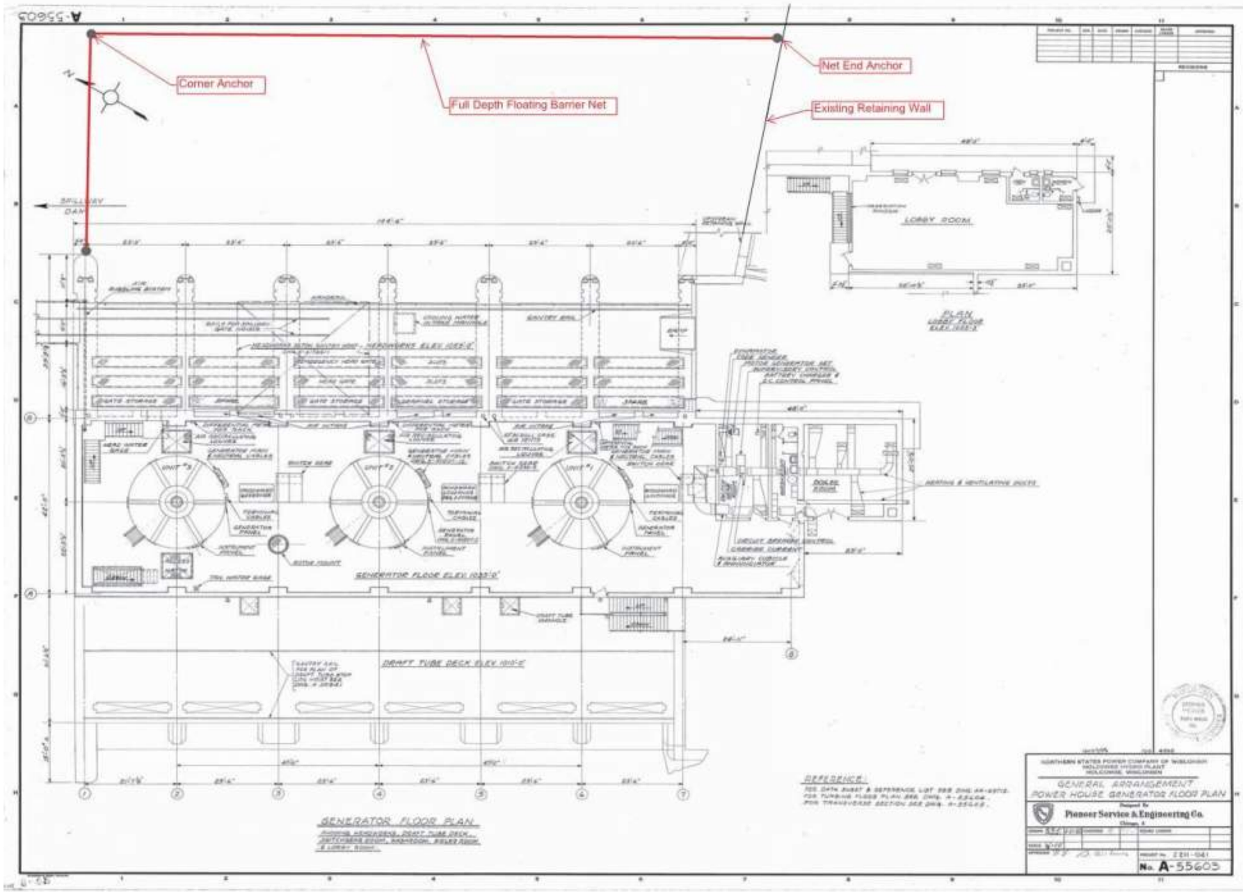


End Closure
Trash Rake
Inclined Trashrack Structure with Narrow Spaced Trashracks
SPILLWAY DAM
LOBBY ROOM
GENERATOR FLOOR PLAN
DRAFT TUBE DECK
REFERENCE:
GENERAL ARRANGEMENT
POWER HOUSE GENERATOR FLOOR PLAN
Pioneer Service & Engineering Co.
No. A-55603

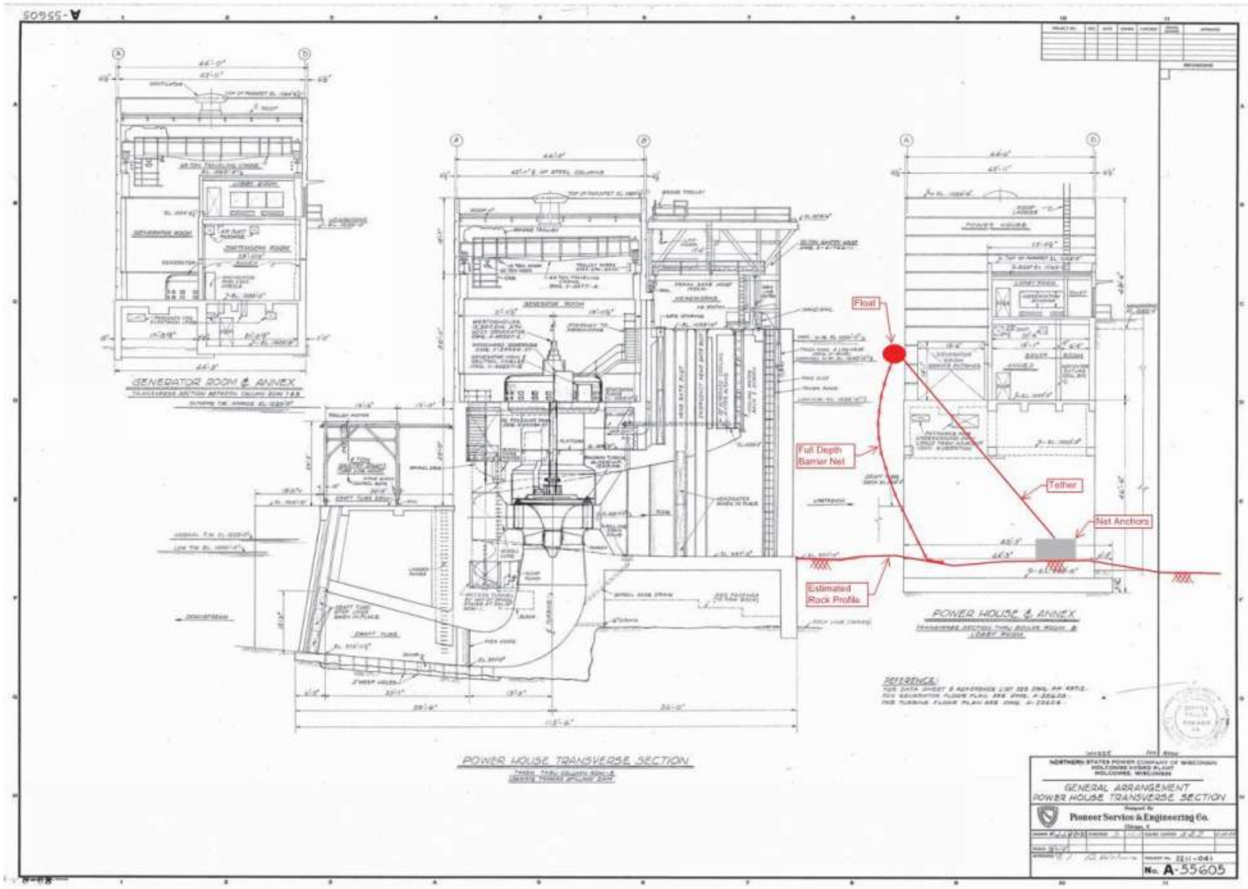

GENERATOR ROOM & ANNEX
POWER HOUSE TRANSVERSE SECTION
Grating Deck
Guardrail
Trashrack Support Beam
Narrow Spaced Trashracks
Inclined Rack Frame
20 deg
Continuous Footing
Estimated Rock Profile
POWER HOUSE & ANNEX
REFERENCE:
NORTHERN STATES POWER COMPANY OF WISCONSIN
HOLCOMBE HYDRO PLANT
HOLCOMBE, WISCONSIN
GENERAL ARRANGEMENT
POWER HOUSE TRANSVERSE SECTION
Pioneer Service & Engineering Co.
No. A-55605

HOLCOMBE

FLOATING BARRIER NET

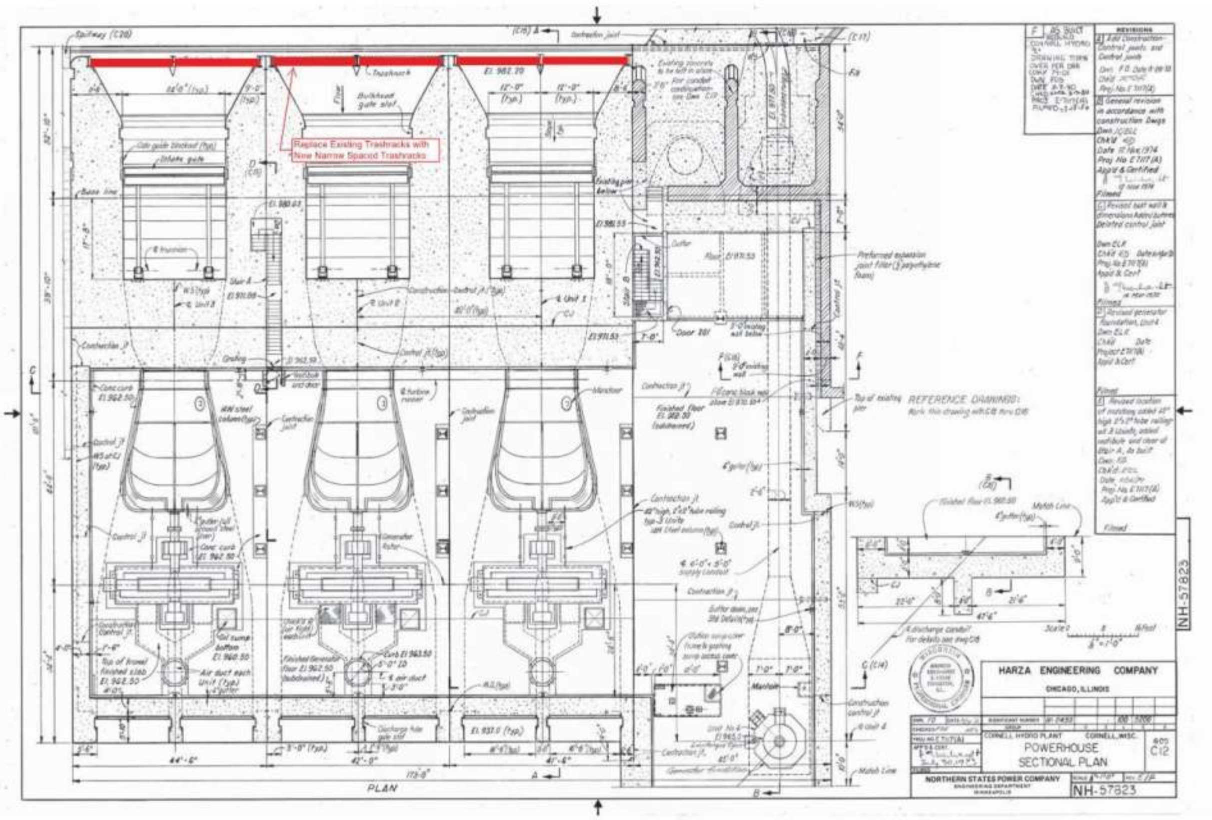


Corner Anchor
Full Depth Floating Barrier Net
Net End Anchor
Existing Retaining Wall
LOBBY ROOM
GENERATOR FLOOR PLAN
DRAFT TUBE DECK
REFERENCE:
GENERAL ARRANGEMENT
POWER HOUSE GENERATOR FLOOR PLAN
Pioneer Service & Engineering Co.
No. A-55603

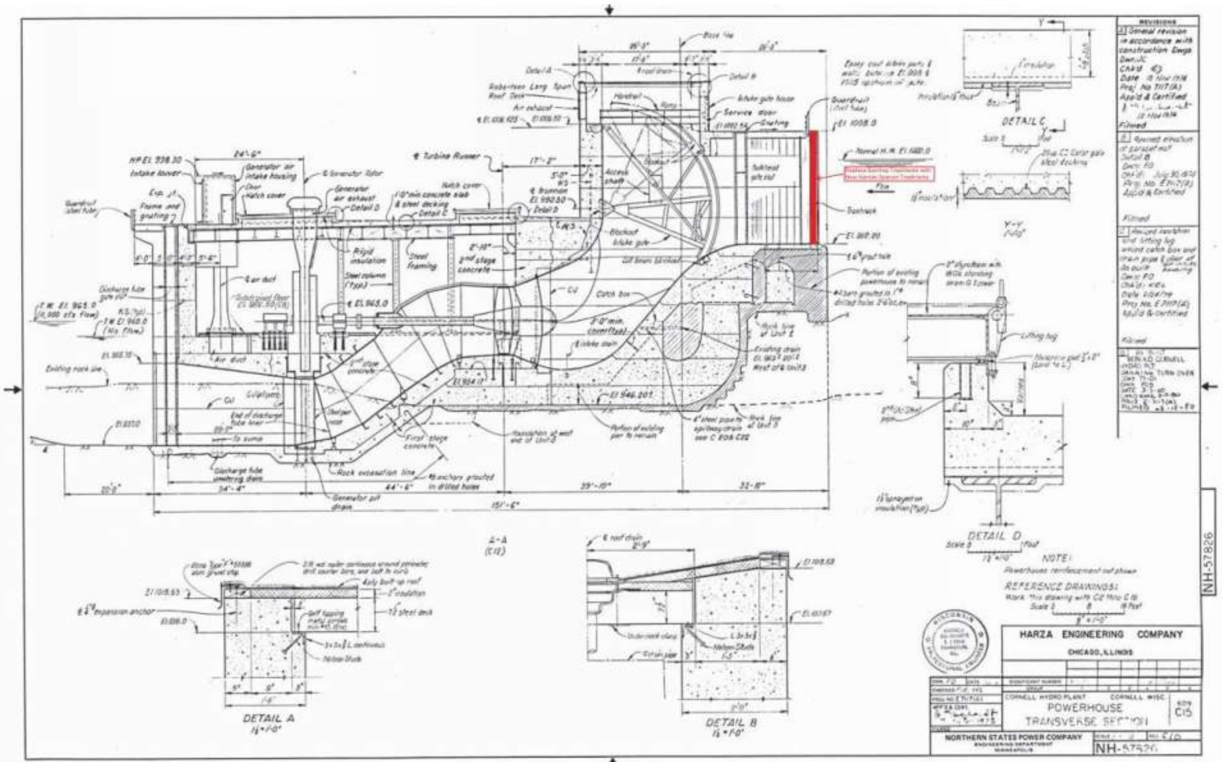

GENERATOR ROOM & ANNEX
Float
Full Depth Barrier Net
Tether
Net Anchors
Estimated Rock Profile
POWER HOUSE & ANNEX
POWER HOUSE TRANSVERSE SECTION
NORTHERN STATES POWER COMPANY OF WISCONSIN
HOLCOMBE HYDRO PLANT
HOLCOMBE, WISCONSIN
GENERAL ARRANGEMENT
POWER HOUSE TRANSVERSE SECTION
Pioneer Service & Engineering Co.
No. A-55605

CORNELL

REPLACE EXISTING TRASHRACKS WITH NEW NARROWLY SPACED TRASHRACKS



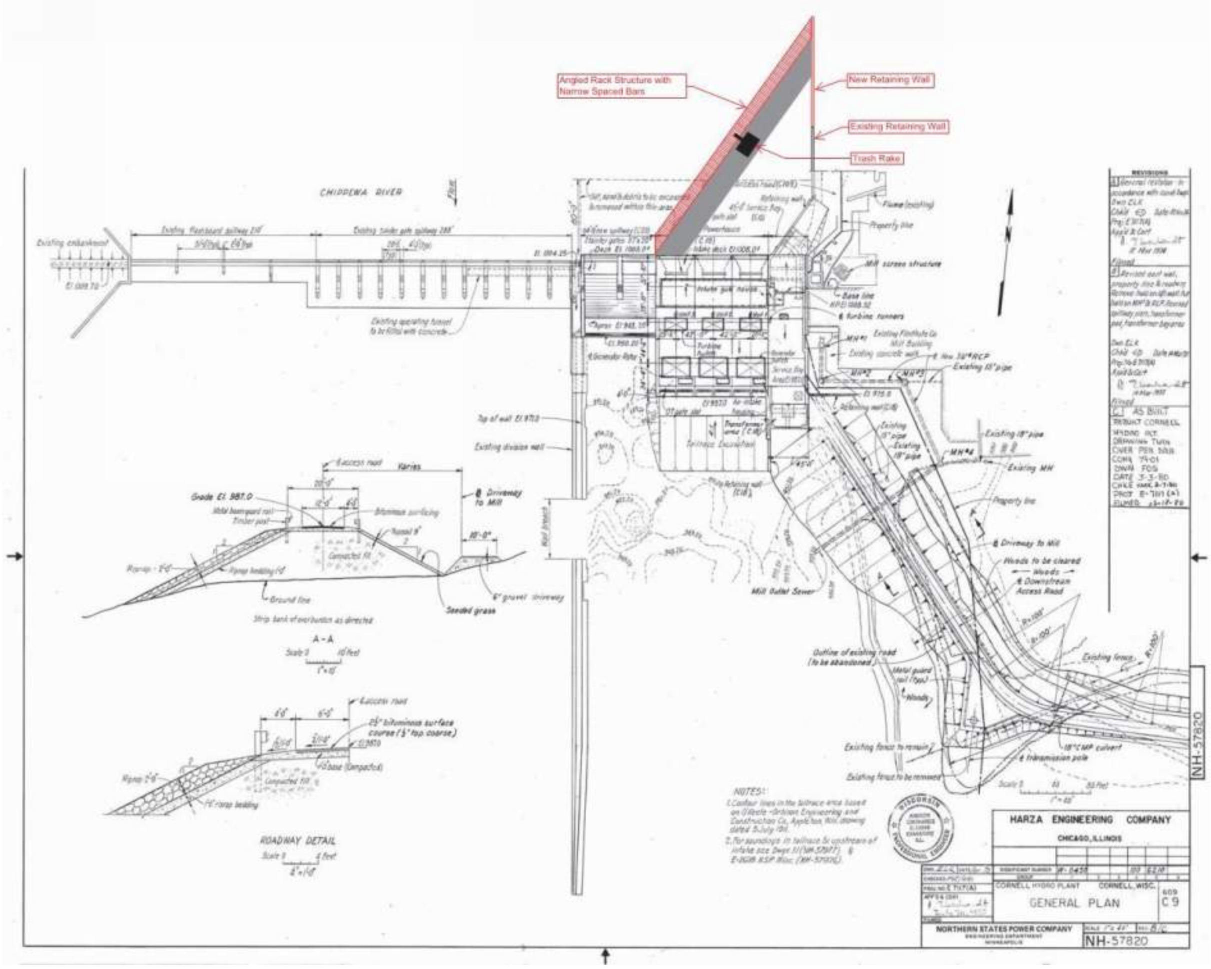
Replace Existing Trashracks with
New Narrow Spaced Trashracks
REFERENCE DRAWINGS:
PLAN
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
CORNELL HYDRO PLANT
CORNELL, WISC.
POWERHOUSE
SECTIONAL PLAN
C12
NORTHERN STATES POWER COMPANY
NH-57823



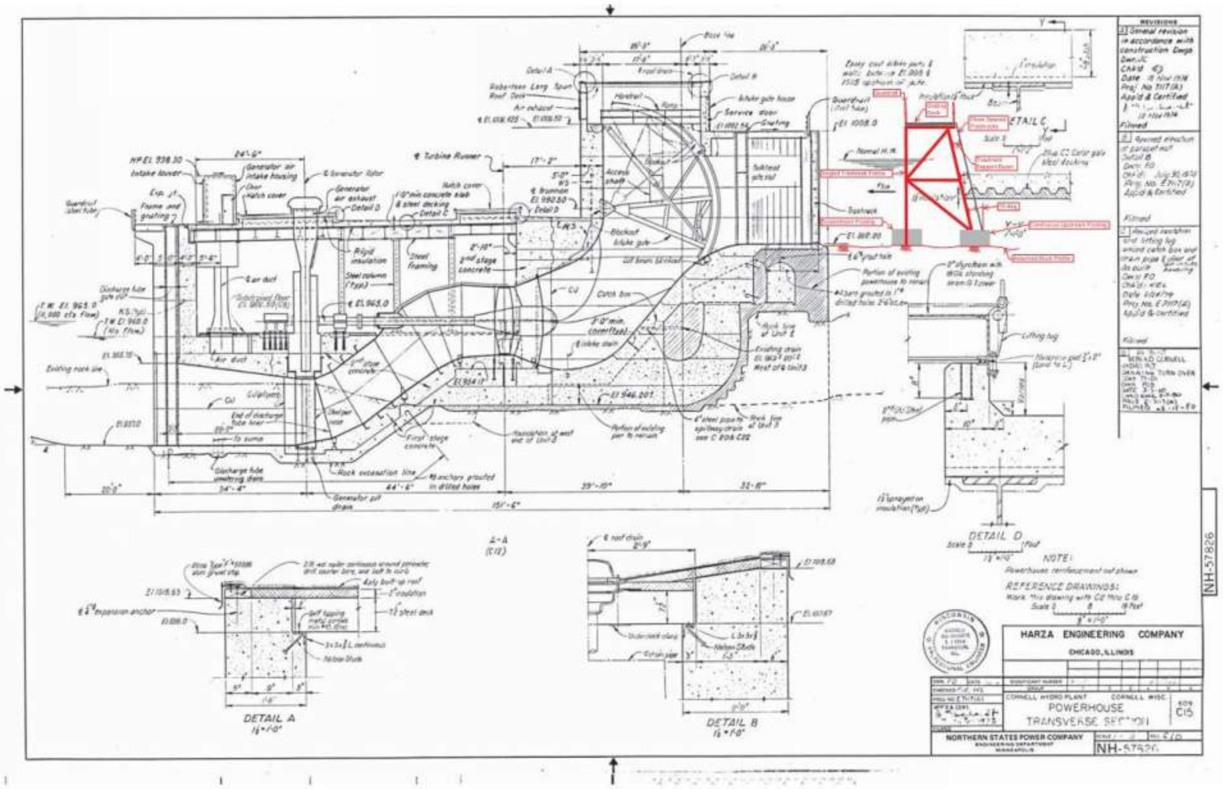
Detail A
Generator air intake housing
Turbine Runner
Catch box
Tailrace
Normal H.W. El. 1000.0
DETAIL C
DETAIL D
DETAIL A
DETAIL B
A-A
NOTE:
REFERENCE DRAWINGS:
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
CORNELL HYDRO PLANT
CORNELL WISC.
POWERHOUSE
TRANSVERSE SECTION
C15
NORTHERN STATES POWER COMPANY
ENGINEERING DEPARTMENT
MINNEAPOLIS
NH-57826

CORNELL

ANGLED BAR RACK WITH NARROWLY SPACED BARS

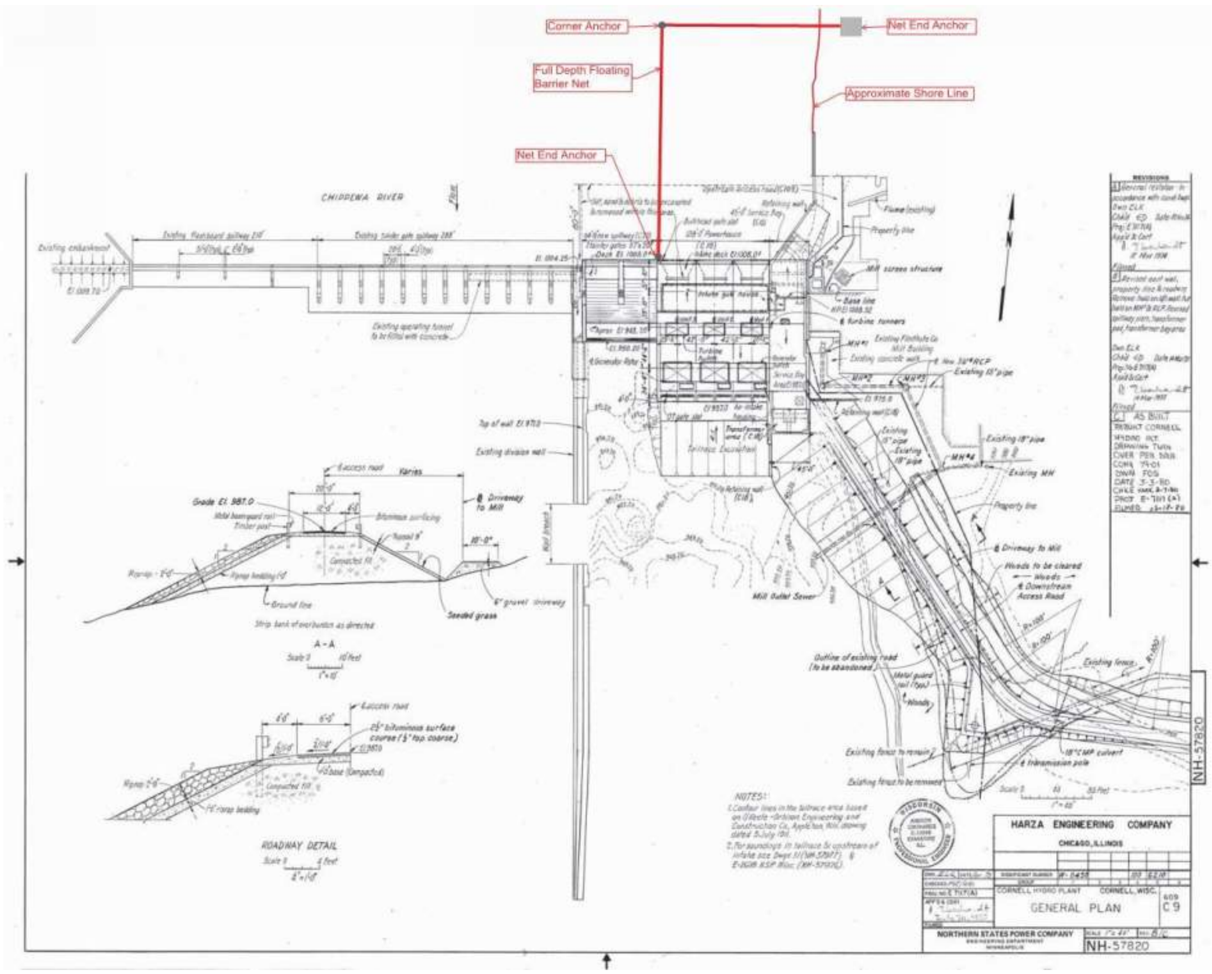


Angled Rack Structure with Narrow Spaced Bars
New Retaining Wall
Existing Retaining Wall
Trash Rake
CHIPPEWA RIVER
Mill screen structure
Base line
Driveway to Mill
Mill Outlet Sewer
Seeded grass
A-A
ROADWAY DETAIL
NOTES:
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
CORNELL HYDRO PLANT
CORNELL, WISC.
GENERAL PLAN
609
C9
NORTHERN STATES POWER COMPANY
NH-57820

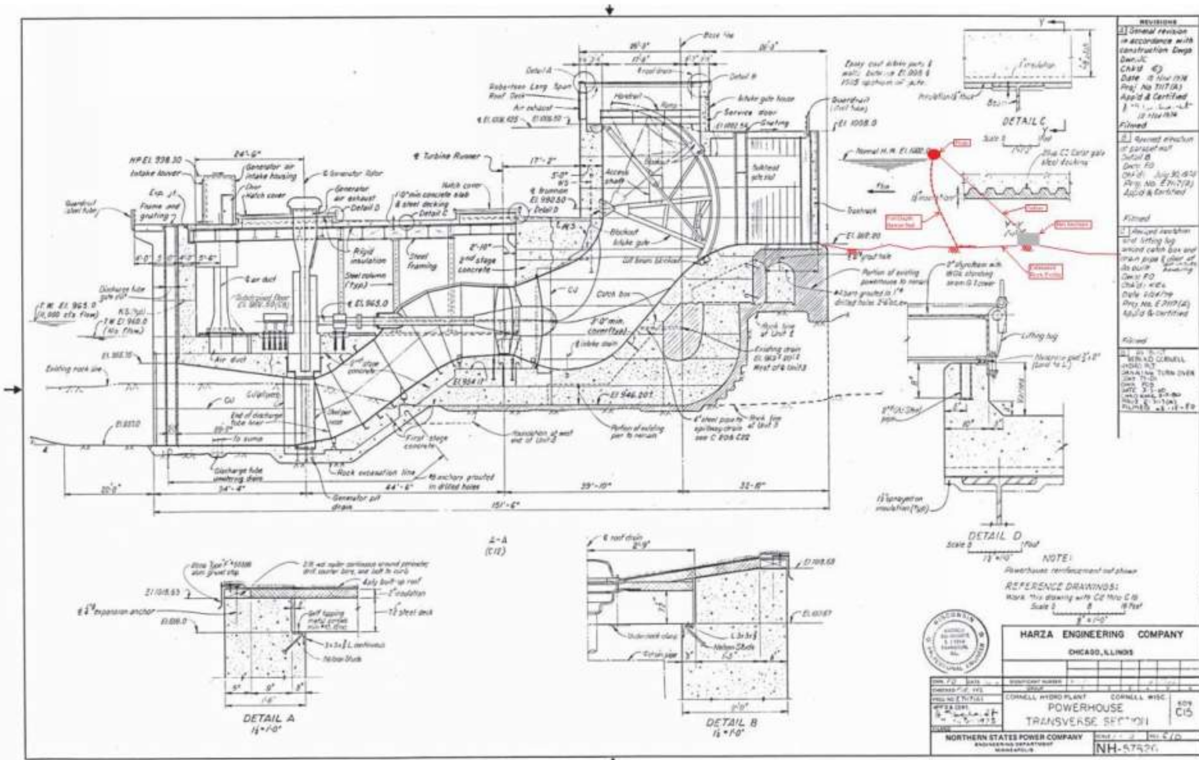

HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
NORTHERN STATES POWER COMPANY
POWERHOUSE
TRANSVERSE SECTION
DETAIL A
DETAIL B
DETAIL C
DETAIL D
NH-57826

CORNELL

FLOATING BARRIER NET

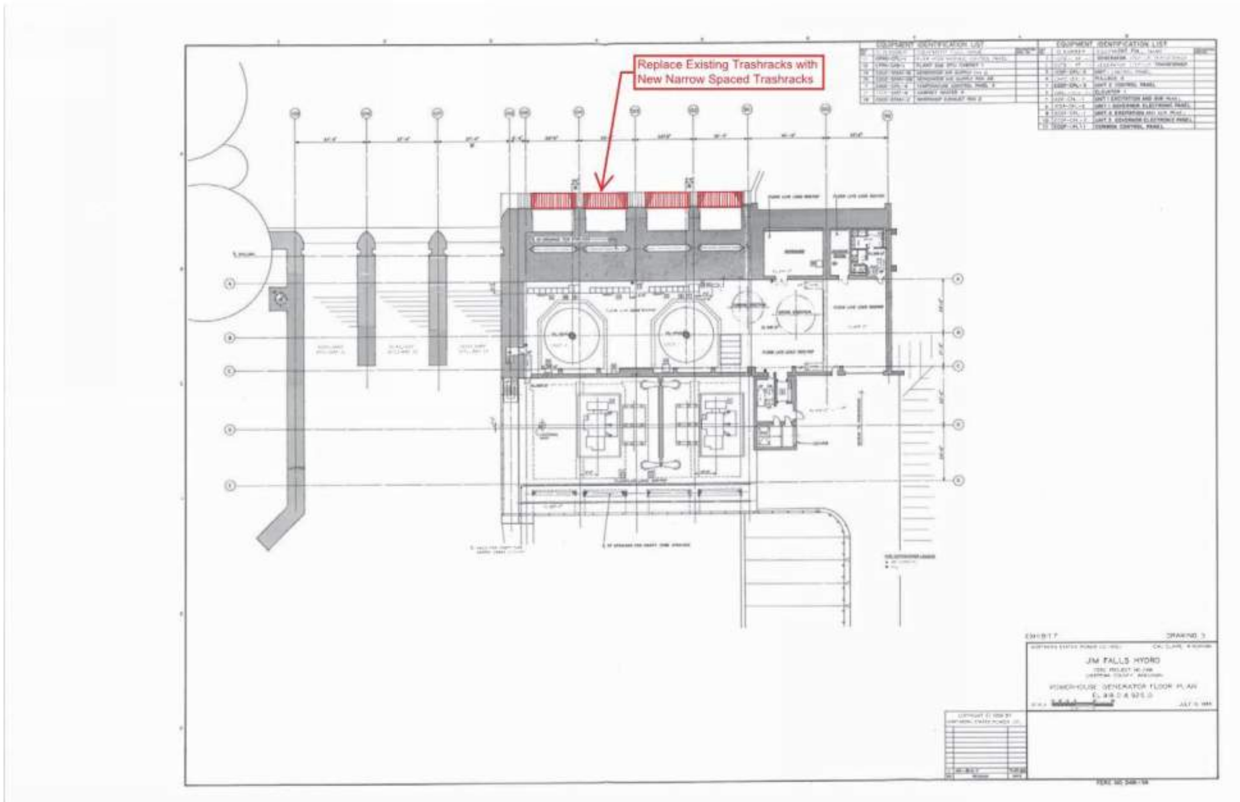


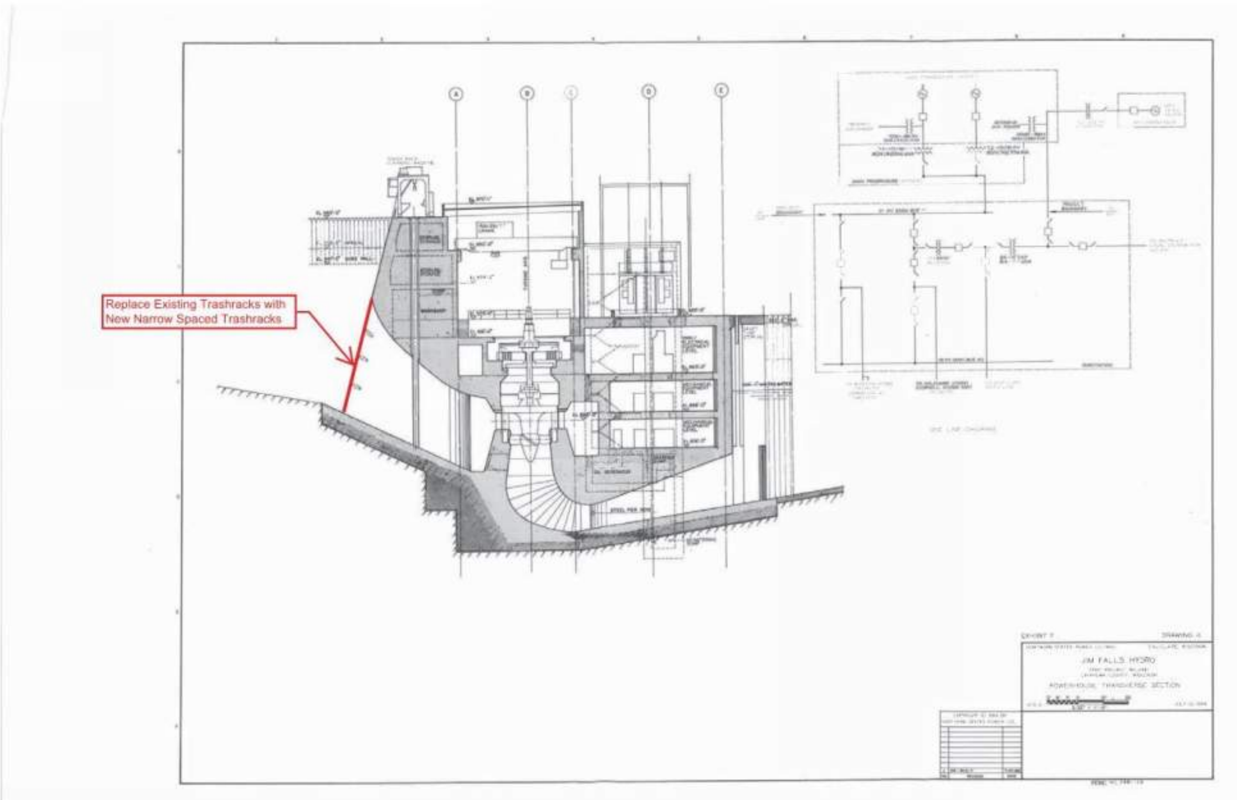
Corner Anchor
Net End Anchor
Full Depth Floating Barrier Net
Approximate Shore Line
Net End Anchor
CHIPPEWA RIVER
Existing embankment
Existing flashboard spillway
Existing tainter gate spillway
Intake gate house
Flume (existing)
Property line
Base line
Turbine runners
Existing Flambeau Co Mill Building
Existing concrete wall
Existing 18" pipe
Top of wall
Existing division wall
Tailrace Excavation
Mill Outlet Sewer
Driveway to Mill
Woods to be cleared
Downstream Access Road
Outline of existing road (to be abandoned)
Metal guard rail (Typ.)
Woods
Existing fence
Existing fence to remain
Existing fence to be removed
18" CMP culvert
Transmission pole
Grade El. 987.0
Bituminous surfacing
Compacted fill
Ground line
Seeded grass
6" gravel driveway
A - A
25" bituminous surface course (1/2" top coarse)
Compacted fill
ROADWAY DETAIL
NOTES:
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
CORNELL HYDRO PLANT
CORNELL, WISC.
GENERAL PLAN
C9
NORTHERN STATES POWER COMPANY
NH-57820


DETAIL A
DETAIL B
DETAIL C
DETAIL D
NOTE:
REFERENCE DRAWINGS:
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
CORNELL HYDRO PLANT
CORNELL WISC.
POWERHOUSE
C15
NORTHERN STATES POWER COMPANY
NH-57826

JIM FALLS

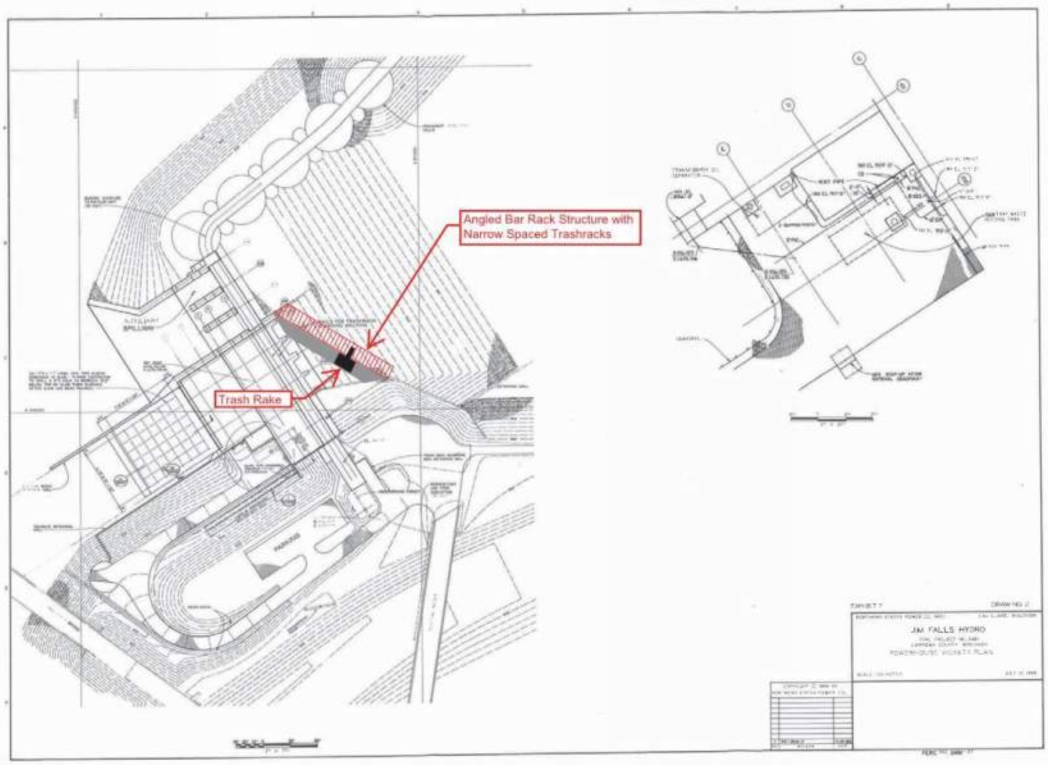
REPLACE EXISTING TRASHRACKS WITH NEW NARROWLY SPACED TRASHRACKS

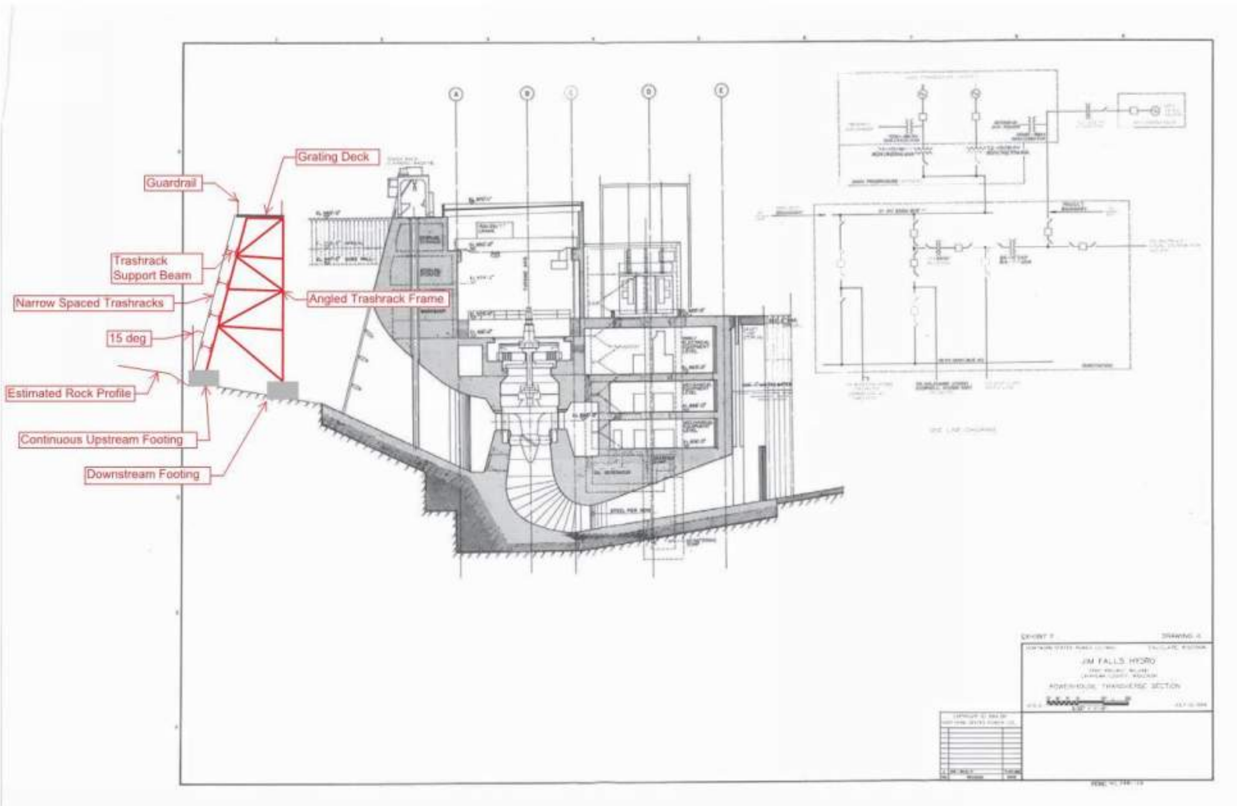

Replace Existing Trashracks with
New Narrow Spaced Trashracks
EXHIBIT F
DRAWING 3
JIM FALLS HYDRO
POWERHOUSE GENERATOR FLOOR PLAN


Replace Existing Trashracks with
New Narrow Spaced Trashracks
JIM FALLS HYDRO
POWERHOUSE TRANSVERSE SECTION

JIM FALLS

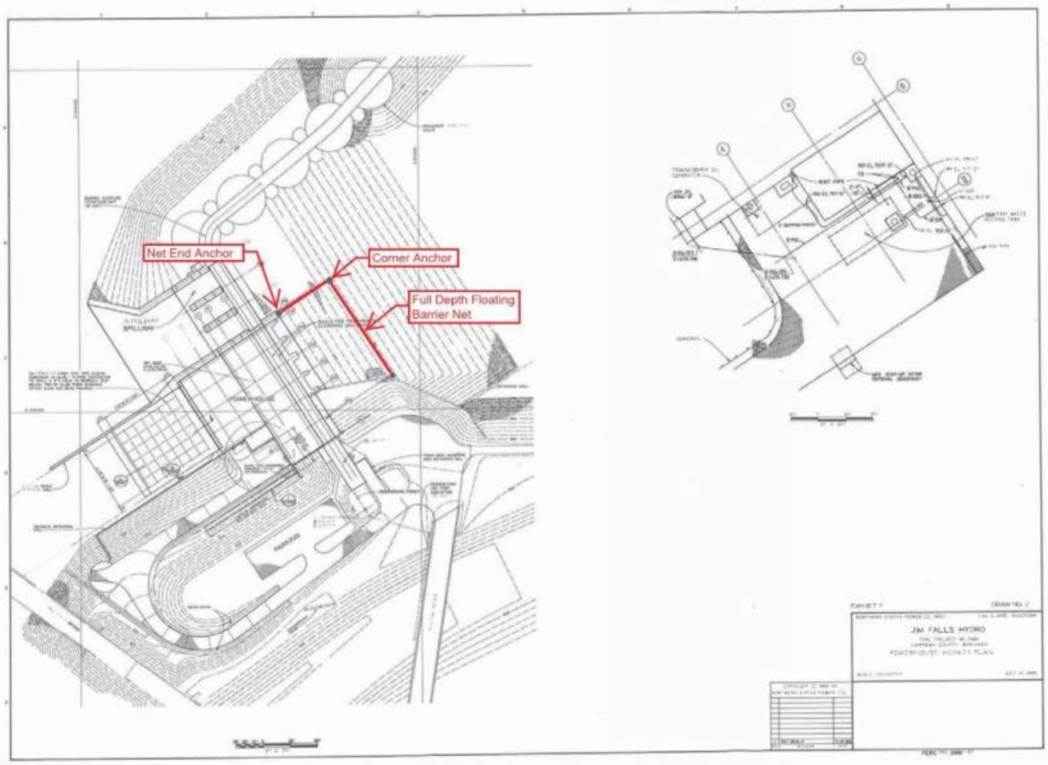
ANGLED BAR RACK WITH NARROWLY SPACED BARS

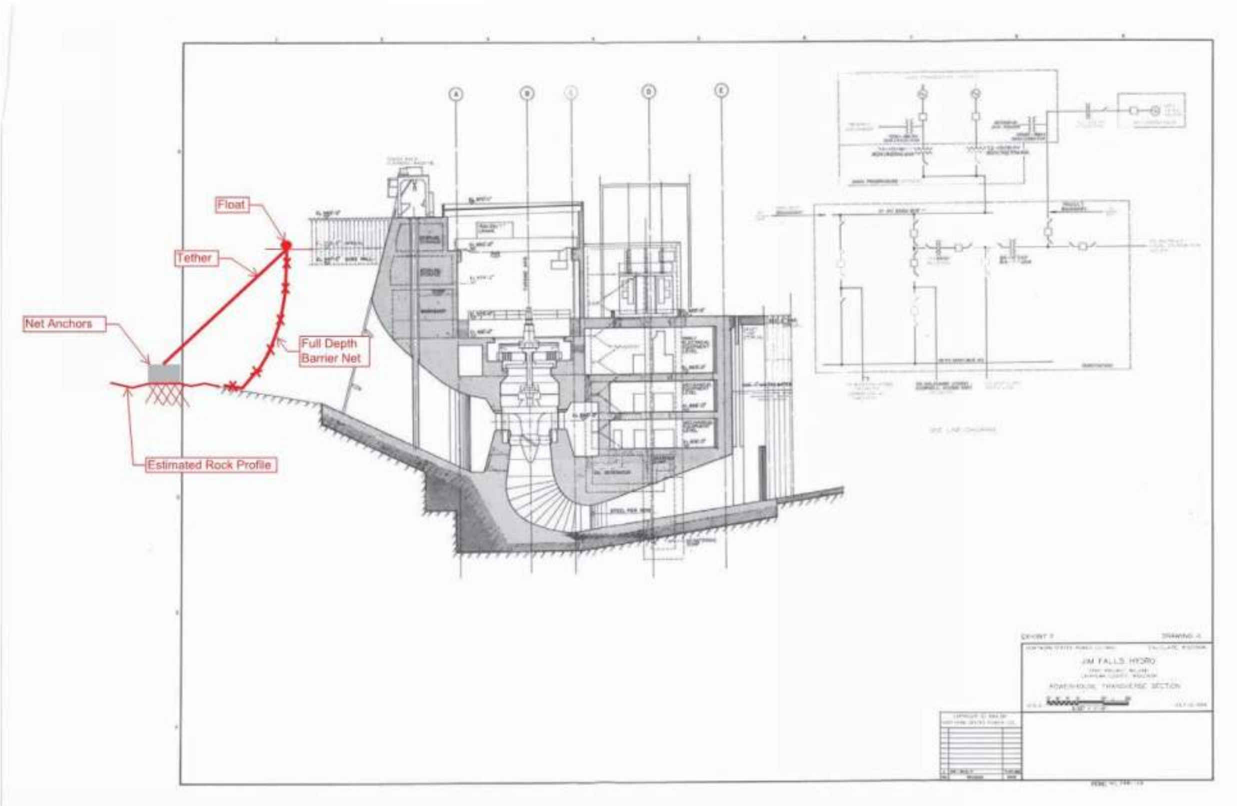

Angled Bar Rack Structure with
Narrow Spaced Trashracks
Trash Rake
JIM FALLS HYDRO
POWERHOUSE VICINITY PLAN


Grating Deck
Guardrail
Trashrack
Support Beam
Narrow Spaced Trashracks
Angled Trashrack Frame
15 deg
Estimated Rock Profile
Continuous Upstream Footing
Downstream Footing
JIM FALLS HYDRO
POWERHOUSE TRANSVERSE SECTION

JIM FALLS

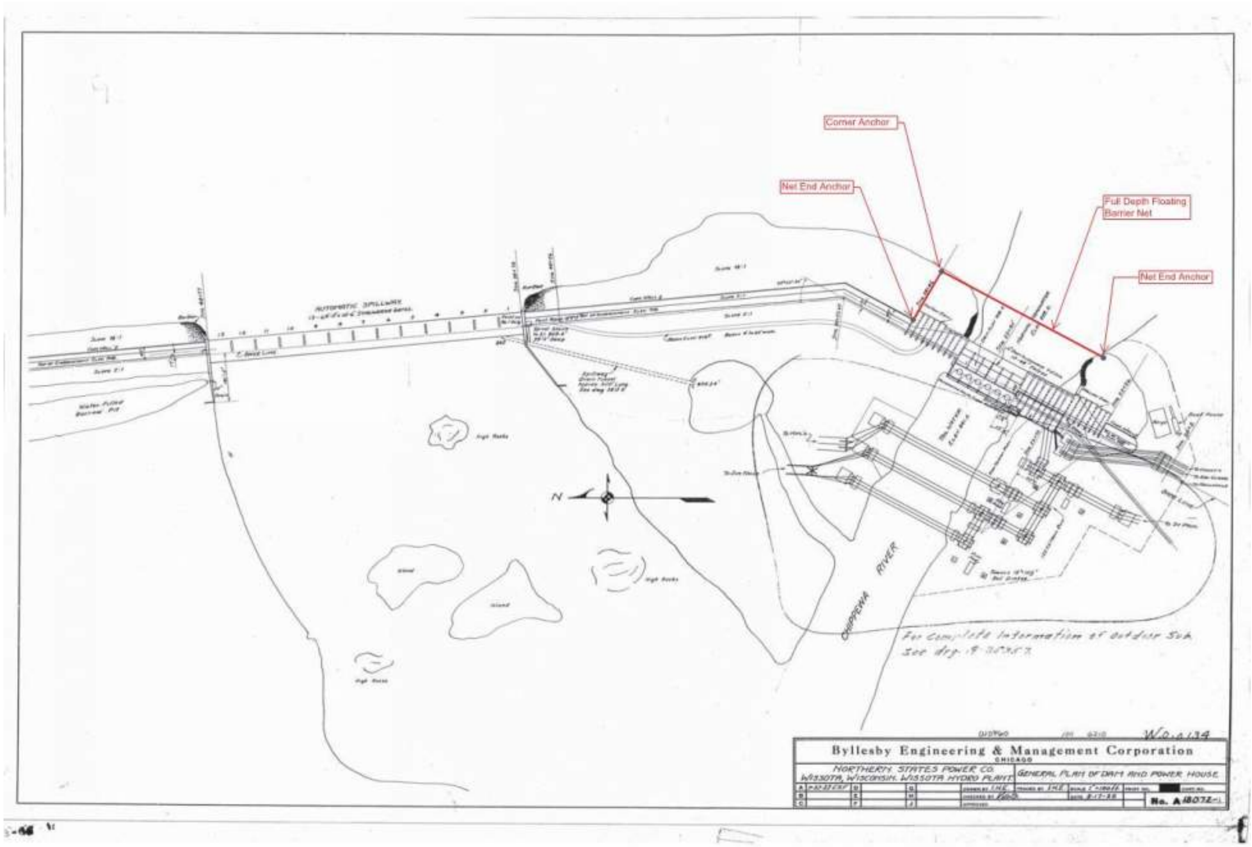
FLOATING BARRIER NET

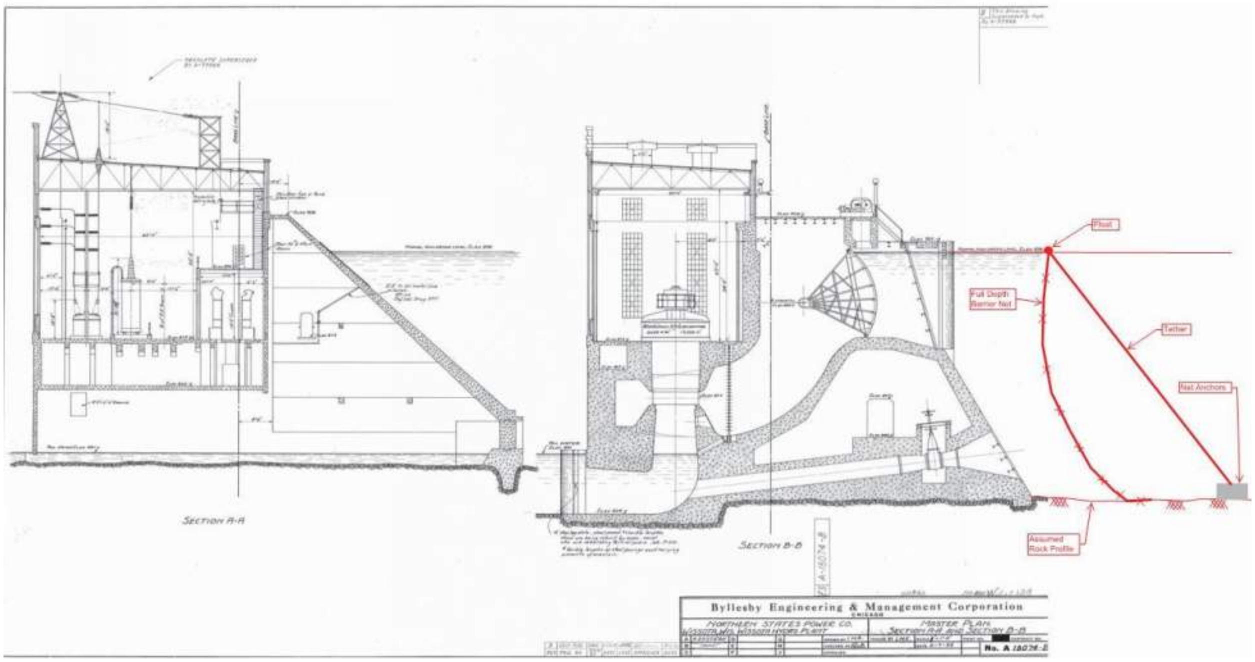

Net End Anchor
Corner Anchor
Full Depth Floating Barrier Net
AUXILIARY SPILLWAY
POWERHOUSE
PARKING
EXHIBIT 7
DRAWING NO. 2
JIM FALLS HYDRO
POWERHOUSE VICINITY PLAN


Float
Tether
Net Anchors
Full Depth Barrier Net
Estimated Rock Profile
JIM FALLS HYDRO

WISSOTA

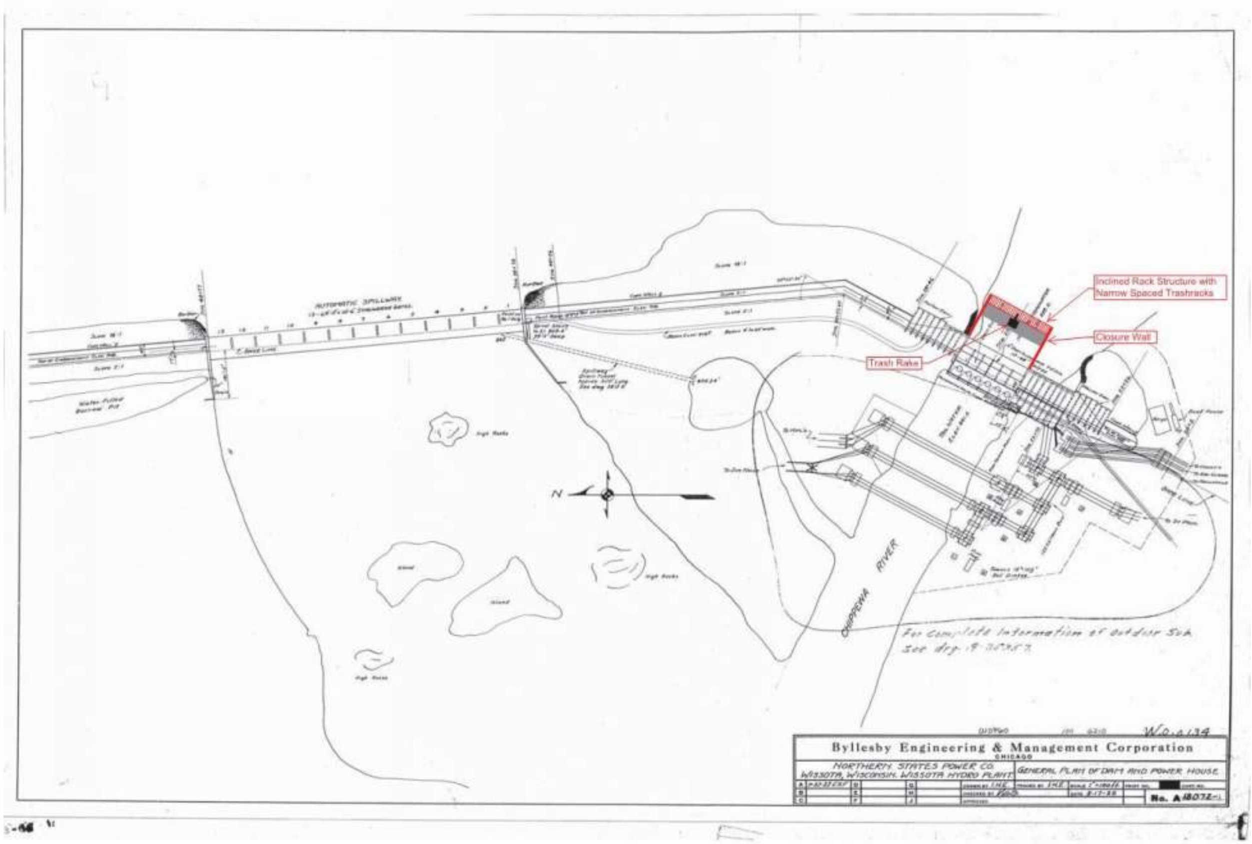
FLOATING BARRIER NET


Corner Anchor
Net End Anchor
Full Depth Floating Barrier Net
Net End Anchor
AUTOMATIC SPILLWAY
N
CHIPPEWA RIVER
For complete information of outdoor Sub. See dwg. 19-30357
W.O. A134
Byllesby Engineering & Management Corporation
CHICAGO
NORTHERN STATES POWER CO.
WISSOTA, WISCONSIN. WISSOTA HYDRO PLANT
GENERAL PLAN OF DAM AND POWER HOUSE
No. A 18072-1

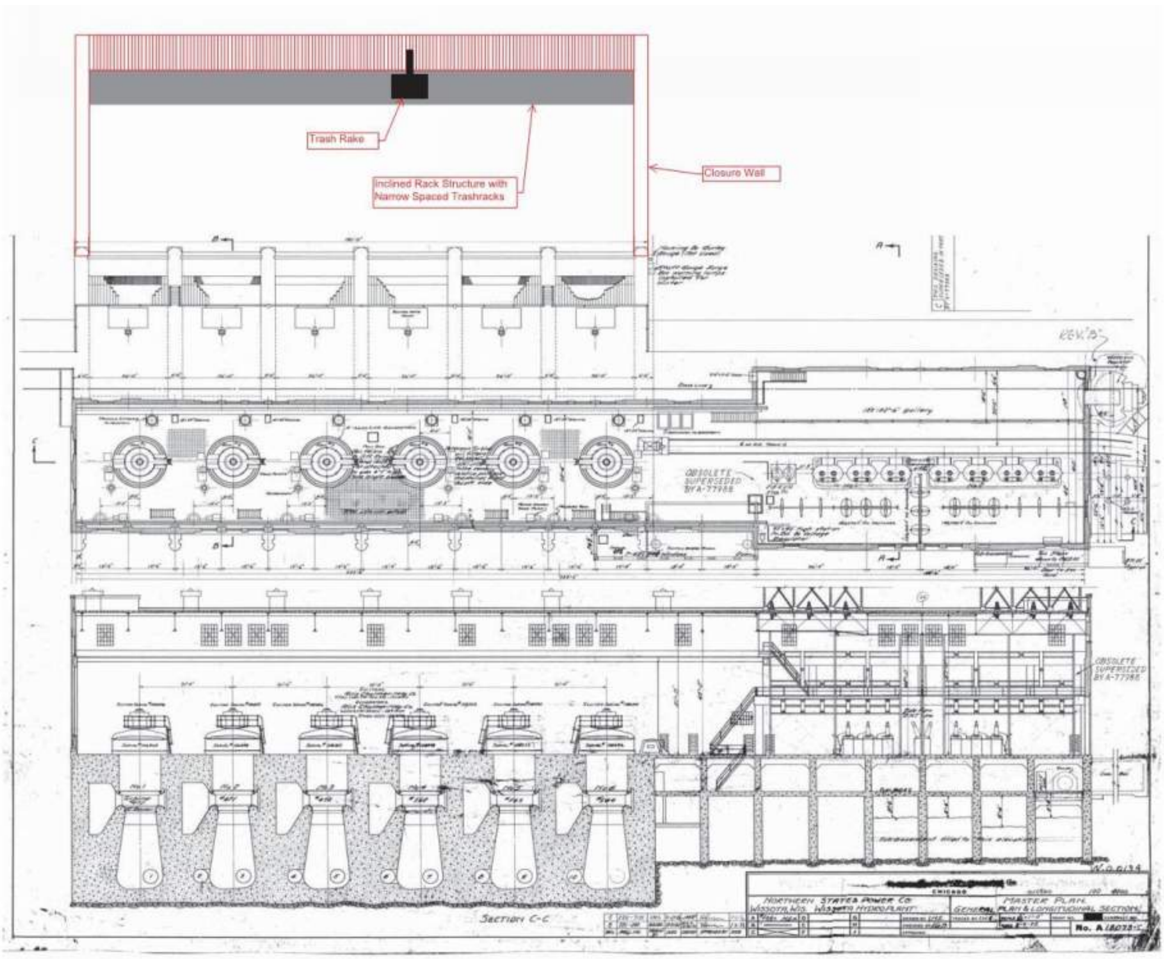

SECTION A-A
SECTION B-B
Float
Full Depth Barrier Net
Tether
Net Anchors
Assumed Rock Profile
Byllesby Engineering & Management Corporation
CHICAGO
NORTHERN STATES POWER CO.
WISSOTA, WIS. WISSOTA HYDRO PLANT
MASTER PLAN
SECTION A-A AND SECTION B-B

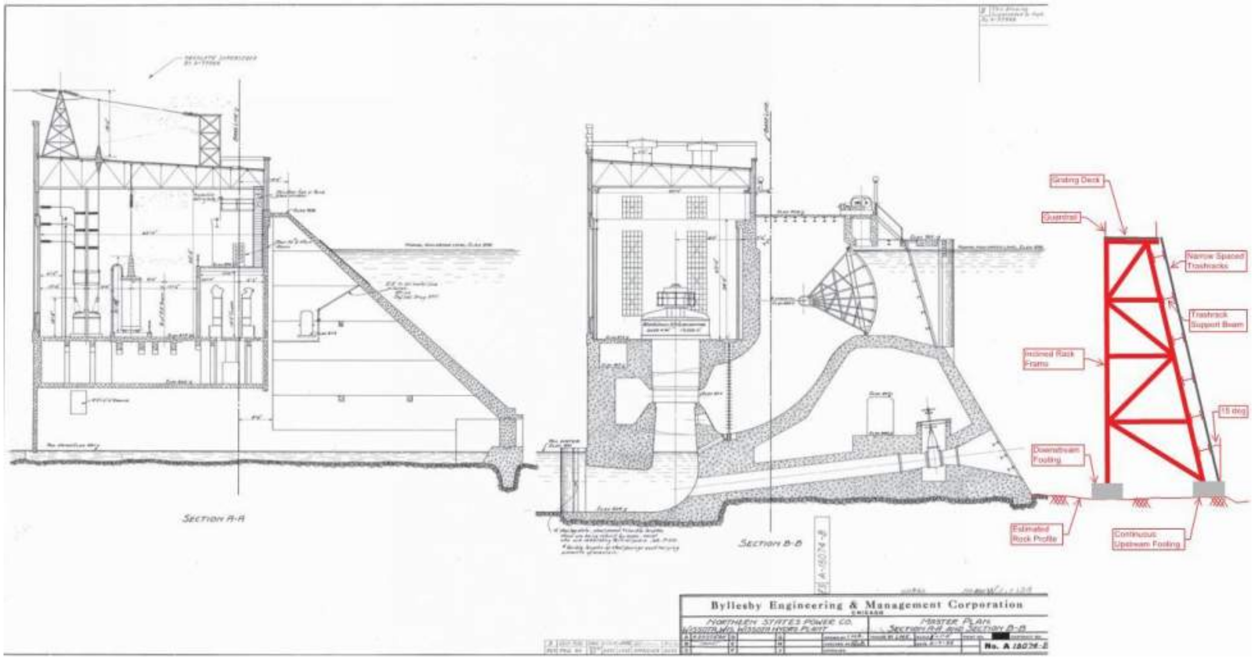
WISSOTA

INCLINED BAR RACK WITH NARROWLY SPACED BARS



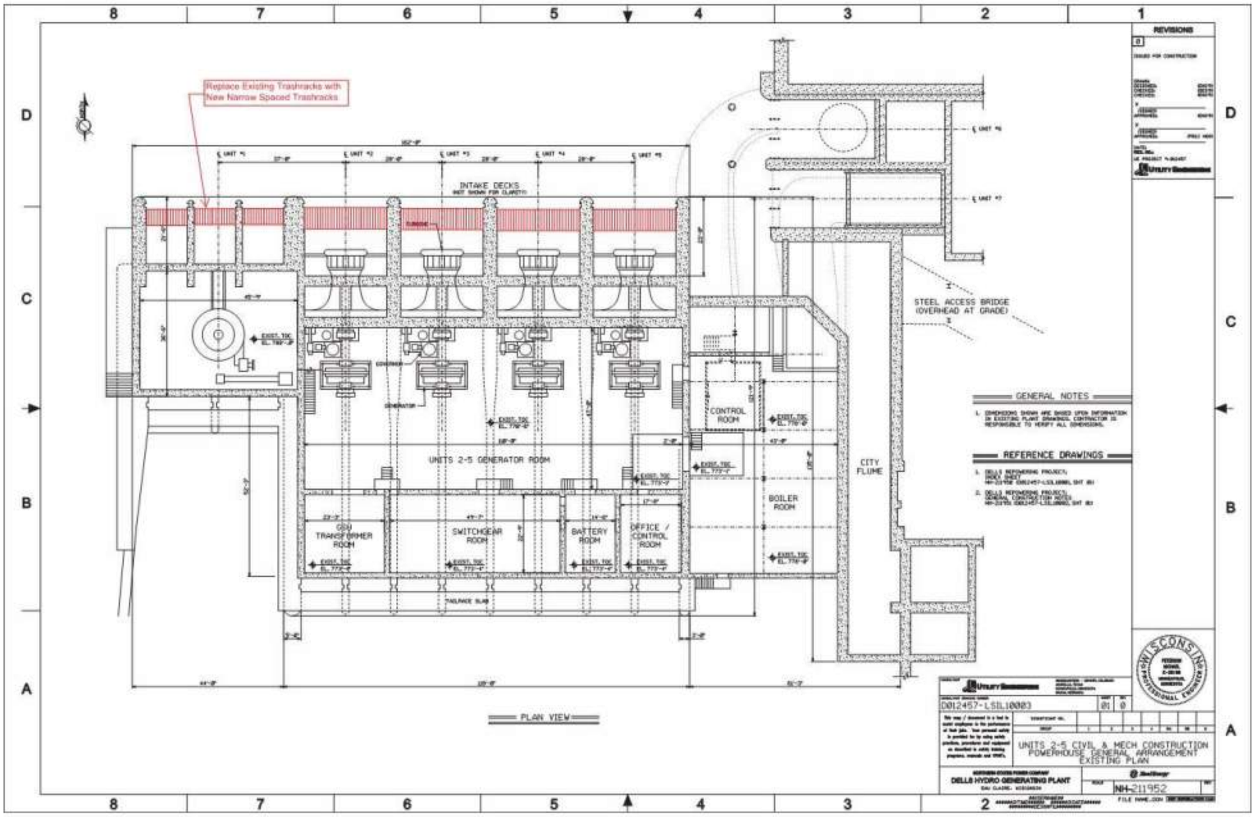
Inclined Rack Structure with Narrow Spaced Trashracks
Closure Wall
Trash Rake
AUTOMATIC SPILLWAY
N
CHIPPEWA RIVER
For complete information of outdoor Sub. see drg. 19-30353
W.O. 4134
Byllesby Engineering & Management Corporation
CHICAGO
NORTHERN STATES POWER CO.
WISSOTA, WISCONSIN. WISSOTA HYDRO PLANT
GENERAL PLAN OF DAM AND POWER HOUSE
No. A18072-1


Trash Rake
Inclined Rack Structure with Narrow Spaced Trashracks
Closure Wall
OBSOLETE SUPERSEDED BY A-77955
OBSOLETE SUPERSEDED BY A-77955
SECTION C-C
CHICAGO
NORTHERN STATES POWER CO.
WISSOTA, WIS. WISSOTA HYDRO PLANT
MASTER PLAN
GENERAL PLAN & LONGITUDINAL SECTION
No. A 18073-C

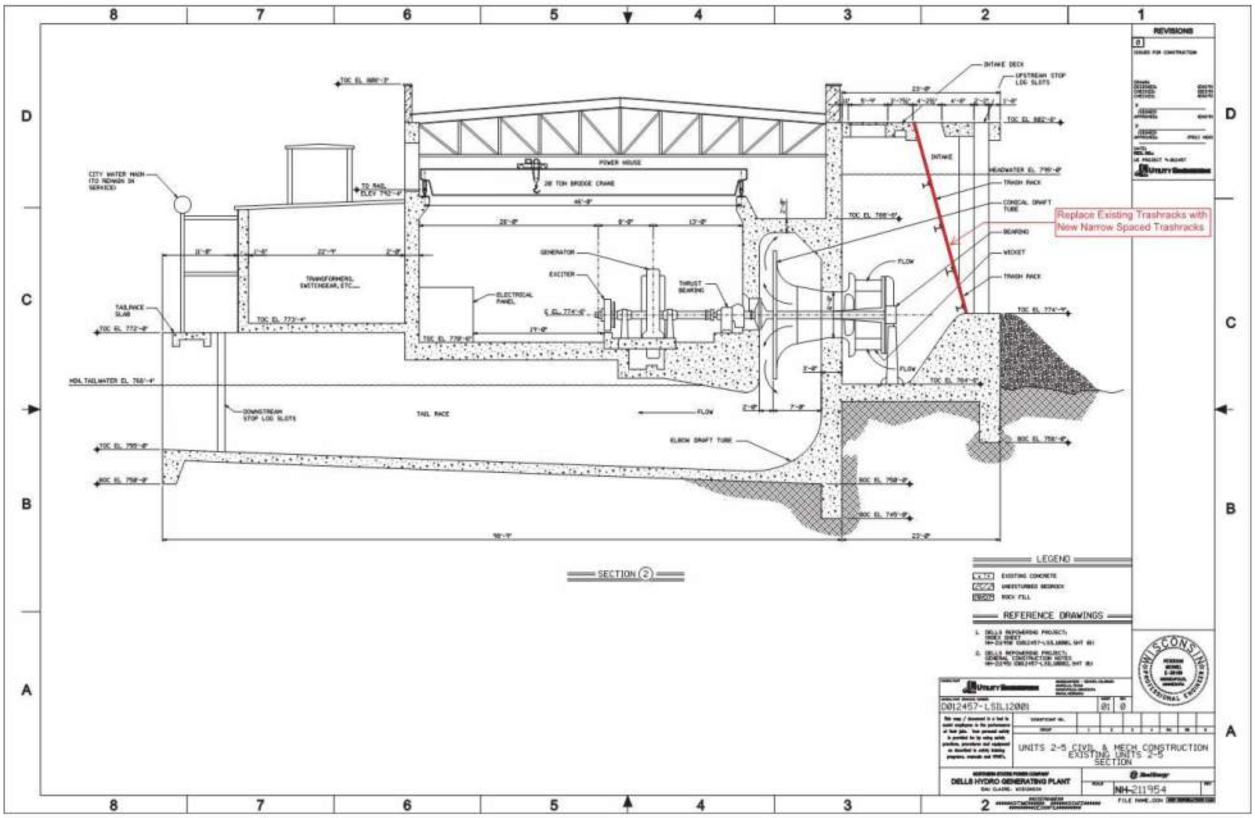

SECTION A-A
SECTION B-B
Byllesby Engineering & Management Corporation
CHICAGO
NORTHERN STATES POWER CO.
MASTER PLAN
SECTION A-A AND SECTION B-B
No. A 18074-B
Grating Deck
Guardrail
Narrow Spaced Trashracks
Trashrack Support Beam
Inclined Rack Frame
15 deg
Downstream Footing
Estimated Rock Profile
Continuous Upstream Footing

DELLS

REPLACE EXISTING TRASHRACKS WITH NEW NARROWLY SPACED TRASHRACKS

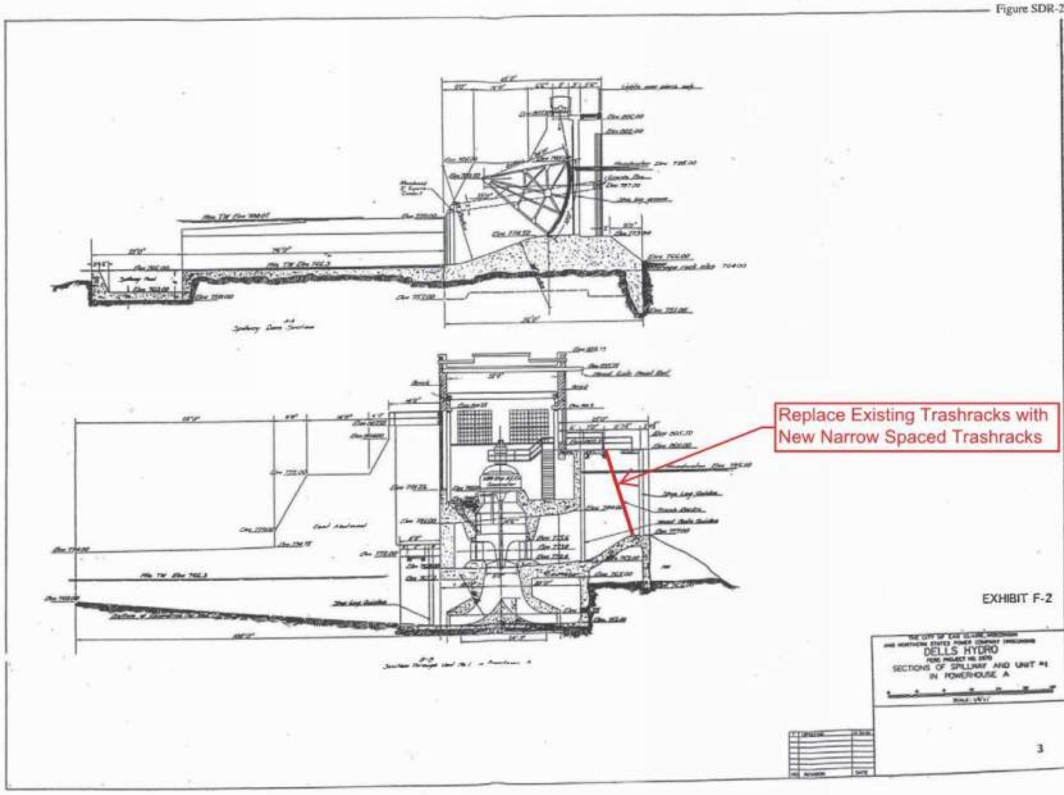


Replace Existing Trashracks with New Narrow Spaced Trashracks
INTAKE DECKS
UNITS 2-5 GENERATOR ROOM
CONTROL ROOM
GSU TRANSFORMER ROOM
SWITCHGEAR ROOM
BATTERY ROOM
OFFICE / CONTROL ROOM
BOILER ROOM
CITY FLUME
STEEL ACCESS BRIDGE (OVERHEAD AT GRADE)
PLAN VIEW
GENERAL NOTES
REFERENCE DRAWINGS
D012457-LSIL10003
UNITS 2-5 CIVIL & MECH CONSTRUCTION
POWERHOUSE GENERAL ARRANGEMENT
EXISTING PLAN
DELLS HYDRO GENERATING PLANT
NH-211952
WISCONSIN



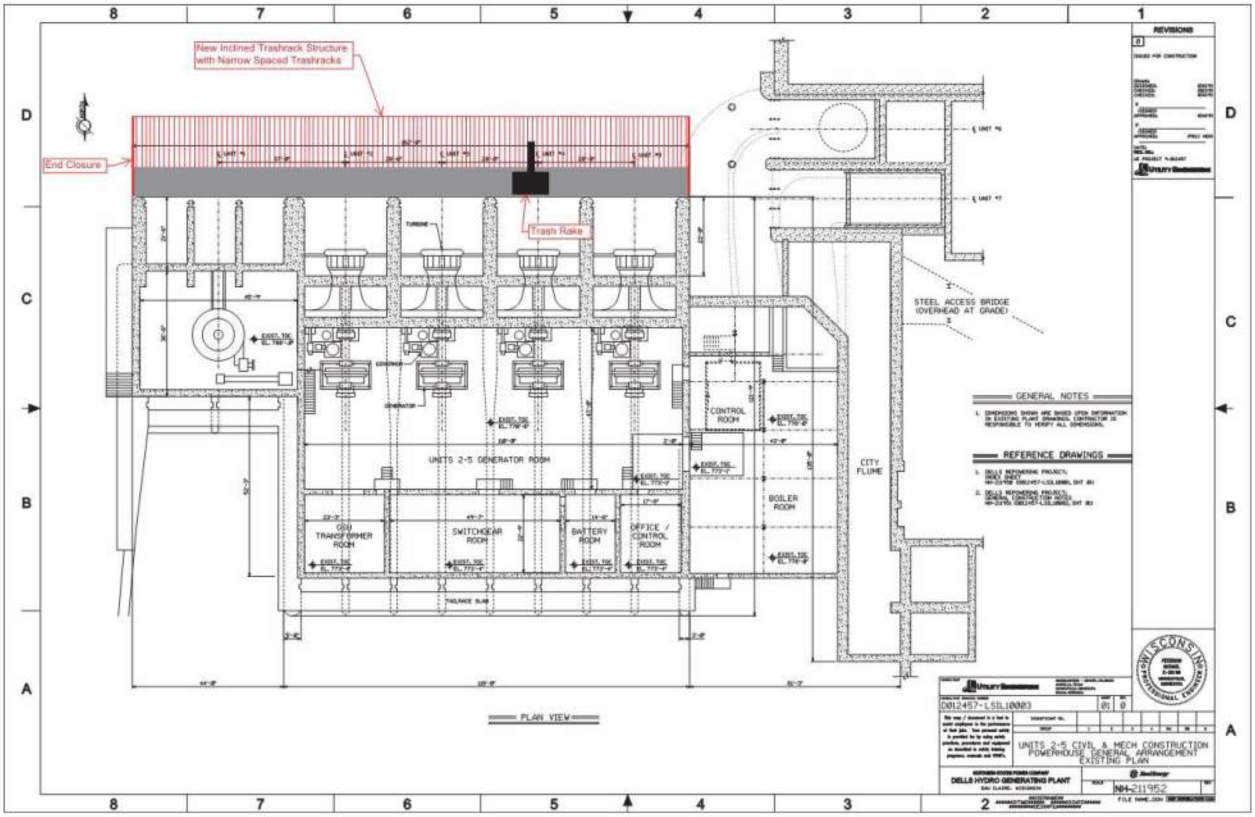
REVISIONS
INTAKE DECK
UPSTREAM STOP LOG SLOTS
POWER HOUSE
20 TON BRIDGE CRANE
INTAKE
HEADWATER EL 795'-0"
TRASH RACK
CONICAL DRAFT TUBE
Replace Existing Trashracks with New Narrow Spaced Trashracks
BEARING
WICKET
FLOW
CITY WATER MAIN (TO REMAIN IN SERVICE)
TRANSFORMERS, SWITCHGEAR, ETC.
GENERATOR
EXCITER
THRUST BEARING
ELECTRICAL PANEL
TAILRACE SLAB
DOWNSTREAM STOP LOG SLOTS
TAIL RACE
ELBOW DRAFT TUBE
SECTION 2
LEGEND
EXISTING CONCRETE
UNDISTURBED BEDROCK
ROCK FILL
REFERENCE DRAWINGS
D012457-LSIL1200I
UNITS 2-5 CIVIL & MECH CONSTRUCTION
EXISTING UNITS 2-5
SECTION
DELLS HYDRO GENERATING PLANT
NH-211954
WISCONSIN

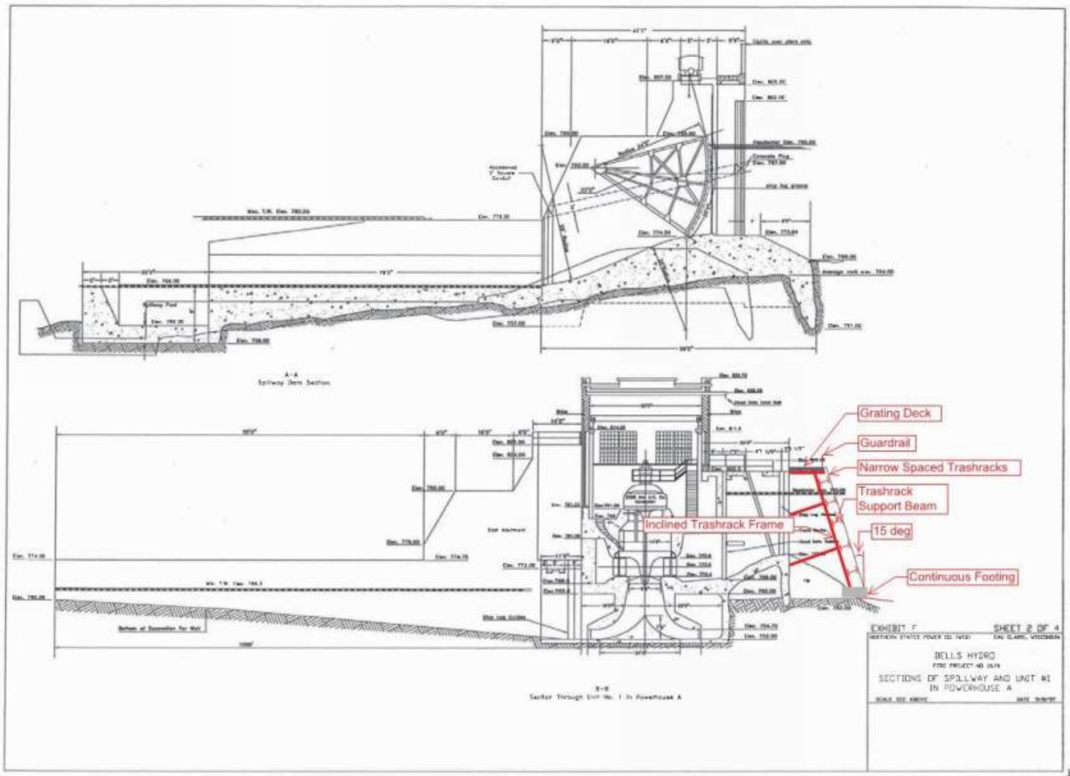
Figure SDR-2 (b)



DELLS

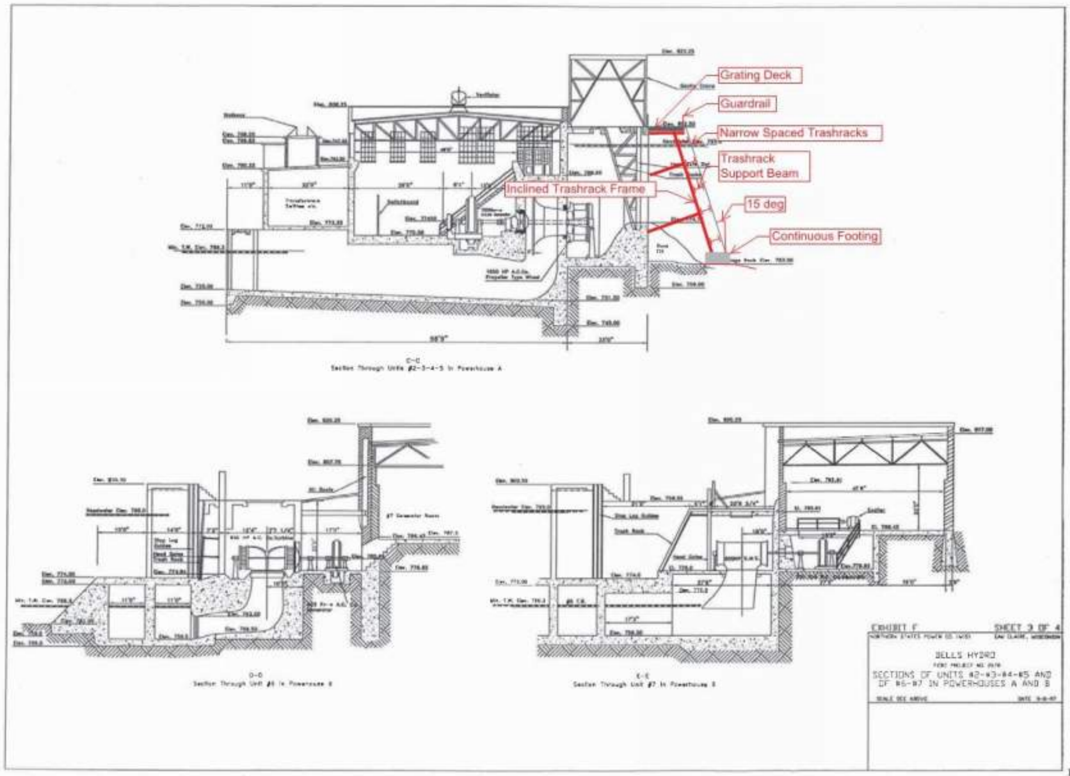
INCLINED BAR RACK WITH NARROWLY SPACED BARS


New Inclined Trashrack Structure with Narrow Spaced Trashracks
End Closure
Trash Rake
STEEL ACCESS BRIDGE (OVERHEAD AT GRADE)
CONTROL ROOM
UNITS 2-5 GENERATOR ROOM
CITY FLUME
BOILER ROOM
GSU TRANSFORMER ROOM
SWITCHGEAR ROOM
BATTERY ROOM
OFFICE / CONTROL ROOM
GENERAL NOTES
REFERENCE DRAWINGS
PLAN VIEW
REVISIONS
WISCONSIN PROFESSIONAL ENGINEER
D012457-LSIL10003
UNITS 2-5 CIVIL & MECH CONSTRUCTION
POWERHOUSE GENERAL ARRANGEMENT
EXISTING PLAN
DELLS HYDRO GENERATING PLANT
NH-211952



Grating Deck
Guardrail
Narrow Spaced Trashracks
Trashrack
Support Beam
Inclined Trashrack Frame
15 deg
Continuous Footing
EXHIBIT F
SHEET 2 OF 4
DELLS HYDRO
SECTIONS OF SPILLWAY AND UNIT #1
IN POWERHOUSE A

F-2


Grating Deck
Guardrail
Narrow Spaced Trashracks
Trashrack
Support Beam
Inclined Trashrack Frame
15 deg
Continuous Footing
C-C
Section Through Units #2-3-4-5 In Powerhouse A
D-D
Section Through Unit #6 In Powerhouse B
E-E
Section Through Unit #7 In Powerhouse B
EXHIBIT F
SHEET 3 OF 4
DELLS HYDRO
SECTIONS OF UNITS #2-#3-#4-#5 AND
OF #6-#7 IN POWERHOUSES A AND B

APPENDIX G

OPINIONS OF PROBABLE CONSTRUCTION COST

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
HOLCOMB OPTION 1 - CLOSE SPACED BAR RACKS

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 159,500
1	MOBILIZATION/DEMOBILIZATION		10%	$ 107,000	$ 107,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 5,000	$ 5,000	$ 5,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	0.25 MONTH	$ 50,000 /MONTH	$ 12,500	$ 12,500	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION						$ 281,000
6	REMOVE EXISTING TRASHRACKS	7800 SF	$ 10 /SF	$ 78,000	$ 78,000	
7	MODIFICATIONS TO HEADGATE GANTRY AND TRASH RAKE	1 LS	$ 200,000	$ 200,000	$ 200,000	
8	DIVERS	1 DAY	$ 3,000 /DAY	$ 3,000	$ 3,000	
D. CIVIL						$ 7,950
9	REMOVE SEDIMENT AND DEBRIS AT BASE OF RACKS	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
10	HAULING	65 CY	$ 10 /CY	$ 650	$ 650	
11	DIVERS	2 DAYS	$ 3,000 /DAY	$ 6,000	$ 6,000	
E. CONCRETE (THIS SECTION NOT USED)						$ -
F. STRUCTURAL STEEL						$ 237,000
12	TRASHRACK PANELS	7800 SF	$ 30 /SF	$ 234,000	$ 234,000	
13	DIVERS	1 DAY	$ 3,000 /DAY	$ 3,000	$ 3,000	
G. MECHANICAL						$ 300,000
14	TRASHRAKE	1 LS	$ 300,000	$ 300,000	$ 300,000	
H. ELECTRICAL						$ 188,600
15	TRASHRAKE ELECTRIC SUPPLY	1 LS	$ 10,000	$ 10,000	$ 10,000	
16	CONTROL PANEL	1 LS	$ 20,000	$ 20,000	$ 20,000	
17	TRANSFORMER	1 LS	$ 8,000	$ 8,000	$ 8,000	
18	PLC	1 LS	$ 60,000	$ 60,000	$ 60,000	
19	POWER DISTRIBUTION				$ 27,500	
	POWER CABLE & CONDUIT	1 LS	$ 20,000	$ 20,000		
	SAFETY SWITCH	1 LS	$ 4,000	$ 4,000		
	POWER PANEL AND BREAKERS	1 LS	$ 3,500	$ 3,500		
20	HOIST SERVICE & CONTROL				$ 23,100	
	HOIST & GATE ACTUATOR	1 LS	$ 18,600	$ 18,600		
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$ 4,500	$ 4,500		
21	GROUNDING	1 LS	$ 10,000	$ 10,000	$ 10,000	
22	MISC CABINETS, CONDUITS AND WIRES	1 LS	$ 30,000	$ 30,000	$ 30,000	
	SUM OF DIRECT CONSTRUCTION COSTS				*$ 1,174,000*	
	Contingency	25%			$ 294,000	
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 1,468,000**	
G1	ENGINEERING & PERMITTING	12%			$ 176,000	
G2	CONSTRUCTION MONITORING	10%			$ 147,000	
	SUM OF INDIRECT COSTS				*$ 323,000*	
	Contingency	25%			$ 81,000	
	SUBTOTAL OF INDIRECT COSTS				**$ 404,000**	
	TOTAL PROJECT COSTS				**$ 1,872,000**	
OPERATIONS AND MAINTENANCE						
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 15,000	$ 15,000	$ 15,000	
	OPERATIONS COST (COST PER YEAR)	365 HR	$ 70 /HR	$ 25,550	$ 25,550	

NOTES:
1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
HOLCOMB OPTION 2 - INCLINED BAR RACK STRUCTURE

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 391,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 201,000	$ 201,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 5,000	$ 5,000	$ 5,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	3 MONTHS	$ 50,000 /MONTH	$ 150,000	$ 150,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION						$ 281,000
6	REMOVE EXISTING TRASHRACKS	7800 SF	$ 10 /SF	$ 78,000	$ 78,000	
7	MODIFICATIONS TO HEADGATE GANTRY AND TRASH RAKE	1 LS	$ 200,000	$ 200,000	$ 200,000	
8	DIVERS	1 DAY	$ 3,000 /DAY	$ 3,000	$ 3,000	
D. CIVIL						$ 10,950
9	SOIL EXCAVATION FOR UPSTREAM FOOTING	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
10	HAULING	65 CY	$ 10 /CY	$ 650	$ 650	
11	DIVERS	3 DAYS	$ 3,000 /DAY	$ 9,000	$ 9,000	
E. CONCRETE						$ 36,000
12	UPSTREAM FOOTING	40 CY	$ 600 /CY	$ 24,000	$ 24,000	
13	DIVERS	4 DAYS	$ 3,000 /DAY	$ 12,000	$ 12,000	
F. STRUCTURAL STEEL						$ 999,700
14	ANGLED SUPPORTS BEAMS (W16X50)	17800 LBS	$ 5 /LBS	$ 89,000	$ 89,000	
15	SUPPORTS BEAM BRACES (W10X30)	5400 LBS	$ 5 /LBS	$ 27,000	$ 27,000	
16	RACK SUPPORTS (W18X50)	39900 LBS	$ 5 /LBS	$ 199,500	$ 199,500	
17	BOTTOM RACK SUPPORT (L6X6X3/8)	2700 LBS	$ 5 /LBS	$ 13,500	$ 13,500	
18	TRASHRACK PANELS	7400 SF	$ 60 /SF	$ 444,000	$ 444,000	
19	END CLOSURE TRASHRACK PANELS	600 SF	$ 60 /SF	$ 36,000	$ 36,000	
20	GRATING SUPPORTS (W12X30)	9300 LBS	$ 5 /LBS	$ 46,500	$ 46,500	
21	GRATING	850 SF	$ 37 /SF	$ 31,450	$ 31,450	
22	GUARDRAIL	150 FT	$ 45 /FT	$ 6,750	$ 6,750	
23	TRASH RAKE SUPPORT RAILS	3200 LBS	$ 5 /LBS	$ 16,000	$ 16,000	
24	DIVERS	30 DAYS	$ 3,000 /DAY	$ 90,000	$ 90,000	
G. MECHANICAL						$ 300,000
25	TRASHRAKE	1 LS	$ 300,000	$ 300,000	$ 300,000	
H. ELECTRICAL						$ 188,600
26	TRASHRAKE ELECTRIC SUPPLY	1 LS	$ 10,000	$ 10,000	$ 10,000	
27	CONTROL PANEL	1 LS	$ 20,000	$ 20,000	$ 20,000	
28	TRANSFORMER	1 LS	$ 8,000	$ 8,000	$ 8,000	
28	PLC	1 LS	$ 60,000	$ 60,000	$ 60,000	
29	POWER DISTRIBUTION				$ 27,500	
	POWER CABLE & CONDUIT	1 LS	$ 20,000	$ 20,000		
	SAFETY SWITCH	1 LS	$ 4,000	$ 4,000		
	POWER PANEL AND BREAKERS	1 LS	$ 3,500	$ 3,500		
30	HOIST SERVICE & CONTROL				$ 23,100	
	HOIST & GATE ACTUATOR	1 LS	$ 18,600	$ 18,600		
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$ 4,500	$ 4,500		
31	GROUNDING	1 LS	$ 10,000	$ 10,000	$ 10,000	

32	MISC CABINETS, CONDUITS AND WIRES	1 LS	$ 30,000	$ 30,000	$ 30,000
	SUM OF DIRECT CONSTRUCTION COSTS				$ 2,207,000
	Contingency	25%			$ 552,000
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 2,759,000**
G1	ENGINEERING & PERMITTING	12%			$ 331,000
G2	CONSTRUCTION MONITORING	10%			$ 276,000
	SUM OF INDIRECT COSTS				$ 607,000
	Contingency	25%			$ 152,000
	SUBTOTAL OF INDIRECT COSTS				**$ 759,000**
	TOTAL PROJECT COSTS				**$ 3,518,000**
OPERATIONS AND MAINTENANCE					
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 40,000	$ 40,000	$ 40,000
	OPERATIONS COST (COST PER YEAR)	365 HR	$ 70 /HR	$ 25,550	$ 25,550

NOTES:

1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
HOLCOMB OPTION 3 - FULL DEPTH BARRIER NET

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 151,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 61,000	$ 61,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 5,000	$ 5,000	$ 5,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	1 MONTH	$ 50,000 /MONTH	$ 50,000	$ 50,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION (THIS SECTION NOT USED)						$ -
D. CIVIL						$ 7,950
6	RIVER BOTTOM PREP	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
7	HAULING	65 CY	$ 10 /CY	$ 650	$ 650	
8	DIVERS	2 DAYS	$ 3,000 /DAY	$ 6,000	$ 6,000	
E. CONCRETE						$ 48,000
9	PRECAST CONCRETE NET BOTTOM ANCHORS	25 CY	$ 600 /CY	$ 15,000	$ 15,000	
10	PRECAST CONCRETE NET CORNER ANCHOR	5 CY	$ 600 /CY	$ 3,000	$ 3,000	
11	DIVERS	10 DAYS	$ 3,000 /DAY	$ 30,000	$ 30,000	
F. STRUCTURAL STEEL						$ 8,000
12	NET END ANCHORS	1000 LBS	$ 5 /LBS	$ 5,000	$ 5,000	
13	DIVERS	1 DAY	$ 3,000 /DAY	$ 3,000	$ 3,000	
G. BARRIER NET						$ 458,000
14	NET	11000 SF	$ 40 /SF	$ 440,000	$ 440,000	
15	DIVERS	6 DAYS	$ 3,000 /DAY	$ 18,000	$ 18,000	
	SUM OF DIRECT CONSTRUCTION COSTS				*$ 673,000*	
	Contingency	25%			$ 168,000	
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 841,000**	
G1	ENGINEERING & PERMITTING	12%			$ 101,000	
G2	CONSTRUCTION MONITORING	10%			$ 84,000	
	SUM OF INDIRECT COSTS				*$ 185,000*	
	Contingency	25%			$ 46,000	
	SUBTOTAL OF INDIRECT COSTS				**$ 231,000**	
	TOTAL PROJECT COSTS				**$ 1,072,000**	
OPERATIONS AND MAINTENANCE						
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 50,000	$ 50,000	$ 50,000	
	OPERATIONS COST (DIVERS COST PER YEAR)	10 DAYS	$ 3,000 /DAY	$ 30,000	$ 30,000	

NOTES:

1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
CORNELL OPTION 1 - CLOSE SPACED BAR RACKS

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 121,500
1	MOBILIZATION/DEMOBILIZATION		10%	$ 69,000	$ 69,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 5,000	$ 5,000	$ 5,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	0.25 MONTH	$ 50,000 /MONTH	$ 12,500	$ 12,500	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION						$ 37,000
6	REMOVE EXISTING TRASHRACKS	3400 SF	$ 10 /SF	$ 34,000	$ 34,000	
7	DIVERS	1 DAY	$ 3,000 /DAY	$ 3,000	$ 3,000	
D. CIVIL						$ 7,950
8	REMOVE SEDIMENT AND DEBRIS AT BASE OF RACKS	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
9	HAULING	65 CY	$ 10 /CY	$ 650	$ 650	
10	DIVERS	2 DAYS	$ 3,000 /DAY	$ 6,000	$ 6,000	
E. CONCRETE (THIS SECTION NOT USED)						$ -
F. STRUCTURAL STEEL						$ 102,000
11	TRASHRACK PANELS	3300 SF	$ 30 /SF	$ 99,000	$ 99,000	
12	DIVERS	1 DAY	$ 3,000 /DAY	$ 3,000	$ 3,000	
G. MECHANICAL						$ 300,000
13	TRASH RAKE	1 LS	$ 300,000	$ 300,000	$ 300,000	
H ELECTRICAL						$ 188,600
14	TRASHRAKE ELECTRIC SUPPLY	1 LS	$ 10,000	$ 10,000	$ 10,000	
15	CONTROL PANEL	1 LS	$ 20,000	$ 20,000	$ 20,000	
16	TRANSFORMER	1 LS	$ 8,000	$ 8,000	$ 8,000	
17	PLC	1 LS	$ 60,000	$ 60,000	$ 60,000	
18	POWER DISTRIBUTION				$ 27,500	
	POWER CABLE & CONDUIT	1 LS	$ 20,000	$ 20,000		
	SAFETY SWITCH	1 LS	$ 4,000	$ 4,000		
	POWER PANEL AND BREAKERS	1 LS	$ 3,500	$ 3,500		
19	HOIST SERVICE & CONTROL				$ 23,100	
	HOIST & GATE ACTUATOR	1 LS	$ 18,600	$ 18,600		
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$ 4,500	$ 4,500		
20	GROUNDING	1 LS	$ 10,000	$ 10,000	$ 10,000	
21	MISC CABINETS, CONDUITS AND WIRES	1 LS	$ 30,000	$ 30,000	$ 30,000	
	SUM OF DIRECT CONSTRUCTION COSTS				*$ 757,000*	
	Contingency	25%			$ 189,000	
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 946,000**	
G1	ENGINEERING & PERMITTING	12%			$ 114,000	
G2	CONSTRUCTION MONITORING	10%			$ 95,000	
	SUM OF INDIRECT COSTS				*$ 209,000*	
	Contingency	25%			$ 52,000	
	SUBTOTAL OF INDIRECT COSTS				**$ 261,000**	
	TOTAL PROJECT COSTS				**$ 1,207,000**	
OPERATIONS AND MAINTENANCE						
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 15,000	$ 15,000	$ 15,000	
	OPERATIONS COST (COST PER YEAR)	365 HR	$ 70 /HR	$ 25,550	$ 25,550	

NOTES:
1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
CORNELL OPTION 2 - ANGLED BAR RACK STRUCTURE

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 923,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 398,000	$ 398,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 20,000	$ 20,000	$ 20,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	9 MONTHS	$ 50,000 /MONTH	$ 450,000	$ 450,000	
6	BARGE MOBILIZATION/DEMOBILIZATION	1 LS	$ 5,000	$ 5,000	$ 5,000	
7	BARGE	1 MONTH	$ 15,000 /MONTH	$ 15,000	$ 15,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION						$ 29,000
8	MODIFICATIONS TO THE EXISTING INTAKE STRUCTURE	1 LS	$ 20,000	$ 20,000	$ 20,000	
9	DIVERS	3 DAYS	$ 3,000 /DAY	$ 9,000	$ 9,000	
D. CIVIL						$ 99,300
10	SOIL EXCAVATION FOR RETAINING WALL EXTENSION	1500 CY	$ 26 /CY	$ 39,000	$ 39,000	
11	FILL BEHIND RETAINING WALL	400 CY	$ 5 /CY	$ 2,000	$ 2,000	
12	SOIL EXCAVATION FOR ANGLED BAR RACK UPSTREAM FOOTING	150 CY	$ 26 /CY	$ 3,900	$ 3,900	
13	SOIL EXCAVATION FOR ANGLED BAR RACK DOWNSTREAM FOOTING	150 CY	$ 26 /CY	$ 3,900	$ 3,900	
14	HAULING	2750 CY	$ 10 /CY	$ 27,500	$ 27,500	
15	GRADING AND SEEDING	1 LS	$ 5,000	$ 5,000	$ 5,000	
16	DIVERS	6 DAYS	$ 3,000 /DAY	$ 18,000	$ 18,000	
E. CONCRETE						$ 544,000
17	UPSTREAM ANGLED BAR RACK FOOTING	80 CY	$ 600 /CY	$ 48,000	$ 48,000	
18	DOWNSTREAM ANGLED BAR RACK FOOTINGS	70 CY	$ 600 /CY	$ 42,000	$ 42,000	
19	VERTICAL ROCK ANCHORS	60 EA	$ 600 /EA	$ 36,000	$ 36,000	
20	EXTEND EXISTING RETAINING WALL (STEM)	170 CY	$ 800 /CY	$ 136,000	$ 136,000	
21	EXTEND EXISTING RETAINING WALL (FOOTER)	170 CY	$ 600 /CY	$ 102,000	$ 102,000	
22	DIVERS	60 DAYS	$ 3,000 /DAY	$ 180,000	$ 180,000	
F. STRUCTURAL STEEL						$ 2,298,200
23	RACK PANEL GUIDES (W4X13)	26100 LBS	$ 5 /LBS	$ 130,500	$ 130,500	
24	SUPPORT COLUMNS (W16X50)	41300 LBS	$ 5 /LBS	$ 206,500	$ 206,500	
25	TRASH RAKE SUPPORT BEAMS (W24X68)	54600 LBS	$ 5 /LBS	$ 273,000	$ 273,000	
26	TRASH RACK SUPPORT BEAMS (W14X48)	57800 LBS	$ 5 /LBS	$ 289,000	$ 289,000	
27	CROSS BEAMS (W14X48)	11900 LBS	$ 5 /LBS	$ 59,500	$ 59,500	
28	CROSS BEAMS (W12X26)	31300 LBS	$ 5 /LBS	$ 156,500	$ 156,500	
29	CROSS BRACE (LL6X6X1/2)	23500 LBS	$ 5 /LBS	$ 117,500	$ 117,500	
30	TOP RACK PANEL GUIDE SUPPORT (L5X3-1/2X3/8)	4200 LBS	$ 5 /LBS	$ 21,000	$ 21,000	
31	BOTTOM RACK PANEL GUIDE SUPPORT (L6X6X3/8)	6000 LBS	$ 5 /LBS	$ 30,000	$ 30,000	
32	TRASHRACK PANELS	9200 SF	$ 60 /SF	$ 552,000	$ 552,000	
33	GRATING	5500 SF	$ 37 /SF	$ 203,500	$ 203,500	
34	GUARDRAIL	760 FT	$ 45 /FT	$ 34,200	$ 34,200	
35	DIVERS	75 DAYS	$ 3,000 /DAY	$ 225,000	$ 225,000	

	G. MECHANICAL								$	300,000
36	TRASHRAKE	1 LS	$	300,000.00	$	300,000	$	300,000		
	L. ELECTRICAL								$	188,600
37	TRASHRAKE ELECTRIC SUPPLY	1 LS	$	10,000	$	10,000	$	10,000		
38	CONTROL PANEL	1 LS	$	20,000	$	20,000	$	20,000		
39	TRANSFORMER	1 LS	$	8,000	$	8,000	$	8,000		
40	PLC	1 LS	$	60,000	$	60,000	$	60,000		
41	POWER DISTRIBUTION						$	27,500		
	POWER CABLE & CONDUIT	1 LS	$	20,000	$	20,000				
	SAFETY SWITCH	1 LS	$	4,000	$	4,000				
	POWER PANEL AND BREAKERS	1 LS	$	3,500	$	3,500				
42	HOIST SERVICE & CONTROL						$	23,100		
	HOIST & GATE ACTUATOR	1 LS	$	18,600	$	18,600				
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$	4,500	$	4,500				
43	GROUNDING	1 LS	$	10,000	$	10,000	$	10,000		
44	MISC CABINETS, CONDUITS AND WIRES	1 LS	$	30,000	$	30,000	$	30,000		
	SUM OF DIRECT CONSTRUCTION COSTS						*$*	*4,382,000*		
	Contingency	25%					$	1,096,000		
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS						**$**	**5,478,000**		
G1	ENGINEERING & PERMITTING	12%					$	657,000		
G2	CONSTRUCTION MONITORING	10%					$	548,000		
	SUM OF INDIRECT COSTS						*$*	*1,205,000*		
	Contingency	25%					$	301,000		
	SUBTOTAL OF INDIRECT COSTS						**$**	**1,506,000**		
	TOTAL PROJECT COSTS						**$**	**6,984,000**		
	OPERATIONS AND MAINTENANCE									
	MAINTENANCE COST (COST PER YEAR)	1 LS	$	80,000	$	80,000	$	80,000		
	OPERATIONS COST (COST PER YEAR)	730 HR	$	70 /HR	$	51,100	$	51,100		

NOTES:

1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
CORNELL OPTION 3 - FULL DEPTH BARRIER NET

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 233,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 88,000	$ 88,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 10,000	$ 10,000	$ 10,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	2 MONTH	$ 50,000 /MONTH	$ 100,000	$ 100,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION (THIS SECTION NOT USED)						$ -
D. CIVIL						$ 19,675
6	RIVER BOTTOM PREP	100 CY	$ 26 /CY	$ 2,600	$ 2,600	
7	HAULING	125 CY	$ 10 /CY	$ 1,250	$ 1,250	
8	DIVERS	3 DAYS	$ 3,000 /DAY	$ 9,000	$ 9,000	
9	UPSTREAM NET END ANCHOR				$ 6,825	
	EXCAVATION	70 CY	$ 20 /CY	$ 1,400		
	BACKFILL	65 CY	$ 5 /CY	$ 325		
	HAULING	10 CY	$ 10 /CY	$ 100		
	GRADING AND SEEDING	1 LS	$ 5,000	$ 5,000		
E. CONCRETE						$ 102,000
10	PRECAST CONCRETE NET BOTTOM ANCHORS	60 CY	$ 600 /CY	$ 36,000	$ 36,000	
11	PRECAST CONCRETE NET CORNER ANCHOR	5 CY	$ 600 /CY	$ 3,000	$ 3,000	
12	DIVERS	20 DAY	$ 3,000 /DAY	$ 60,000	$ 60,000	
13	PRECAST CONCRETE NET END ANCHOR	5 CY	$ 600 /CY	$ 3,000	$ 3,000	
F. STRUCTURAL STEEL						$ 8,000
14	NET END ANCHOR	1000 LBS	$ 5.00 /LBS	$ 5,000	$ 5,000	
15	DIVERS	1 DAY	$ 3,000 /DAY	$ 3,000	$ 3,000	
G. BARRIER NET						$ 604,000
16	NET	14500 SF	$ 40 /SF	$ 580,000	$ 580,000	
17	DIVERS	8 DAYS	$ 3,000 /DAY	$ 24,000	$ 24,000	
	SUM OF DIRECT CONSTRUCTION COSTS				*$ 967,000*	
	Contingency	25%			$ 242,000	
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 1,209,000**	
G1	ENGINEERING & PERMITTING	12%			$ 145,000	
G2	CONSTRUCTION MONITORING	10%			$ 121,000	
	SUM OF INDIRECT COSTS				*$ 266,000*	
	Contingency	25%			$ 67,000	
	SUBTOTAL OF INDIRECT COSTS				**$ 333,000**	
	TOTAL PROJECT COSTS				**$ 1,542,000**	
OPERATIONS AND MAINTENANCE						
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 60,000	$ 60,000	$ 60,000	
	OPERATIONS COST (DIVERS COST PER YEAR)	10 DAYS	$ 3,000 /DAY	$ 30,000	$ 30,000	

NOTES:
1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
JIM FALLS OPTION 1 - CLOSE SPACED BAR RACKS

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 189,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 99,000	$ 99,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 5,000	$ 5,000	$ 5,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	1 MONTH	$ 50,000 /MONTH	$ 50,000	$ 50,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION						$ 138,000
6	REMOVE EXISTING TRASHRACKS	4200 SF	$ 30 /SF	$ 126,000	$ 126,000	
7	DIVERS	4 DAY	$ 3,000 /DAY	$ 12,000	$ 12,000	
D. CIVIL						$ 7,950
8	REMOVE SEDIMENT AND DEBRIS AT BASE OF RACKS	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
9	HAULING	65 CY	$ 10 /CY	$ 650	$ 650	
10	DIVERS	2 DAYS	$ 3,000 /DAY	$ 6,000	$ 6,000	
E. CONCRETE (THIS SECTION NOT USED)						$ -
F. STRUCTURAL STEEL						$ 264,000
11	TRASHRACK PANELS	4200 SF	$ 60 /SF	$ 252,000	$ 252,000	
12	DIVERS	4 DAYS	$ 3,000 /DAY	$ 12,000	$ 12,000	
G. MECHANICAL						$ 300,000
13	TRASH RAKE	1 LS	$ 300,000	$ 300,000	$ 300,000	
H. ELECTRICAL						$ 188,600
14	TRASHRAKE ELECTRIC SUPPLY	1 LS	$ 10,000	$ 10,000	$ 10,000	
15	CONTROL PANEL	1 LS	$ 20,000	$ 20,000	$ 20,000	
16	TRANSFORMER	1 LS	$ 8,000	$ 8,000	$ 8,000	
17	PLC	1 LS	$ 60,000	$ 60,000	$ 60,000	
18	POWER DISTRIBUTION				$ 27,500	
	POWER CABLE & CONDUIT	1 LS	$ 20,000	$ 20,000		
	SAFETY SWITCH	1 LS	$ 4,000	$ 4,000		
	POWER PANEL AND BREAKERS	1 LS	$ 3,500	$ 3,500		
19	HOIST SERVICE & CONTROL				$ 23,100	
	HOIST & GATE ACTUATOR	1 LS	$ 18,600	$ 18,600		
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$ 4,500	$ 4,500		
20	GROUNDING	1 LS	$ 10,000	$ 10,000	$ 10,000	
21	MISC CABINETS, CONDUITS AND WIRES	1 LS	$ 30,000	$ 30,000	$ 30,000	
	SUM OF DIRECT CONSTRUCTION COSTS				*$ 1,088,000*	
	Contingency	25%			$ 272,000	
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 1,360,000**	
G1	ENGINEERING & PERMITTING	12%			$ 163,000	
G2	CONSTRUCTION MONITORING	10%			$ 136,000	
	SUM OF INDIRECT COSTS				*$ 299,000*	
	Contingency	25%			$ 75,000	
	SUBTOTAL OF INDIRECT COSTS				**$ 374,000**	
	TOTAL PROJECT COSTS				**$ 1,734,000**	
OPERATIONS AND MAINTENANCE						
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 15,000	$ 15,000	$ 15,000	
	OPERATIONS COST (COST PER YEAR)	365 HR	$ 70 /HR	$ 25,550	$ 25,550	

NOTES:
1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
JIM FALLS OPTION 2 - ANGLED BAR RACK STRUCTURE

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 622,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 267,000	$ 267,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 20,000	$ 20,000	$ 20,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	6 MONTHS	$ 50,000 /MONTH	$ 300,000	$ 300,000	
6	BARGE MOBILIZATION/DEMOBILIZATION	1 LS	$ 5,000	$ 5,000	$ 5,000	
7	BARGE	1 MONTH	$ 15,000 /MONTH	$ 15,000	$ 15,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						
C. DEMOLITION						$ 19,000
8	MODIFICATIONS TO THE EXISTING INTAKE STRUCTURE	1 LS	$ 10,000	$ 10,000	$ 10,000	
9	DIVERS	3 DAY	$ 3,000 /DAY	$ 9,000	$ 9,000	
D. CIVIL						$ 9,850
10	SOIL EXCAVATION FOR ANGLED BAR RACK UPSTREAM FOOTING	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
11	SOIL EXCAVATION FOR ANGLED BAR RACK DOWNSTREAM FOOTING	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
12	HAULING	125 CY	$ 10 /CY	1250	$ 1,250	
13	DIVERS	2 DAY	$ 3,000 /DAY	$ 6,000	$ 6,000	
E. CONCRETE						$ 111,000
14	UPSTREAM ANGLED BAR RACK FOOTINGS	35 CY	$ 600 /CY	$ 21,000	$ 21,000	
15	DOWNSTREAM ANGLED BAR RACK FOOTINGS	25 CY	$ 600 /CY	$ 15,000	$ 15,000	
16	VERTICAL ROCK ANCHORS	25 EA	$ 600 /EA	$ 15,000	$ 15,000	
17	DIVERS	20 DAYS	$ 3,000 /DAY	$ 60,000	$ 60,000	
F. STRUCTURAL STEEL						$ 1,666,450
18	RACK PANEL GUIDES (W4X13)	27000 LBS	$ 5 /LBS	$ 135,000	$ 135,000	
19	SUPPORT COLUMNS (W16X50)	33000 LBS	$ 5 /LBS	$ 165,000	$ 165,000	
20	TRASH RAKE SUPPORT BEAMS (W24X68)	22500 LBS	$ 5 /LBS	$ 112,500	$ 112,500	
21	TRASH RACK SUPPORT BEAMS (W14X48)	31700 LBS	$ 5 /LBS	$ 158,500	$ 158,500	
22	CROSS BEAMS (W14X48)	19800 LBS	$ 5 /LBS	$ 99,000	$ 99,000	
23	CROSS BEAMS (W12X26)	12400 LBS	$ 5 /LBS	$ 62,000	$ 62,000	
24	CROSS BRACE (LL6X6X1/2)	25900 LBS	$ 5 /LBS	$ 129,500	$ 129,500	
25	TOP RACK PANEL GUIDE SUPPORT (L5X3-1/2X3/8)	1700 LBS	$ 5 /LBS	$ 8,500	$ 8,500	
26	BOTTOM RACK PANEL GUIDE SUPPORT (L6X6X3/8)	2500 LBS	$ 5 /LBS	$ 12,500	$ 12,500	
27	TRASHRACK PANELS	9900 SF	$ 60 /SF	$ 594,000	$ 594,000	
28	GRATING	2300 SF	$ 37 /SF	$ 85,100	$ 85,100	
29	GUARDRAIL	330 FT	$ 45 /FT	$ 14,850	$ 14,850	
30	DIVERS	30 DAYS	$ 3,000 /DAY	$ 90,000	$ 90,000	
G. MECHANICAL						$ 300,000
31	TRASHRAKE	1 LS	$ 300,000.00	$ 300,000	$ 300,000	
L. ELECTRICAL						$ 188,600
32	TRASHRAKE ELECTRIC SUPPLY	1 LS	$ 10,000	$ 10,000	$ 10,000	
33	CONTROL PANEL	1 LS	$ 20,000	$ 20,000	$ 20,000	
34	TRANSFORMER	1 LS	$ 8,000	$ 8,000	$ 8,000	
35	PLC	1 LS	$ 60,000	$ 60,000	$ 60,000	

36	POWER DISTRIBUTION						$	27,500
	POWER CABLE & CONDUIT	1 LS	$	20,000	$	20,000		
	SAFETY SWITCH	1 LS	$	4,000	$	4,000		
	POWER PANEL AND BREAKERS	1 LS	$	3,500	$	3,500		
37	HOIST SERVICE & CONTROL						$	23,100
	HOIST & GATE ACTUATOR	1 LS	$	18,600	$	18,600		
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$	4,500	$	4,500		
38	GROUNDING	1 LS	$	10,000	$	10,000	$	10,000
39	MISC CABINETS, CONDUITS AND WIRES	1 LS	$	30,000	$	30,000	$	30,000
	SUM OF DIRECT CONSTRUCTION COSTS						*$*	*2,937,000*
	Contingency	25%					$	734,000
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS						**$**	**3,671,000**
G1	ENGINEERING & PERMITTING	12%					$	441,000
G2	CONSTRUCTION MONITORING	10%					$	367,000
	SUM OF INDIRECT COSTS						*$*	*808,000*
	Contingency	25%					$	202,000
	SUBTOTAL OF INDIRECT COSTS						**$**	**1,010,000**
	TOTAL PROJECT COSTS						**$**	**4,681,000**
	OPERATIONS AND MAINTENANCE							
	MAINTENANCE COST (COST PER YEAR)	1 LS	$	60,000	$	60,000	$	60,000
	OPERATIONS COST (COST PER YEAR)	730 HR	$	70 /HR	$	51,100	$	51,100

NOTES:

1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
JIM FALLS OPTION 3 - FULL DEPTH BARRIER NET

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 161,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 66,000	$ 66,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 10,000	$ 10,000	$ 10,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	1 MONTH	$ 50,000 /MONTH	$ 50,000	$ 50,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION (THIS SECTION NOT USED)						$ -
D. CIVIL						$ 7,950
6	RIVER BOTTOM PREP	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
7	HAULING	65 CY	$ 10 /CY	$ 650	$ 650	
8	DIVERS	2 DAYS	$ 3,000 /DAY	$ 6,000	$ 6,000	
E. CONCRETE						$ 48,000
9	PRECAST CONCRETE NET BOTTOM ANCHORS	25 CY	$ 600 /CY	$ 15,000	$ 15,000	
10	PRECAST CONCRETE NET CORNER ANCHOR	5 CY	$ 600 /CY	$ 3,000	$ 3,000	
11	DIVERS	10 DAYS	$ 3,000 /DAY	$ 30,000	$ 30,000	
F. STRUCTURAL STEEL						$ 11,000
12	NET END ANCHORS	1000 LBS	$ 5.00 /LBS	$ 5,000	$ 5,000	
13	DIVERS	2 DAYS	$ 3,000 /DAY	$ 6,000	$ 6,000	
G. BARRIER NET						$ 498,000
14	NET	12000 SF	$ 40 /SF	$ 480,000	$ 480,000	
15	DIVERS	6 DAYS	$ 3,000 /DAY	$ 18,000	$ 18,000	
	SUM OF DIRECT CONSTRUCTION COSTS				$ 726,000	
	Contingency	25%			$ 182,000	
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 908,000**	
G1	ENGINEERING & PERMITTING	12%			$ 109,000	
G2	CONSTRUCTION MONITORING	10%			$ 91,000	
	SUM OF INDIRECT COSTS				$ 200,000	
	Contingency	25%			$ 50,000	
	SUBTOTAL OF INDIRECT COSTS				**$ 250,000**	
	TOTAL PROJECT COSTS				**$ 1,158,000**	
OPERATIONS AND MAINTENANCE						
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 50,000	$ 50,000	$ 50,000	
	OPERATIONS COST (DIVERS COST PER YEAR)	10 DAYS	$ 3,000 /DAY	$ 30,000	$ 30,000	

NOTES:
1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
DELLS OPTION 1 - CLOSE SPACED BAR RACKS

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 198,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 108,000	$ 108,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 5,000	$ 5,000	$ 5,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	1 MONTH	$ 50,000 /MONTH	$ 50,000	$ 50,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION						$ 302,000
6	REMOVE EXISTING TRASHRACKS	3100 SF	$ 30 /SF	$ 93,000	$ 93,000	
7	MODIFICATIONS TO HEADGATE GANTRY	1 LS	$ 200,000	$ 200,000	$ 200,000	
8	DIVERS	3 DAYS	$ 3,000 /DAY	$ 9,000	$ 9,000	
D. CIVIL						$ 7,950
9	REMOVE SEDIMENT AND DEBRIS AT BASE OF RACKS	50 CY	$ 26 /CY	$ 1,300	$ 1,300	
10	HAULING	65 CY	$ 10 /CY	$ 650	$ 650	
11	DIVERS	2 DAYS	$ 3,000 /DAY	$ 6,000	$ 6,000	
E. CONCRETE (THIS SECTION NOT USED)						$ -
F. STRUCTURAL STEEL						$ 195,000
12	TRASHRACK PANELS	3100 SF	$ 60 /SF	$ 186,000	$ 186,000	
13	DIVERS	3 DAYS	$ 3,000 /DAY	$ 9,000	$ 9,000	
G. MECHANICAL						$ 300,000
14	TRASH RAKE	1 LS	$ 300,000	$ 300,000	$ 300,000	
H. ELECTRICAL						$ 188,600
15	TRASHRAKE ELECTRIC SUPPLY	1 LS	$ 10,000	$ 10,000	$ 10,000	
16	CONTROL PANEL	1 LS	$ 20,000	$ 20,000	$ 20,000	
17	TRANSFORMER	1 LS	$ 8,000	$ 8,000	$ 8,000	
18	PLC	1 LS	$ 60,000	$ 60,000	$ 60,000	
19	POWER DISTRIBUTION				$ 27,500	
	POWER CABLE & CONDUIT	1 LS	$ 20,000	$ 20,000		
	SAFETY SWITCH	1 LS	$ 4,000	$ 4,000		
	POWER PANEL AND BREAKERS	1 LS	$ 3,500	$ 3,500		
20	HOIST SERVICE & CONTROL				$ 23,100	
	HOIST & GATE ACTUATOR	1 LS	$ 18,600	$ 18,600		
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$ 4,500	$ 4,500		
21	GROUNDING	1 LS	$ 10,000	$ 10,000	$ 10,000	
22	MISC CABINETS, CONDUITS AND WIRES	1 LS	$ 30,000	$ 30,000	$ 30,000	
	SUM OF DIRECT CONSTRUCTION COSTS				*$ 1,192,000*	
	Contingency	25%			$ 298,000	
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS				**$ 1,490,000**	
G1	ENGINEERING & PERMITTING	12%			$ 179,000	
G2	CONSTRUCTION MONITORING	10%			$ 149,000	
	SUM OF INDIRECT COSTS				*$ 328,000*	
	Contingency	25%			$ 82,000	
	SUBTOTAL OF INDIRECT COSTS				**$ 410,000**	
	TOTAL PROJECT COSTS				**$ 1,900,000**	
OPERATIONS AND MAINTENANCE						
	MAINTENANCE COST (COST PER YEAR)	1 LS	$ 15,000	$ 15,000	$ 15,000	
	OPERATIONS COST (COST PER YEAR)	365 HR	$ 70 /HR	$ 25,550	$ 25,550	

NOTES:
1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

WISCONSIN PUBLIC SERVICE
CHIPPEWA RIVER FISH PROTECTION STUDY
DELLS OPTION 2 - INCLINED BAR RACK STRUCTURE

CONCEPTUAL LEVEL - OPINION OF PROBABLE CONSTRUCTION COST
(COST IN $2016)

ITEM#	ITEM DESCRIPTION	QUANTITY	UNIT PRICE ($)	UNIT TOTAL ($)	TOTAL ($)	
A. GENERAL						$ 400,000
1	MOBILIZATION/DEMOBILIZATION		10%	$ 210,000	$ 210,000	
2	ENVIRONMENTAL PROTECTION DEVICES	1 LS	$ 5,000	$ 5,000	$ 5,000	
3	GENERAL SITE ACCESS	1 LS	$ 25,000	$ 25,000	$ 25,000	
4	CRANE MOBILIZATION/DEMOBILIZATION	1 LS	$ 10,000	$ 10,000	$ 10,000	
5	CRANE	3 MONTHS	$ 50,000 /MONTH	$ 150,000	$ 150,000	
B. COFFERDAMS AND TEMPERARY SOIL RETENTION WALLS (THIS SECTION NOT USED)						$ -
C. DEMOLITION						$ 302,000
6	REMOVE EXISTING TRASHRACKS	3100 SF	$ 30 /SF	$ 93,000	$ 93,000	
7	MODIFICATIONS TO HEADGATE GANTRY	1 LS	$ 200,000	$ 200,000	$ 200,000	
8	DIVERS	3 DAYS	$ 3,000 /DAY	$ 9,000	$ 9,000	
D. CIVIL						$ 59,850
9	SOIL EXCAVATION FOR UPSTREAM FOOTING	775 CY	$ 26 /CY	$ 20,150	$ 20,150	
10	HAULING	970 CY	$ 10 /CY	$ 9,700	$ 9,700	
11	DIVERS	10 DAYS	$ 3,000 /DAY	$ 30,000	$ 30,000	
E. CONCRETE						$ 39,000
12	UPSTREAM FOOTING	45 CY	$ 600 /CY	$ 27,000	$ 27,000	
13	DIVERS	4 DAYS	$ 3,000 /DAY	$ 12,000	$ 12,000	
F. STRUCTURAL STEEL						$ 1,019,120
14	ANGLED SUPPORTS BEAMS (W16X50)	17200 LBS	$ 5 /LBS	$ 86,000	$ 86,000	
15	SUPPORTS BEAM BRACES (W10X30)	7900 LBS	$ 5 /LBS	$ 39,500	$ 39,500	
16	RACK SUPPORTS (W18X50)	44600 LBS	$ 5 /LBS	$ 223,000	$ 223,000	
17	BOTTOM RACK SUPPORT (BENT PLATE)	2500 LBS	$ 5 /LBS	$ 12,500	$ 12,500	
18	TRASHRACK PANELS (39FTx162FT)	6300 SF	$ 60 /SF	$ 378,000	$ 378,000	
19	END CLOSURE TRASHRACK PANELS	1100 SF	$ 60 /SF	$ 66,000	$ 66,000	
20	GRATING SUPPORTS (W12X30)	10700 LBS	$ 5 /LBS	$ 53,500	$ 53,500	
21	GRATING	810 SF	$ 37 /SF	$ 29,970	$ 29,970	
22	GUARDRAIL	170 FT	$ 45 /FT	$ 7,650	$ 7,650	
23	TRASH RAKE SUPPORT RAILS	3600 LBS	$ 5 /LBS	$ 18,000	$ 18,000	
24	DIVERS	35 DAYS	$ 3,000 /DAY	$ 105,000	$ 105,000	
G. MECHANICAL						$ 300,000
25	TRASHRAKE	1 LS	$ 300,000	$ 300,000	$ 300,000	
H. ELECTRICAL						$ 188,600
26	TRASHRAKE ELECTRIC SUPPLY	1 LS	$ 10,000	$ 10,000	$ 10,000	
27	CONTROL PANEL	1 LS	$ 20,000	$ 20,000	$ 20,000	
28	TRANSFORMER	1 LS	$ 8,000	$ 8,000	$ 8,000	
29	PLC	1 LS	$ 60,000	$ 60,000	$ 60,000	
30	POWER DISTRIBUTION				$ 27,500	
	POWER CABLE & CONDUIT	1 LS	$ 20,000	$ 20,000		
	SAFETY SWITCH	1 LS	$ 4,000	$ 4,000		
	POWER PANEL AND BREAKERS	1 LS	$ 3,500	$ 3,500		
31	HOIST SERVICE & CONTROL				$ 23,100	
	HOIST & GATE ACTUATOR	1 LS	$ 18,600	$ 18,600		
	LEVEL TRANSMITTER AND STILLING WELL	1 LS	$ 4,500	$ 4,500		
32	GROUNDING	1 LS	$ 10,000	$ 10,000	$ 10,000	
33	MISC CABINETS, CONDUITS AND WIRES	1 LS	$ 30,000	$ 30,000	$ 30,000	

	SUM OF DIRECT CONSTRUCTION COSTS						$	2,309,000
	Contingency	25%					$	577,000
	SUBTOTAL OF DIRECT CONSTRUCTION COSTS						**$**	**2,886,000**
G1	ENGINEERING & PERMITTING	12%					$	346,000
G2	CONSTRUCTION MONITORING	10%					$	289,000
	SUM OF INDIRECT COSTS						$	635,000
	Contingency	25%					$	159,000
	SUBTOTAL OF INDIRECT COSTS						**$**	**794,000**
	TOTAL PROJECT COSTS						**$**	**3,680,000**
OPERATIONS AND MAINTENANCE								
	MAINTENANCE COST (COST PER YEAR)	1 LS	$	40,000	$	40,000	$	40,000
	OPERATIONS COST (COST PER YEAR)	365 HR	$	70 /HR	$	25,550	$	25,550

NOTES:
1. OWNER ADMINISTRATION AND OVERHEAD COSTS ARE NOT INCLUDED.
2. COSTS FOR HYDRO UNIT DOWN TIME RESULTING FROM INSTALLATION ARE NOT INCLUDED.
3. COSTS ASSOCIATED WITH SALES TAX AND INSURANCE ARE NOT INCLUDED.

BY: KLEINSCHMIDT ASSOCIATES

APPENDIX E-22 2020 Cornell Fish Entrainment Survival Study Report

Cornell Fish Entrainment Survival Report

Cornell Hydroelectric Project

FERC No. 2639

Prepared for:

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1.0 INTRODUCTION

The Cornell Hydroelectric Project (FERC No. 2639) is a 31 megawatt (MW) hydroelectric facility on the Lower Chippewa River in Chippewa County, Wisconsin. The Project operates under license from the Federal Energy Regulatory Commission (FERC). As part of the federal relicensing process for the facility, Xcel Energy (licensee) was directed by the Wisconsin Department of Natural Resources (WDNR) to conduct a fish entrainment and mortality study.

Xcel Energy previously assessed fish entrainment at its Chippewa River projects (e.g., Holcombe, Cornell, Jim Falls, Wissota, Chippewa Falls, and Dells). In 2016, Xcel Energy completed a Chippewa River Fish Protection Study to assess the feasibility of entrainment reduction technology at its six hydroelectric projects on the Chippewa River. The WDNR and the River Alliance of Wisconsin (RAW) have since noted that the Cornell Project has the largest trash rack spacing of any of Xcel Energy's dams on the Chippewa River, which may allow more and larger fish to become entrained. The WDNR and RAW noted that a smaller trash rack spacing of 2.0 to 2.5 inches may reduce the potential for entrainment mortality at the Cornell Project. Therefore, Xcel Energy agreed to complete a desktop analysis of fish entrainment at the Cornell Project to determine the probability of entrainment mortality for target fish species. This report outlines the methods and results of that study.

1.1 Report Objectives

The objective of this study was to evaluate the risk of entrainment mortality at the Cornell Project for lake sturgeon, walleye, redhorse species, and muskellunge. Specifically, entrainment mortality risk was evaluated with existing trash rack conditions (5.38-inches) and a hypothetical smaller trash rack spacing of 2.5-inches.

2.0 METHODS

2.1 Turbine Blade Strike Survival Analysis

The Cornell Project has three Kaplan hydroelectric turbines, each with a best gate flow of 3,750 cfs. STRYKE is an individual based model, written in Python[1], that tracks the fate of individual simulated fish as they transition through a hydroelectric facility, and was used to quantitatively estimate the probability of turbine blade strike survival through these units for each target species. STRYKE uses the turbine blade strike equations from Franke et al. (1997) and is based on the USFWS's Turbine Blade Strike Analysis desktop model (Towler and Pica 2018). Model variables include fish length, number of fish, and turbine characteristics (e.g. runner diameter, turbine type, turbine efficiency, hydraulic capacity, runner speed, and head). The STRYKE model was run 10 times for each iteration to allow for estimates of mean and standard deviation. Sample size (# of fish) was set at 100 for each iteration for a sample size of 1,000. Two other critical factors of the model require additional input by the user: the strike mortality correlation factor and fish length.

2.1.1 Strike Mortality Coefficient

The strike mortality correlation factor (i.e. lambda) is built into the model to account for differences in actual turbine mortality derived from field tests as compared to predicted model output (Franke et al. 1997). Three variables are built into the strike mortality correlation factor: the position of the fish relative to the plane of the turbine revolution (i.e., fish orientation during passage), the difference in the impact of a strike relative to the fish's body (i.e., a strike to the anterior region is more detrimental that a strike to the posterior region), and hydraulic characteristics near the leading edge of the blade tip, which may carry a fish around the leading edge, reducing the likelihood of blade strike (Franke et al. 1997). Franke et al. (1997) suggests using a lambda value of 0.10 to 0.20 for Kaplan turbines based on results of field studies compared to model predictability. Model iterations for this analysis were run using lambda values of 0.15.

2.1.2 Fish Length

Turbine passage survival and blade strike probability is influenced more by fish size than species; therefore, the equations do not differentiate between species but only consider

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[1] Python is an open source object oriented extendable programming language with packages that support scientific and advanced numerical computing.

fish size (Franke et al. 1997). STRYKE allows the user to enter fish length plus a standard deviation factor to account for variability in fish length. Fish length information (mean and standard deviation) for target species were obtained from WDNR sampling data collected during 1985-2015. Silver redhorse was used as a surrogate for all redhorse species.

The survival analysis accounted for fish that could be entrained through the existing 5.38-inch trash racks, and under conditions for fish to be entrained through 2.5-inch trash racks.

2.2 Fish Exclusion and Body Width

Body widths were calculated using the species-specific relationships between total length, standard length, and body width (Smith 1985). Fish with body widths wider than trash rack spacing were excluded from the analysis because they would not be capable of physically passing through the rack structures.

2.3 Swim Speeds

The survival analysis did not use swim speeds as an entrainment filter to remove fish that could swim away from the intakes. Swim speeds and intake velocities were still quantified to determine how through-rack velocity may change if a trash rack spacing of 2.5-inches is implemented, and to determine the potential for fish avoidance. Approach and through velocity were calculated by a licensed engineer using trash rack spacing (inches), intake area (ft^2), and the maximum flow capacity (cfs).

Species specific fish swimming speeds were determined using existing literature. Three swim speed modes are generally recognized for fishes, although terminology differ across studies and authors. Swim speeds according to Beamish (1978) were used for this assessment and are defined as follows:

- Sustained swim speed: Maintained indefinitely (i.e. greater than 200 minutes) and does not induce fatigue
- Prolonged swim speed: Can last between 15 seconds and 200 minutes, and can induce fatigue
- Burst swim speed: Short duration, high speed movements that can be maintained for less than 15 seconds

Prolonged swim speed is generally 50-70% of burst swim speed, and sustained swim speed is generally 15-20% of burst swim speed (Bell 1991). The median of these ranges were used to calculate other speed modes from known existing swim speeds.

3.0 RESULTS

Analysts used WDNR data for 709 muskellunge, 340 lake sturgeon, 1,650 walleye, and 134 silver redhorse to calculate mean lengths and standard deviations for the species specific model runs (Table 3-1, Table 3-2).

Table 3-1 Average Lengths of Fish Used in the Trash Rack Survival Analysis – Existing Trash Rack (5.38-inch spacing)

Species	Average Length (in)	Standard Deviation
Muskellunge	32.2	7.8
Lake Sturgeon	44.2	5.8
Walleye	15.9	4.4
Redhorse	18.6	4.0

Table 3-2 Average Lengths of Fish Used in the Trash Rack Survival Analysis – Hypothetical Trash Rack (2.5-inch Spacing)

Species	Average Length (in)	Standard Deviation
Muskellunge	27.3	6.0
Lake Sturgeon	18.9	2.5
Walleye	14.8	3.4
Redhorse	15.2	3.1

3.1 Trash Rack Exclusion and Body Width

The existing trash racks are wide enough that all size classes of muskellunge, redhorse, and walleye could become entrained. Lake sturgeon as long as 47 inches are also susceptible to entrainment. Trash racks with 2.5-inch spacing would exclude muskellunge as long as 30.9 inches, redhorse as long as 15.9 inches, walleye as long as 16.6 inches, and lake sturgeon as long as 22.4 inches (i.e. body widths are greater than 2.5 inches at these sizes) (Table 3-3).

Table 3-3 Length of Fish Excluded by 2.5-inch Trash Racks

Species	Total Length (inches)	Standard Length (inches)
Muskellunge	35	30.9
Lake Sturgeon	27	22.4
Walleye	20	16.6
Redhorse	20	15.9

3.2 Turbine Passage Survival

Calculated mean turbine passage survival at the Cornell Project for each species is outlined in Table 3-4 and Table 3-5. Mean survival rates decrease as length increases for all species. Survival rates for expected juvenile and subadult lifestages range from 73% to 83%. Walleye and redhorse experience similar survival rates, and their lowest survival rates remain above 50%. The largest size classes of muskellunge and lake sturgeon experience lower survival rates of 24% and 10% respectively. These larger size classes are excluded in the scenario that includes a smaller trash rack spacing. Thus, survival is 100% in these scenarios, as the larger fish cannot be entrained. (Table 3-4, Table 3-5).

Table 3-4 Turbine Blade Strike Survival Estimates for Target Fish Species with 5.38-inch Trash Racks

Species	Mean Turbine Survival	Standard Deviation
Muskellunge		
Muskellunge: 10-25 inches	83%	3%
Muskellunge: 26-35 inches	50%	4%
Muskellunge: 36-45 inches	42%	3%
Muskellunge: > 45 inches	24%	5%
Lake Sturgeon		
Lake Sturgeon: 11-20 inches	73%	5%
Lake Sturgeon: 21-30 inches	53%	7%
Lake Sturgeon: 31-40 inches	48%	6%
Lake Sturgeon: > 40 inches	10%	2%
Walleye		
Walleye: 0-10 inches	78%	3%
Walleye: 11-20 inches	73%	6%
Walleye: > 20 inches	56%	2%

Redhorse		
Redhorse: 0-10 inches	81%	3%
Redhorse: 11-20 inches	68%	4%
Redhorse: > 20 inches	37%	4%

Table 3-5 Turbine Blade Strike Survival Estimates for Target Fish Species with 2.5-inch Trash Racks

Species	Mean Turbine Survival	Standard Deviation
Muskellunge		
Muskellunge: 10-25 inches	83%	3%
Muskellunge: 26-35 inches	50%	4%
Muskellunge: 36-45 inches	100% (excluded)	
Muskellunge: > 45 inches	100% (excluded)	
Lake Sturgeon		
Lake Sturgeon: 11-20 inches	73%	5%
Lake Sturgeon: 21-30 inches	53%	7%
Lake Sturgeon: 31-40 inches	100% (excluded)	
Lake Sturgeon: > 40 inches	100% (excluded)	
Walleye		
Walleye: 0-10 inches	78%	3%
Walleye: 11-20 inches	73%	6%
Walleye: > 20 inches	100% (excluded)	
Redhorse		
Redhorse: 0-10 inches	81%	3%
Redhorse: 11-20 inches	68%	4%
Redhorse: > 20 inches	100% (excluded)	

3.3 Swim Speeds

Current approach and through velocities at the Project are 5.41 and 6.04 feet per second (fps), respectively. The approach velocity would remain the same with 2.5-inch trash racks, while through-rack velocity would increase to 6.8 fps. Existing literature suggests that some adults of all species would be able to avoid intake velocities when utilizing burst movements, while prolonged and sustained swim speeds may be lower than the intake velocities for most species. Specifically, burst swim speeds for all four target species at adult size classes are higher than intake velocities, with muskellunge at 18 fps, redhorse at 11 fps, lake sturgeon at 9.9 fps, and walleye at 7 fps. Mature muskellunge, redhorse, and lake sturgeon may also have prolonged swim speeds that would allow them to avoid intake velocities (Table 3-6).

Table 3-6 Fish Swimming Speed by Length

Species	Body Length (in)	Sustained Swim Speed (fps)	Prolonged Swim Speed (fps)	Burst Swim Speed (fps)	Literature
Muskellunge*	Adult Lifestage	3.3	10.8	18***	Videler 1993
Redhorse Species**	Adult Lifestage	2.0	6.6	11***	Peake 2008
Lake Sturgeon	47	2.75	9.6	16***	Peake et al. 1997
Walleye	16		2.3	7	Peake et al. 2000

*Northern pike used as surrogate
**White sucker used a surrogate
***Calculated from known sustained or prolonged swim speeds based on ratios described in Bell (1991)

4.0 SUMMARY

Kleinschmidt Associates' (Kleinschmidt) turbine blade strike and whole station survival model, which was developed based on the USFWS's Turbine Blade Strike Analysis model (Towler and Pica 2018), provided an automated method to run multiple iterations of turbine and whole station survival estimates for multiple target species. The current trash rack spacing allows for all life stages of target species to potentially become entrained, with smaller fish unable to avoid intake velocities and larger fish potentially entering the intakes when undertaking downstream movements. The largest individuals of all species are the most susceptible to blade strike mortality, and the largest fish experience lower survival. Although these larger size classes experience lower survival rates with the current trash rack spacing, they would only encounter the project if they were volitionally swimming into the intakes.

This assessment did not use swim speed as a factor to exclude fish from potential entrainment. Larger fish have a higher probability of blade strike mortality, however, healthy adults of each of the four target species would have burst and/or prolonged swim speed greater than intake velocities. While these fish would still be susceptible to entrainment if they volitionally move downstream and into the intake, they would be expected to successfully avoid the intake in other instances, thereby reducing the number of large fish that comprise the entrainment total. The ability of healthy adult fish to avoid the intakes likely reduces the number of large fish entrained, thereby increasing survival estimates.

Swim speeds are partially dependent upon water temperatures, with fish attaining higher sustained, prolonged, and burst speeds in warmer water temperatures, and slower swim speeds in cooler water temperatures (Peake et al. 1997). Thus, target species may be less susceptible to entrainment during the warmer months when they can maintain sustained and prolonged speeds for longer time intervals, while also attaining increased burst speeds. While a reduction in trash rack spacing would reduce entrainment potential for size classes that have body widths larger than 2.5 inches, adults of all target species would be able to utilize burst swim speed modes to outswim entrainment velocities in instances where they encounter the Project under current conditions. Thus, a reduction in trash rack spacing may not appreciably reduce the number of adult muskellunge, redhorse, lake sturgeon, and walleye that are entrained, as these individuals can already avoid entrainment.

The adult target fish species can outswim intake velocities. However, there is a potential for individuals to volitionally enter the intake area. All four target species are spring spawners, and are more likely to move upstream and downstream to find suitable spawning habitat during this timeframe. Walleye move throughout river systems to find suitable spawning habitat in the spring, and subsequently move to feeding areas elsewhere in river systems after spawning is complete (Rasmussen et al. 2002). Lake sturgeon exhibit similar life history characteristics, as individuals at northern latitudes move upstream during periods of high flow. The post-spawn period for lake sturgeon can involve subsequent large-scale downstream movements (Rusak and Mosindy 1997). During this timeframe lake sturgeon in the Chippewa River may be more likely to continue downstream movements and attempt to move into reaches below the Project. Similarly, redhorse species that may remain in a reach throughout the year generally make upstream movements prior to the Spring spawn (Parker 1987) and may encounter the Project during post-spawn downstream movements.

Muskellunge differ from the other three target species in that, while they spawn during the spring, their spawning habits do not always involve large scale latitudinal movement, but rather a shift to shallower littoral habitat. Although muskellunge may be less inclined to make large scale movements during the Spring, they do move most during the pre-spawn period, and also move throughout the year to follow prey. These movements can include the following of walleye and redhorse species that make larger scale spawning (upstream) and post-spawn (downstream) runs (Beck and Brooks 2000). Like the other target species, muskellunge may be more likely to encounter the Project during the post-spawn period when prey species are making large scale downstream movements. While individuals may encounter project intakes during periods of downstream movements, these post-spawn timeframes are generally characterized by high flows, and some fish moving downstream may pass via open spillway gates.

While a reduction in trash rack spacing would potentially reduce the number of adult fish entrained annually, it would not affect entrainment rates of juvenile and some intermediate lifestages whichwould still be capable of passing through the smaller 2.5-inch spacing. Intermediate lifestages that would be excluded by 2.5-inch spacing tended to have survival rates greater than 50%. Thus, a reduction in trash rack spacing would not likely reduce mortality for size classes that already experience low turbine related mortality. It is also unlikely that a reduction in trash rack spacing would have a population level effect on any of the target species, as a majority of fish that would be excluded by smaller trash racks are likely excluded now by swim speed, and larger adults volitionally entering the intakes would not be expected to make up a large percentage of the total population under current conditions.

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APPENDIX E-23 2020 Mussel Study Report

FRESHWATER MUSSEL SURVEY ON THE CHIPPEWA RIVER FOR THE CORNELL HYDRO FERC RELICENSING

Chippewa County, Wisconsin

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Freshwater Mussel Survey on the Chippewa River for the Cornell Hydro FERC Relicensing

Draft Report

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Authorization for Release

The analyses, opinions, and conclusions in this document are based entirely on EnviroScience's unbiased, professional judgment. EnviroScience's compensation is not in any way contingent on any action or event resulting from this study.

To the best of their knowledge, the undersigned attest that this document and the information contained herein are accurate and conform to EnviroScience's internal Quality Assurance standards.

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1.0 INTRODUCTION

EnviroScience, Inc., on behalf of Xcel Energy, performed a freshwater mussel survey in the Chippewa River, Chippewa County, Wisconsin. The survey was requested by the Wisconsin Department of Natural Resources (WDNR) and the River Alliance of Wisconsin (RAW) as part of the federal relicensing process for the Cornell Hydroelectric Project (Project). The Project is owned and operated by Northern States Power Company – Wisconsin (NSPW), d/b/a Xcel Energy, and operates under license issued by the Federal Energy Regulatory Commission (FERC). The Project is designated as FERC Project #2639 with the current license due to expire in 2024. The purpose of the survey was to determine the presence or absence of freshwater mussel resources upstream and downstream of the Cornel Dam. Information collected from this survey provides information on native freshwater mussel distribution and habitat upstream and downstream of the dam.

Background

The Chippewa River is known to support a diverse mussel fauna. Historical records of mussels in the Chippewa River include 33 species, several of which are federally and/or state listed (Table 1). Recent studies have been performed elsewhere in the Chippewa River; however, survey data for Chippewa County is lacking and outdated (1990's). A desktop review revealed 16 species previously recorded in the Chippewa River in Chippewa County, including the state endangered Purple Wartyback (*Cyclonaias tuberculata*). A 2019 mussel survey conducted along the east shoreline immediately below the dam documented four species (EnviroScience, pers. comm., 2019). Species observed in that survey included: Spike (*Eurynia dilatata*), Plain Pocketbook (*Lampsilis cardium*), Fatmucket (*Lampsilis siliquoidea*), and Black Sandshell (*Ligumia recta*). No other recent survey information is known for this stretch of the Chippewa River.

WDNR and RAW requested the 2020 survey to provide information on mussel species present, their diversity, their density, and provide a better understanding of baseline conditions at the Project. The FERC Project boundary for Cornell Hydro includes the Chippewa River from just below the Cornell Dam upstream approximately 5.5 miles to the Holcombe Dam. EnviroScience coordinated the mussel survey with WDNR and proposed two target survey areas. Based on the conditions and proximity to the Cornell Dam, two reaches, one upstream of the dam and one downstream of the dam, were pre-selected for evaluation (Figure 1). Information from this study will aid WDNR and RAW in their understanding of the baseline conditions of the mussel community within the Project area.

2.0 METHODS

The 2015 WDNR Guidelines for Sampling Freshwater Mussels in Wadable Streams (Guidelines; Piette, 2015), and other standard survey methodologies routinely used by EnviroScience, were used to develop the mussel survey protocol. A draft survey plan was submitted to and approved by the WDNR on April 2 and April 13, 2020, respectively. The survey plan, agency approval, and applicable scientific collection permit are provided in Appendix A.

EnviroScience proposed one 1,000 meter (m) long reach for evaluation in both the upstream and downstream portions of the Chippewa River not influenced by the Project impoundment or tailraces. Reach 1 is approximately 3.5 miles upstream of the dam and within the FERC Project Boundary (Figure 1). Reach 2 began downstream outside the zone of influence of the dam tailrace and extended 1,000m downstream. Each stretch was selected based upon suitable mussel habitat as determined by field staff.

The survey consisted of a series of transects within Reach 1 and Reach 2. The amount of transect needed for the survey was based on the detectability of rare species within each reach. It was pre-determined that completing 900m of transects within each reach, with an assumed search rate efficiency of 20%, would result in an 83.4% probability of detecting rare or threatened species, if present (Smith, 2006). Where feasible, transect placement was pre-determined at 100m intervals in each reach, creating a series of 11 possible transects per reach. A random number generator was used to select transects for the survey. Transect placement was determined in the field at the malacologist's discretion or at pre-determined locations, as described above (Figure 2a and Figure 2b).

Surveying along each transect was completed in 10m segments, with surveying extending 0.5m on each side of the transect. A rapid visual search for signs of freshwater mussels (living or shell material) was performed within the segment. The rapid visual search entailed an initial search rate of 0.2 minutes per m^2 (min/m^2) along each 10m segment to determine if mussels were present. If mussels were present in a segment, additional time was spent for a total search rate of $1 min/m^2$. Divers visually searched and probed the substrate and turned over rocks to detect small or burrowed mussels.

Data and Mussel Handling

Live mussels found were kept submersed in ambient river water and kept cool and moist during processing. All live mussels were identified to species, counted, and sexed (sexually dimorphic species only) by the team malacologist. Dead shell specimens were scored as fresh dead (dead <1 year, lustrous nacre), weathered dead (dead one to many years; chalky nacre, fragmented, and worn periostracum), or subfossil (dead many years to many decades; severely worn and fragmented). Detailed digital images of the study area and representative mussel species were recorded. A station location data sheet was also populated per the study guidelines. Data was recorded to distinguish between timed searches, generate a species richness curve, and to determine a surface density estimate. General stream conditions and morphology within the study area were also recorded. River bottom substrate composition using the Wentworth Scale (% observed of silt, sand, gravel, etc.) was recorded for each transect segment. Mussel taxonomy followed the names presented by Williams et al., 2017.

3.0 RESULTS

Ms. Becca Winterringer was the field team leader and WDNR permit holder. The survey was conducted on September 24 and 25, 2020. All survey work was conducted within the air and temperature limits prescribed in the guidelines. A photographic record of the survey reaches and observed mussel species is provided in Appendix B. Raw data sheets and field forms are provided in Appendix C.

Due to access restrictions at the rapids near the confluence of French Creek and the Chippewa River (Figure 1) from low river flow conditions, Reach 2 was moved downstream. The Reach 2 survey area was also inaccessible from upstream due to low flow conditions at the time of fieldwork. Based on a cursory review of the area near the French Creek confluence by the field malacologist, the modified Reach 2 survey area was deemed suitable for evaluation. This area is within and above the FERC project boundary for the Jim Falls Hydroelectric Project, the next regulated dam downstream. However, this portion of the impoundment (Old Abe Flowage) is riverine and flowing. Live mussels and shell material along island margins were present, and habitat was conducive to mussel colonization. Transect placement in Reach 2 was at the discretion of the malacologist based on substrate, water depth, and spacing within the modified Reach 2 area. The modified Reach 2 survey area was approved by the WDNR prior to initiating the survey. A summary of the effort performed during the survey is provided in Table 2.

Reach 1 was primarily uniform in depth and substrate from bank to bank throughout the entire reach. The maximum depth recorded was 15 feet with typical depths between seven and 13 feet along the transects (Figure 3a). Reach 1 was primarily a pool with some observable flow. Boulder, cobble, gravel, and sand were the predominant substrate components of each segment with less coarse substrates (silt and sand) at the river margins (0-20m from the banks) (Figure 3a). Reach 2 had a maximum depth of seven feet with typical depths between three and five feet (Figure 3b). Reach 2 was a fast run over a coarse substrate of boulder, cobble, and gravel (Figure 3b). Flow refugia were common around the island margins. Water depth and substrate characteristics per transect segment within Reach 1 and Reach 2 are provided in Table 3.

Overall, 179 live mussels representing 12 species were collected during the study (Table 4). Species composition, abundance, and surface density differed between Reach 1 and Reach 2. While a greater number of live mussels were observed in Reach 1, more species were collected from Reach 2. A total of 121 live mussels were observed in Reach 1 and 58 in Reach 2, despite a similar amount of effort in each reach. Surface densities for Reach 1 and 2 were 0.13/m^2 and 0.06/m^2, respectively. The two dominant species in Reach 1 were the Spike (38.8%) and Fatmucket (19.8%), whereas the dominant species in Reach 2 were the Black Sandshell (31%) and Plain Pocketbook (24.1%). Also observed in Reach 2 was the state endangered Purple Wartyback (n=1). Mussels were more commonly encountered along the river margins between 0 and 30m from the banks in Reach 1 (Figure 4a). There is some evidence that mussels are more evenly distributed in the left descending bank and downstream portion of Reach 2, which is most likely a reflection of low flow and suitable substrate features. Transects 1 and 2 in Reach 2 were in areas of generally higher flow with a greater percentage of large substrate characteristics (e.g.: boulder and cobble).

Cumulative species richness curves were generated for both reaches as well as the survey overall (Table 4). Rarefaction species richness analysis of Reach 1 samples resulted in another 104 mussels that would need to have been collected to observe a ninth species. Another 44 individuals would need to have been collected to observe an eleventh species in Reach 2. All data combined indicated that another 486 live mussels would need to have been collected to observe a 13th species. The rarefaction species richness results from the overall survey provides evidence that most of the species present in this portion of the Chippewa River were collected without a significant effort. Species richness curves are provided in Figure 5.

4.0 CONCLUSIONS

A total of 121 mussels representing eight species were observed in Reach 1 and 58 individuals of 10 species were observed in Reach 2. The state endangered Purple Wartyback was collected in Reach 2; no state listed species were observed in Reach 1. The results from this survey confirm that freshwater mussels are present within the proposed Project area.

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Table 1. Mussels known to occur in the Chippewa River watershed in Wisconsin.

Species[1]		Status[2]	Year Observed[3]		
			Chippewa County	Upriver	Downriver
Mucket	*Actinonaias ligamentina*		1997	2017	2016
Elktoe	*Alasmidonta marginata*	SC	-	2017	2016
Threeridge	*Amblema plicata*		1989	2017	1989
Spectacle Case	*Cumberlandia monodonta*	FE, SE	1989	-	-
Purple Wartyback	*Cyclonaias tuberculata*	SE	1997	2017	-
Butterfly	*Ellipsaria lineolata*	SE	-	-	2016
Spike	*Eurynia dilatata*		1994	2017	1987
Wabash Pigtoe	*Fusconaia flava*		1989	2017	2016
Plain Pocketbook	*Lampsilis cardium*		1997	2017	2016
Higgins' Eye	*Lampsilis higginsii*	FE, SE	-	-	2018
Fatmucket	*Lampsilis siliquoidea*		1997	2017	2016
Creek Heelsplitter	*Lasmigona compressa*		-	2006	-
Fluted-shell	*Lasmigona costata*		1994	2017	2016
Fragile Papershell	*Leptodea fragilis*		-	2012	2016
Black Sandshell	*Ligumia recta*		1997	2017	2016
Threehorn Wartyback	*Obliquaria reflexa*		-	2006	2016
Hickorynut	*Obovaria olivaria*		1994	2017	2016
Bullhead	*Plethobasus cyphyus*	FE, SE	-	2017	2016
Round Pigtoe	*Pleurobema sintoxia*		1997	2017	1996
Pink Heelsplitter	*Potamilus alatus*		-	2012	2016
Pink Papershell	*Potamilus ohiensis*		-	-	1989
Giant Floater	*Pyganodon grandis*		1994	1997	1998
Winged Mapleleaf	*Quadrula fragosa*	FE, SE	-	-	2018
Monkeyface	*Theliderma metanevra*	ST	-	-	1989
Wartyback	*Cyclonaias nodulata*	ST	-	-	1888
Pimpleback	*Cyclonaias pustulosa*		1997	2017	2016
Salamander Mussel	*Simpsonaias ambigua*	ST	-	-	1998
Creeper	*Strophitus undulatus*		1994	2017	2016
Lilliput	*Toxolasma parvus*		-	-	1989
Buckhorn	*Tritogonia verrucosa*	ST	-	-	2016
Fawnsfoot	*Truncilla donaciformis*	ST	-	-	1996
Deertoe	*Truncilla truncata*		-	2012	2016
Paper Pondshell	*Utterbackia imbecillis*		1994	-	2016
Total	33		16	21	30

[1] WIDNR (2018); nomenclature follows Williams et al. (2017)

[2] WIDNR (2015); WIDNR (2016)

[3] Species observations from WIDNR (2018). Project study area ia located in Chippewa County. Upriver observations are from Rusk and Sawyer Counties and downriver observations are compiled from Eau Claire, Dunn and Pepin Counties.

Table 2. Summary of effort performed in Reach 1 and Reach 2.

Site	Transect ID	Number of Samples	Sample Unit	Total Area (m^2)
Reach 1	T1	18	$10m^2$	180
	T2	18	$10m^2$	180
	T3	18	$10m^2$	180
	T4	18	$10m^2$	180
	T5	18	$10m^2$	180
Subtotal				*900*
Reach 2	T1	18	$10m^2$	180
	T2	9	$10m^2$	90
	T3	4	$10m^2$	40
	T4	5	$10m^2$	50
	T5	10	$10m^2$	100
	T6	9	$10m^2$	90
	T7	19	$10m^2$	190
	T8	20	$10m^2$	200
Subtotal				*940*

Table 3. Substrate and water depth per segment within Reach 1 and Reach 2.

Reach/Transect	Segment	Depth (ft)	Substrate Chacteristic (%)						
			Bedrock	Boulder	Cobble	Gravel	Sand	Silt	LWD
Reach 1									
T1									
	0	8	0	0	0	0	20	80	0
	10	10	0	0	0	0	90	10	0
	20	10	0	0	0	0	90	10	0
	30	10	0	0	20	40	40	0	0
	40	7	0	10	30	30	30	0	0
	50	7	0	10	30	30	30	0	0
	60	7	0	10	30	40	20	0	0
	70	8	0	10	30	30	30	0	0
	80	9	0	20	20	40	20	0	0
	90	10	0	40	30	20	10	0	0
	100	10	0	50	30	10	10	0	0
	110	12	0	50	30	10	10	0	0
	120	15	0	10	40	20	30	0	0
	130	14	0	10	40	30	20	0	0
	140	12	0	40	20	20	20	0	0
	150	8	0	50	10	20	20	0	0
	160	7	0	40	20	20	20	0	0
	170	4	0	30	20	20	30	0	0
	180	3	0	0	0	0	90	10	0
T2									
	0	3	0	0	0	0	90	10	0
	10	8	0	20	20	20	30	10	0
	20	12	0	20	20	30	30	0	0
	30	13	0	20	20	30	30	0	0
	40	13	0	20	20	30	30	0	0
	50	12	0	20	30	30	20	0	0
	60	12	0	30	30	20	20	0	0
	70	10	0	40	40	10	10	0	0
	80	10	0	40	30	20	10	0	0
	90	9	0	30	30	30	10	0	0
	100	10	0	10	40	40	10	0	0
	110	8	0	20	30	30	20	0	0
	120	8	0	10	40	30	20	0	0
	130	8	0	0	30	40	30	0	0
	140	8	0	0	20	40	40	0	0
	150	9	0	0	20	50	30	0	0
	160	7	0	0	20	50	30	0	0
	170	7	0	0	20	50	30	0	0
	180	7	0	0	0	0	20	80	0
T3									
	0	8	0	0	40	40	20	0	0
	10	9	0	0	20	40	40	0	0
	20	8	0	0	30	40	30	0	0

Table 3. Substrate and water depth per segment within Reach 1 and Reach 2.

			Substrate Chacteristic (%)						
Reach/Transect	Segment	Depth (ft)	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	LWD
Reach 1 - T3	30	9	0	0	20	40	40	0	0
Cont'd	40	8	0	20	40	20	20	0	0
	50	8	0	20	30	30	20	0	0
	60	9	0	10	30	30	30	0	0
	70	10	0	10	30	30	30	0	0
	80	11	0	20	30	20	30	0	0
	90	12	0	20	20	30	30	0	0
	100	11	0	30	30	20	20	0	0
	110	11	0	10	20	40	20	0	10
	120	12	0	20	50	30	0	0	0
	130	13	0	0	40	40	20	0	0
	140	10	0	20	10	40	30	0	0
	150	12	0	20	10	40	30	0	0
	160	8	0	10	40	40	10	0	0
	170	4	0	0	30	40	30	0	0
	180	2	0	0	30	40	30	0	0
T4	0	3	0	10	80	0	0	10	0
	20	9	0	20	20	30	30	0	0
	30	10	0	10	30	30	30	0	0
	40	11	0	10	30	30	30	0	0
	50	12	0	10	30	30	30	0	0
	60	12	0	40	20	20	20	0	0
	70	10	0	50	30	10	10	0	0
	80	11	0	10	30	30	30	0	0
	90	10	0	20	30	30	20	0	0
	10	3	0	10	80	0	0	10	0
	100	10	0	20	40	20	20	0	0
	110	10	0	40	30	10	20	0	0
	120	10	0	20	20	20	40	0	0
	130	10	0	0	20	50	30	0	0
	140	13	0	10	30	30	30	0	0
	150	11	0	0	40	30	30	0	0
	160	10	0	0	40	30	30	0	0
	170	8	0	0	10	10	80	0	0
	180	3	0	5	0	0	95	0	0
T5	0	4	0	10	70	10	10	0	0
	10	7	0	0	10	0	90	0	0
	20	7	0	10	40	30	20	0	0
	30	10	0	20	30	30	20	0	0
	40	10	0	20	30	30	20	0	0
	50	13	0	20	30	20	30	0	0
	60	13	0	10	40	30	20	0	0
	70	10	0	20	30	30	20	0	0

Table 3. Substrate and water depth per segment within Reach 1 and Reach 2.

Reach/Transect	Segment	Depth (ft)	Substrate Chacteristic (%)						
			Bedrock	Boulder	Cobble	Gravel	Sand	Silt	LWD
Reach 1 - T5	80	10	0	30	30	20	20	0	0
Cont'd	90	10	0	40	30	20	10	0	0
	100	12	0	40	30	20	10	0	0
	110	11	0	30	30	20	20	0	0
	120	11	0	0	30	50	20	0	0
	130	8	0	30	20	30	20	0	0
	140	10	0	20	30	30	20	0	0
	150	10	0	10	30	30	30	0	0
	160	8	0	0	30	40	30	0	0
	170	3	0	0	30	40	30	0	0
	180	3	0	0	30	40	30	0	0
Reach 2									
T1	0	2	0	0	0	90	0	10	0
	10	4	0	0	20	40	40	0	0
	20	4	0	10	0	40	50	0	0
	30	4	0	10	10	40	40	0	0
	40	5	0	20	20	30	30	0	0
	50	5	0	10	20	40	30	0	0
	60	5	0	10	20	40	30	0	0
	70	5	0	10	30	30	30	0	0
	80	5	0	30	20	30	20	0	0
	90	5	0	30	20	30	20	0	0
	100	5	0	50	20	20	10	0	0
	110	5	0	40	20	20	20	0	0
	120	5	0	0	30	30	40	0	0
	130	4	0	10	20	30	40	0	0
	140	5	0	10	30	30	30	0	0
	150	3	0	70	10	10	10	0	0
	160	3	0	80	10	0	0	10	0
	170	2	0	70	10	0	0	20	0
	180	2	0	70	10	0	0	20	0
T2	0	2	0	60	30	0	0	10	0
	10	3	0	70	30	0	0	0	0
	20	5	0	20	30	30	20	0	0
	30	5	0	25	25	25	25	0	0
	40	5	0	25	25	25	25	0	0
	50	7	0	25	25	25	25	0	0
	60	6	0	10	30	30	30	0	0
	70	5	0	10	30	30	30	0	0
	80	3	0	0	40	40	20	0	0
	90	3	0	0	20	40	40	0	0

Table 3. Substrate and water depth per segment within Reach 1 and Reach 2.

Reach/Transect	Segment	Depth (ft)	Substrate Chacteristic (%)						
			Bedrock	Boulder	Cobble	Gravel	Sand	Silt	LWD
Reach 2 - T3	0	2	0	0	80	0	10	10	0
	10	2	0	0	80	0	20	0	0
	20	3	0	50	50	0	0	0	0
	30	3	0	50	50	0	0	0	0
	35	3	0	50	50	0	0	0	0
T4	0	3	20	70	0	0	10	0	0
	10	5	20	70	0	0	10	0	0
	20	5	10	50	0	0	40	0	0
	30	5	10	40	10	25	15	0	0
	40	5	10	40	10	0	40	0	0
	50	3	0	25	50	0	25	0	0
T5	0	2	0	0	0	20	80	0	0
	10	3	0	0	0	40	60	0	0
	20	3	0	0	0	50	50	0	0
	30	3	0	0	10	50	40	0	0
	40	3	0	0	10	50	40	0	0
	50	3	0	0	10	50	40	0	0
	60	3	0	0	10	50	40	0	0
	70	3	0	25	25	25	25	0	0
	80	3	0	10	10	40	40	0	0
	90	3	0	25	25	25	25	0	0
	100	1	0	50	40	0	10	0	0
T6	0	2	0	0	0	0	100	0	0
	10	3	0	0	0	0	100	0	0
	20	3	0	0	10	45	45	0	0
	30	3	0	10	25	25	40	0	0
	40	3	0	10	25	25	40	0	0
	50	3	0	10	25	25	40	0	0
	60	3	0	80	10	5	5	0	0
	70	3	0	80	10	10	0	0	0
	80	3	0	10	10	40	20	0	0
T7	0	2	0	100	0	0	0	0	0
	10	3	0	75	25	0	0	0	0
	20	3	0	60	40	0	0	0	0
	30	3	0	10	40	40	10	0	0
	40	3	0	0	30	35	35	0	0
	50	3	0	0	30	35	35	0	0
	60	3	0	0	30	35	35	0	0
	70	3	0	0	30	35	35	0	0
	80	2	0	0	0	80	20	0	0
	90	1	0	0	0	50	60	0	0

Table 3. Substrate and water depth per segment within Reach 1 and Reach 2.

			Substrate Chacteristic (%)						
Reach/Transect	Segment	Depth (ft)	Bedrock	Boulder	Cobble	Gravel	Sand	Silt	LWD
Reach 2 - T7	100	1	0	0	0	50	50	0	0
Cont'd	110	1.5	0	0	0	50	50	0	0
	120	2	0	0	25	25	50	0	0
	130	4	0	10	40	40	10	0	0
	140	4	0	10	40	40	10	0	0
	150	4	0	10	30	40	20	0	0
	160	3	0	10	30	40	20	0	0
	170	4	0	20	20	40	20	0	0
	180	2	0	0	0	10	80	10	0
	190	2	0	0	75	10	15	0	0
T8	0	3	0	50	50	0	0	0	0
	10	3	0	50	20	15	15	0	0
	20	3	0	50	20	15	15	0	0
	30	3	0	50	20	15	15	0	0
	40	3	0	50	20	15	15	0	0
	50	3	0	25	50	10	15	0	0
	60	3	0	25	50	10	15	0	0
	70	3	0	25	50	10	15	0	0
	80	3	0	25	50	10	15	0	0
	90	3	0	25	50	10	15	0	0
	100	3	0	25	50	10	15	0	0
	110	3	0	25	50	10	15	0	0
	120	3	0	25	50	10	15	0	0
	130	4	0	25	50	10	15	0	0
	140	4	0	25	50	10	15	0	0
	150	4	0	25	50	10	15	0	0
	160	5	0	25	50	10	15	0	0
	170	5	0	25	50	10	15	0	0
	180	6	0	25	50	10	15	0	0
	190	3	0	25	50	10	15	0	0
	200	1	0	0	10	40	40	10	0

Table 4. Mussels observed in Reach 1 and Reach 2.

	Reach 1							Reach 2											
Species	T1	T2	T3	T4	T5	Total	%	T1	T2	T3	T4	T5	T6	T7	T8	Total	%	Total	Rel. Ab.
Mucket	-	1	-	-	1	2	1.7	-	-	-	-	-	-	-	-	0	0.0	2	1.1
Pimpleback	8	3	6	4	-	21	17.4	1	-	-	1	-	-	3	2	7	12.1	28	15.6
Purple Wartyback	**-**	**-**	**-**	**-**	**-**	**0**	**0.0**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**2**	**4**	**6.9**	**4**	**2.2**
Spike	10	13	6	13	5	47	38.8	-	-	1	-	2	-	-	-	3	5.2	50	27.9
Wabash Pigtoe	-	-	1	-	-	1	0.8	-	-	-	-	-	-	2	-	2	3.4	3	1.7
Plain Pocketbook	2	2	3	5	2	14	11.6	2	-	-	-	5	-	2	5	14	24.1	28	15.6
Fatmucket	6	10	5	2	1	24	19.8	1	-	-	-	-	1	1	1	4	6.9	28	15.6
Fluted-shell	-	-	-	-	-	0	0.0	-	-	-	-	-	-	-	1	1	1.7	1	0.6
Black Sandshell	5	3	1	1	1	11	9.1	-	1	-	1	3	1	7	5	18	31.0	29	16.2
Hickorynut	-	-	-	-	-	0	0.0	1	-	-	-	1	-	1	1	4	6.9	4	2.2
Giant Floater	1	-	-	-	-	1	0.8	-	-	-	-	-	-	-	-	0	0.0	1	0.6
Paper Pondshell	-	-	-	-	-	0	0.0	-	-	-	-	-	-	-	1	1	1.7	1	0.6
Abundance	32	32	22	25	10	121		5	1	1	2	11	3	17	18	58		179	
Species (Live)	6	6	6	5	5	8		4	1	1	2	4	3	7	8	10		12	
Effort (m^2)	180	180	180	180	180	900		180	90	40	50	100	90	190	200	940			
Surface Density (no./m^2)	0.18	0.18	0.12	0.14	0.06	0.13		0.03	0.01	0.03	0.04	0.11	0.03	0.09	0.09	0.06			
Rarefaction Species Richness																			
			$y = 1.4383\ln(x) + 1.2125$								$y = 2.6311\ln(x) - 1.1632$							$y = 1.547\ln(x) + 2.9405$	
No. Ind. Additional Species			*104*							*44*								*486*	
50			7							9								9	
100			8							11								10	
200			9							13								11	
300			9							14								12	
400			10							15								12	
600			10							16								13	

Bold type indicate state listed species.

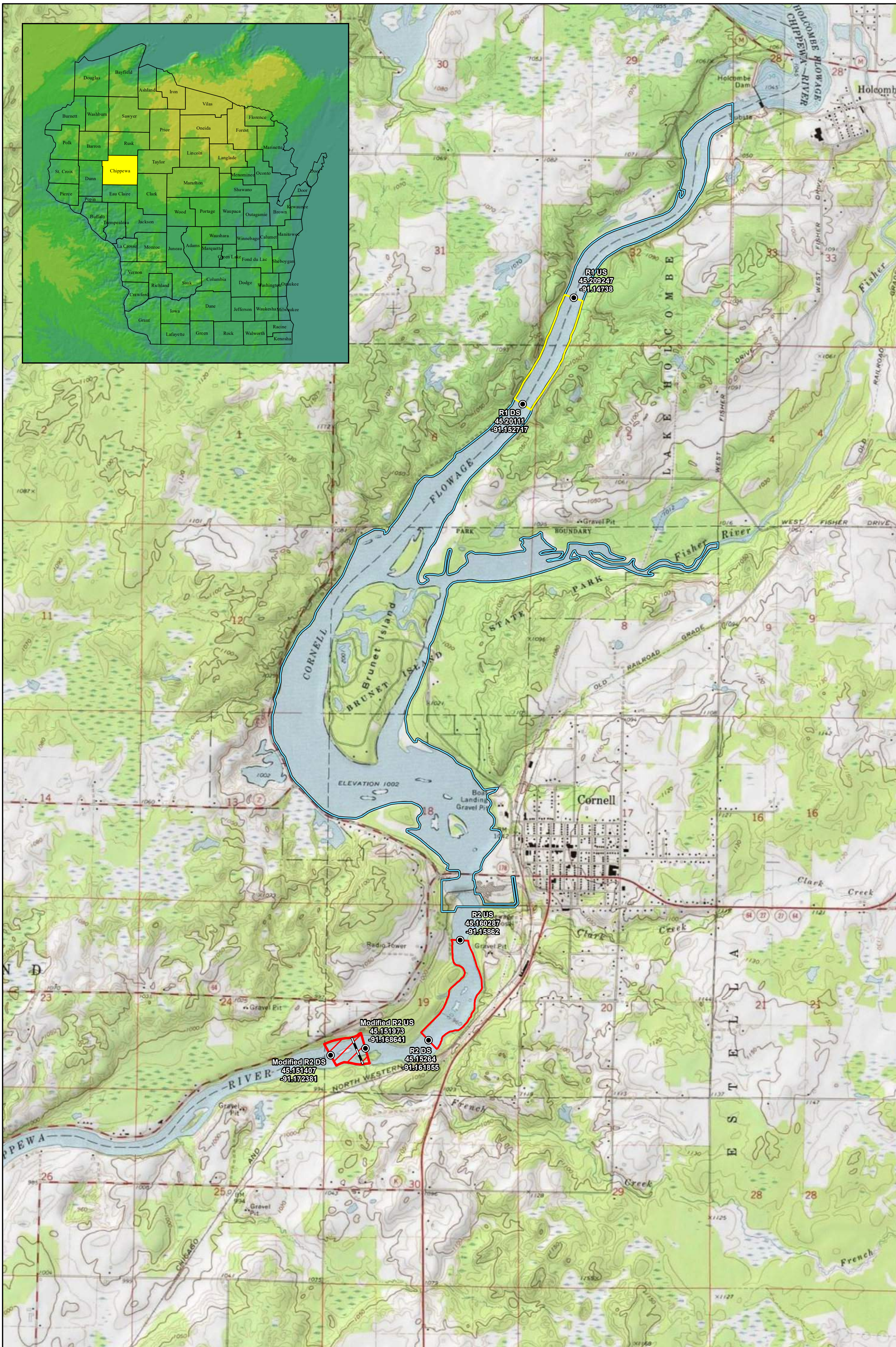

Figure 1. Location of Site, Proposed FERC Project Boundary, and Survey Reaches 1 and 2 Chippewa County, Wisconsin.

- Survey Reach Endpoint
- Jim Falls Upper Limit Boundary
- Cornell Hydroelectric Project Boundary
- Survey Reach 1
- Survey Reach 2
- Modified Survey Reach 2

0 1,500 3,000 6,000 Feet

0 500 1,000 2,000 Meters

EnviroScience
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Path: C:\Users\Anna Giordano\Desktop\GIS_13335\Map1_Location.mxd

Date: 11/3/2020

Basemap courtesy of National Geographic Society (2013).

Figure 2a.
Transect Survey Locations
for the Upstream Survey Reach.
Chippewa County, Wisconsin.

Transect
Survey Reach

0 75 150 300 Feet
0 25 50 100 Meters

EnviroScience
Excellence In Any Environment

Date: 11/2/2020 Path: C:\Users\Anna Giordano\Desktop\GIS_13335\Map2a_Survey.mxd

Basemap courtesy of Esri.

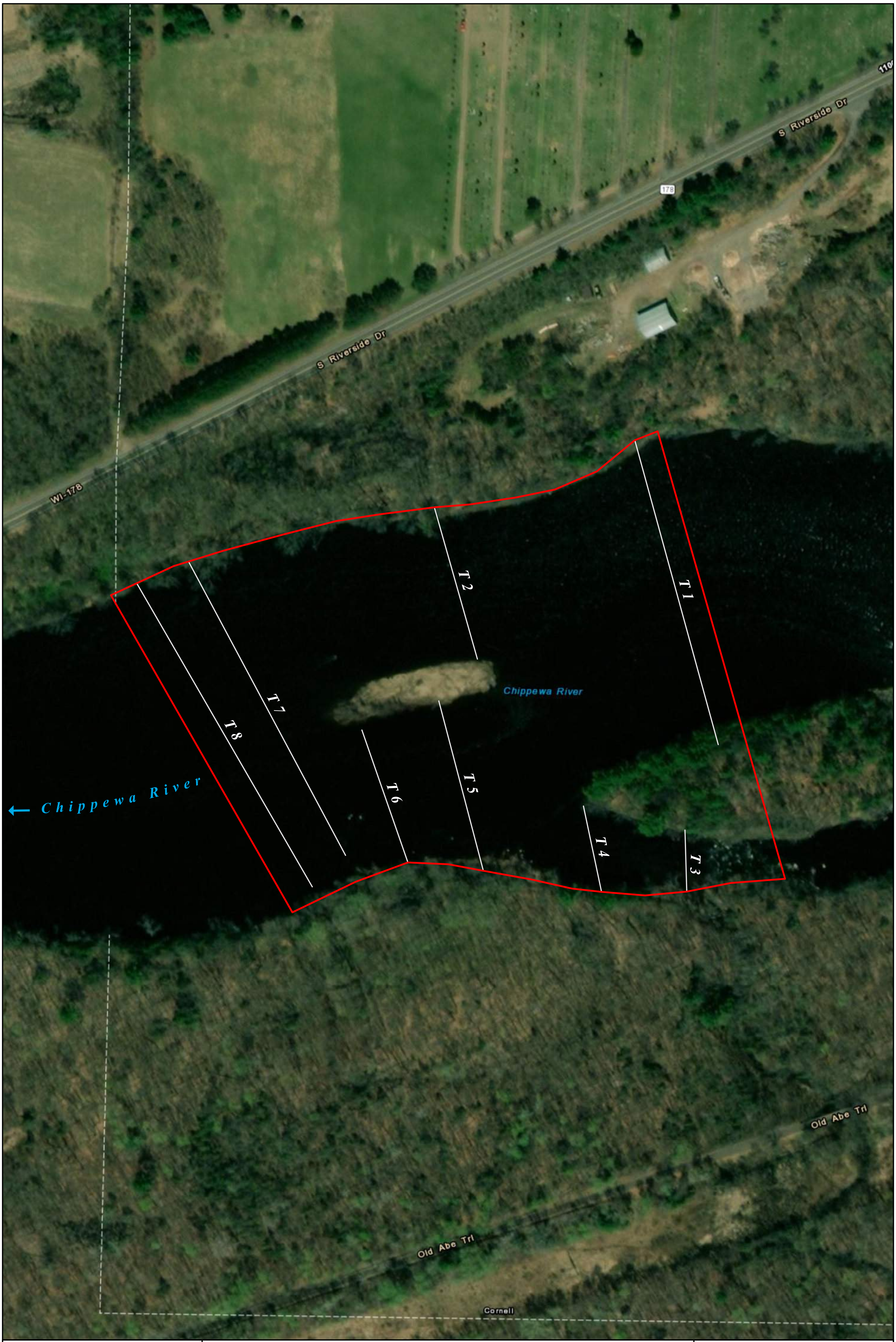

Figure 2b.
Transect Survey Locations
for the Downstream Survey Reach.
Chippewa County, Wisconsin.

Transect
Survey Reach

0 50 100 200 Feet
0 15 30 60 Meters

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Path: C:\Users\Anna Giordano\Desktop\GIS_13335\Map2b_Survey.mxd

Date: 11/2/2020

Basemap courtesy of Esri.

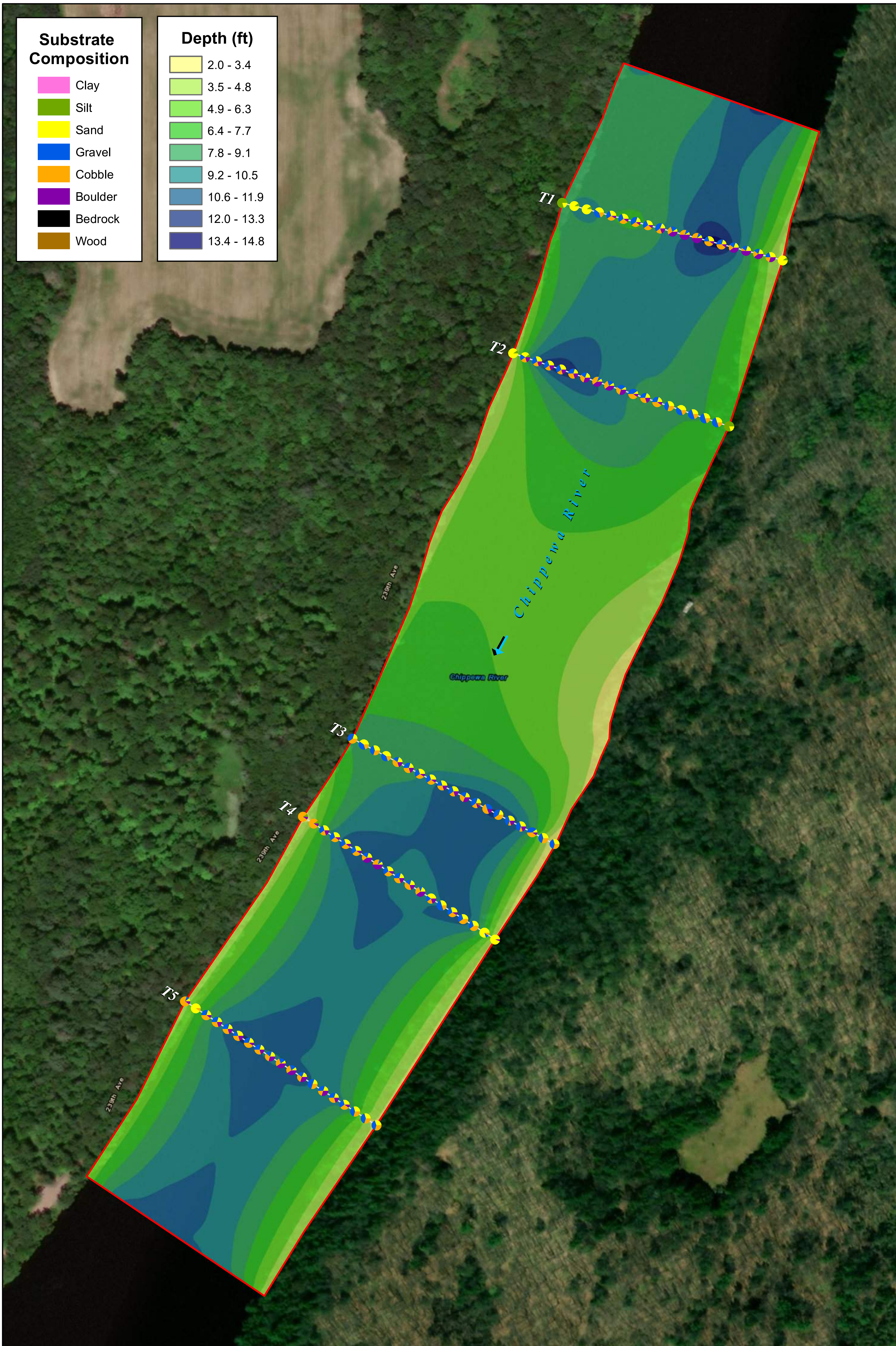

Figure 3a.
Substrate and Depth
Along Upstream Transects.
Chippewa County, Wisconsin.

Transect
Survey Reach

0 75 150 300 Feet
0 25 50 100 Meters

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Date: 11/3/2020 Path: C:\Users\Anna Giordano\Desktop\GIS_13335\Map3a_Substrate.mxd

Basemap courtesy of Esri.

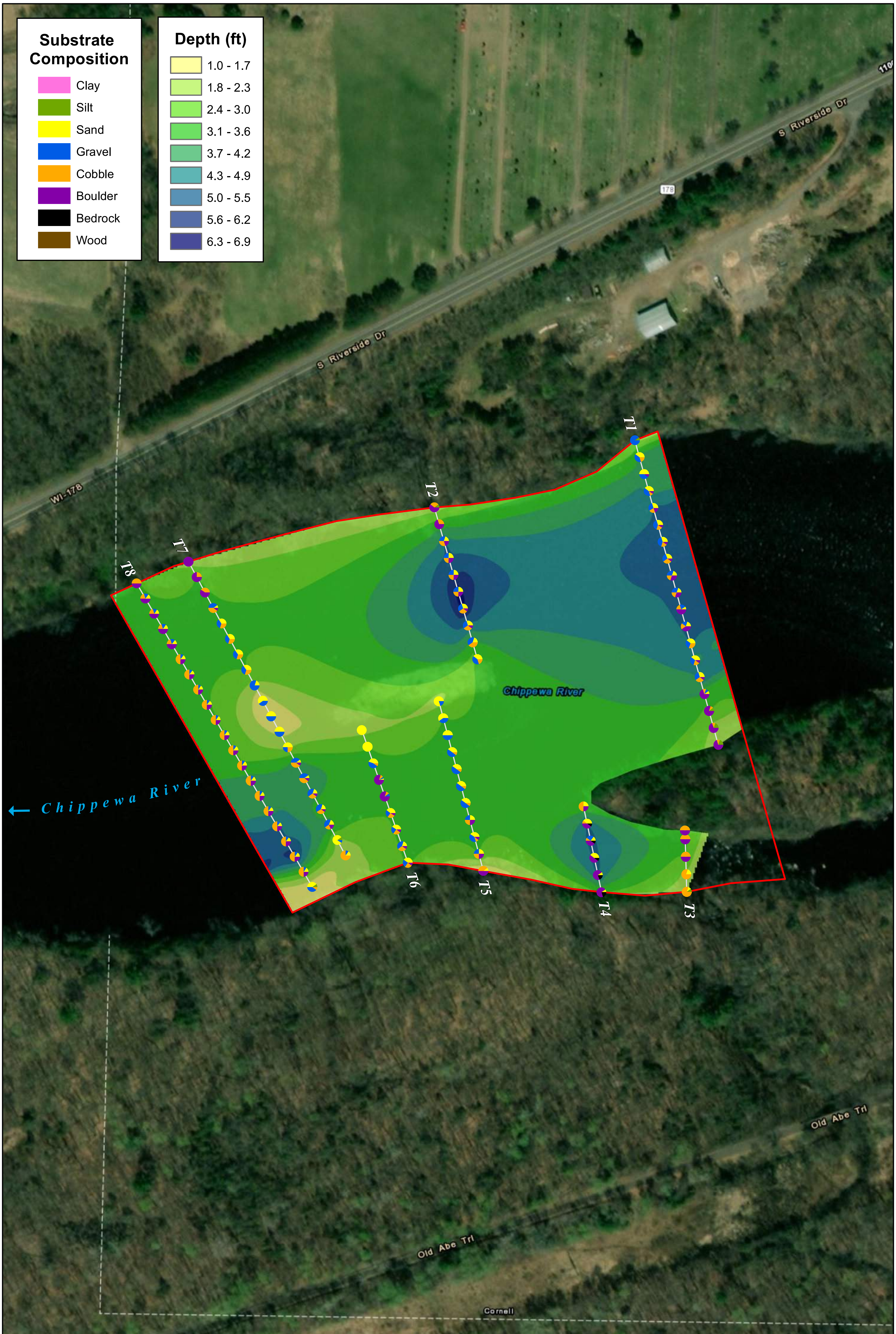

Figure 3b.
Substrate and Depth
Along Downstream Transects.
Chippewa County, Wisconsin.

Transect
Survey Reach

0 50 100 200 Feet
0 15 30 60 Meters

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Path: C:\Users\Anna Giordano\Desktop\GIS_13335\Map3b_Substrate.mxd

Date: 11/3/2020

Basemap courtesy of Esri.

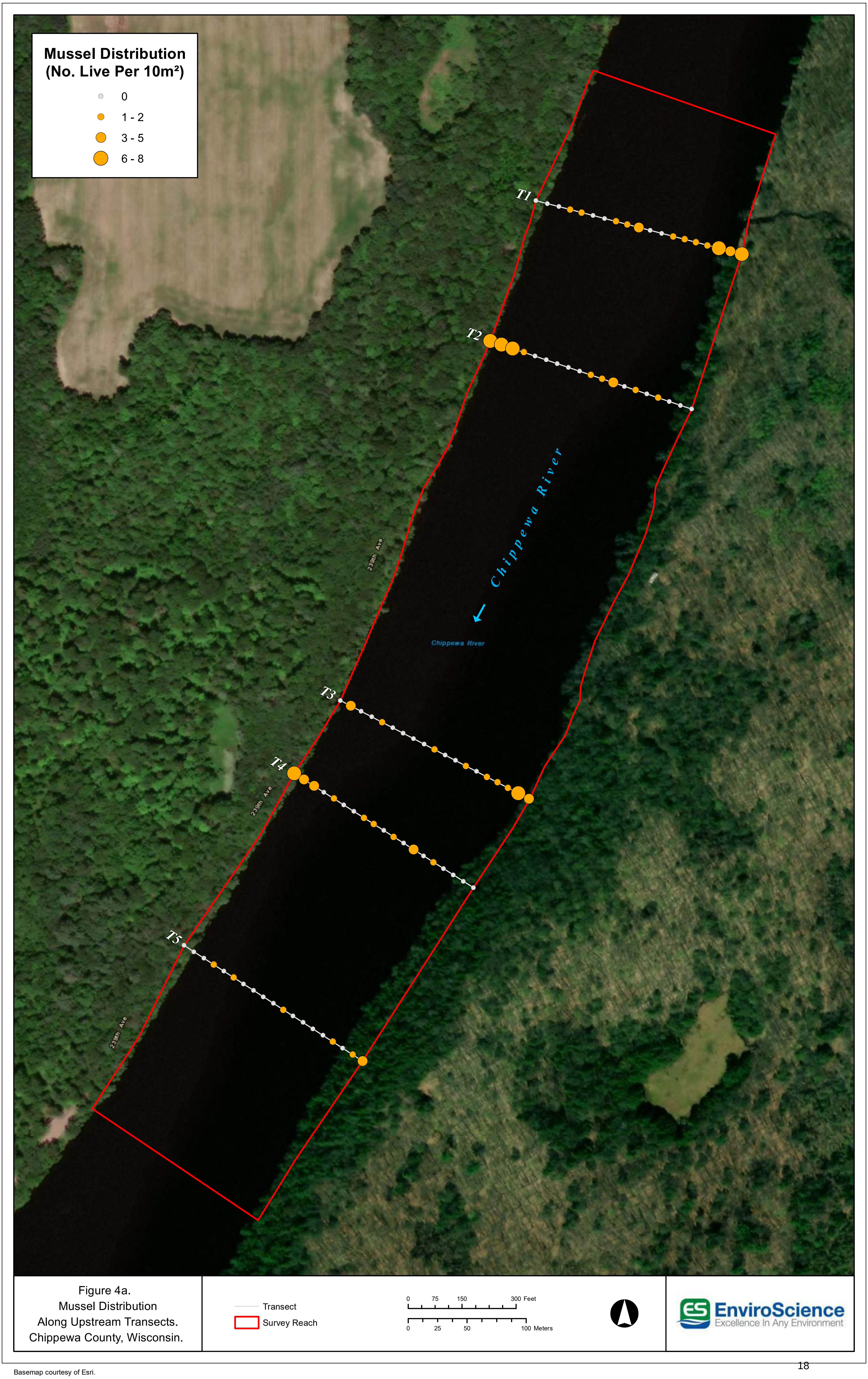

Figure 4a.
Mussel Distribution
Along Upstream Transects.
Chippewa County, Wisconsin.

Basemap courtesy of Esri.

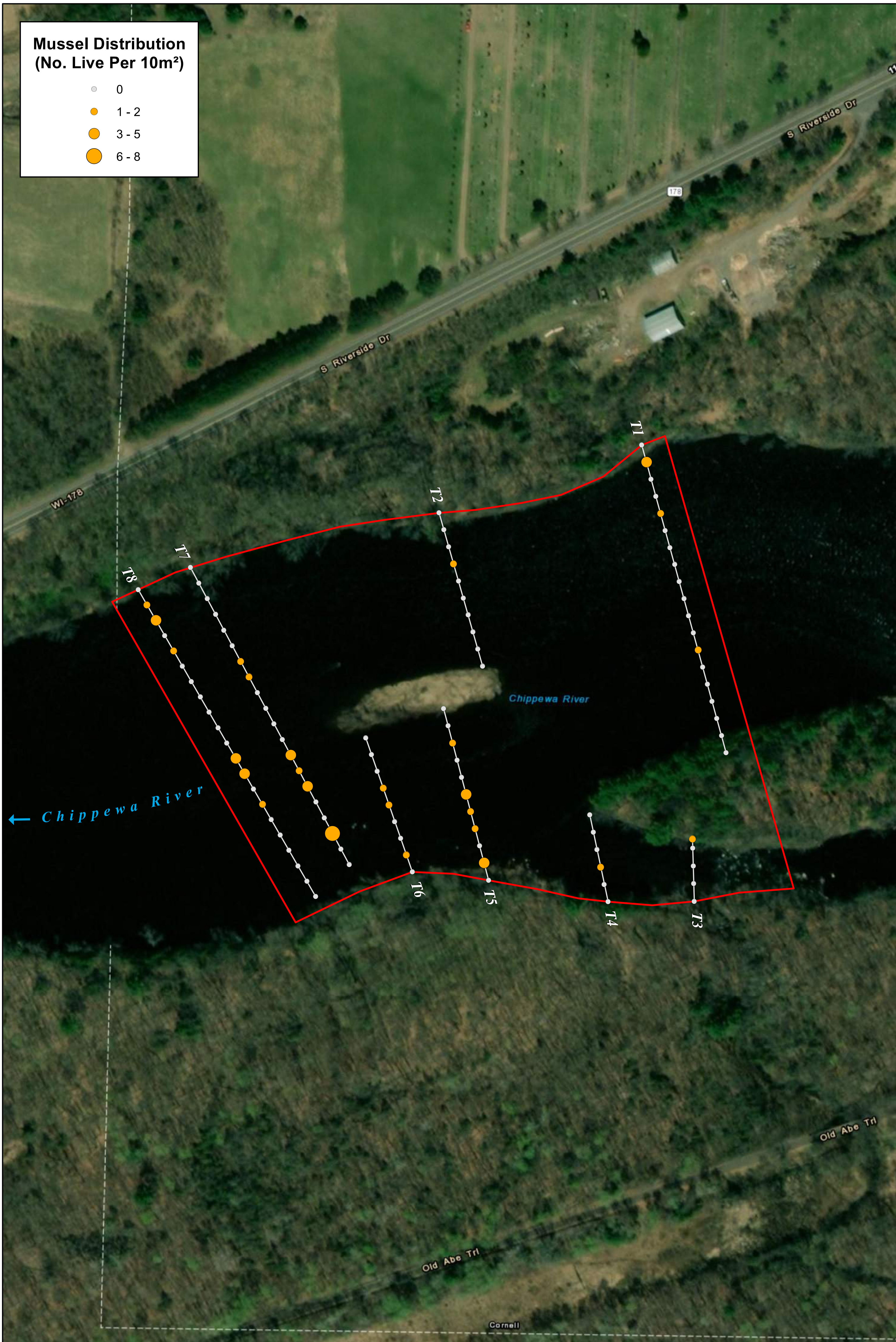

Figure 4b.
Mussel Distribution
Along Downstream Transects.
Chippewa County, Wisconsin.

Transect
Survey Reach

0 50 100 200 Feet
0 15 30 60 Meters

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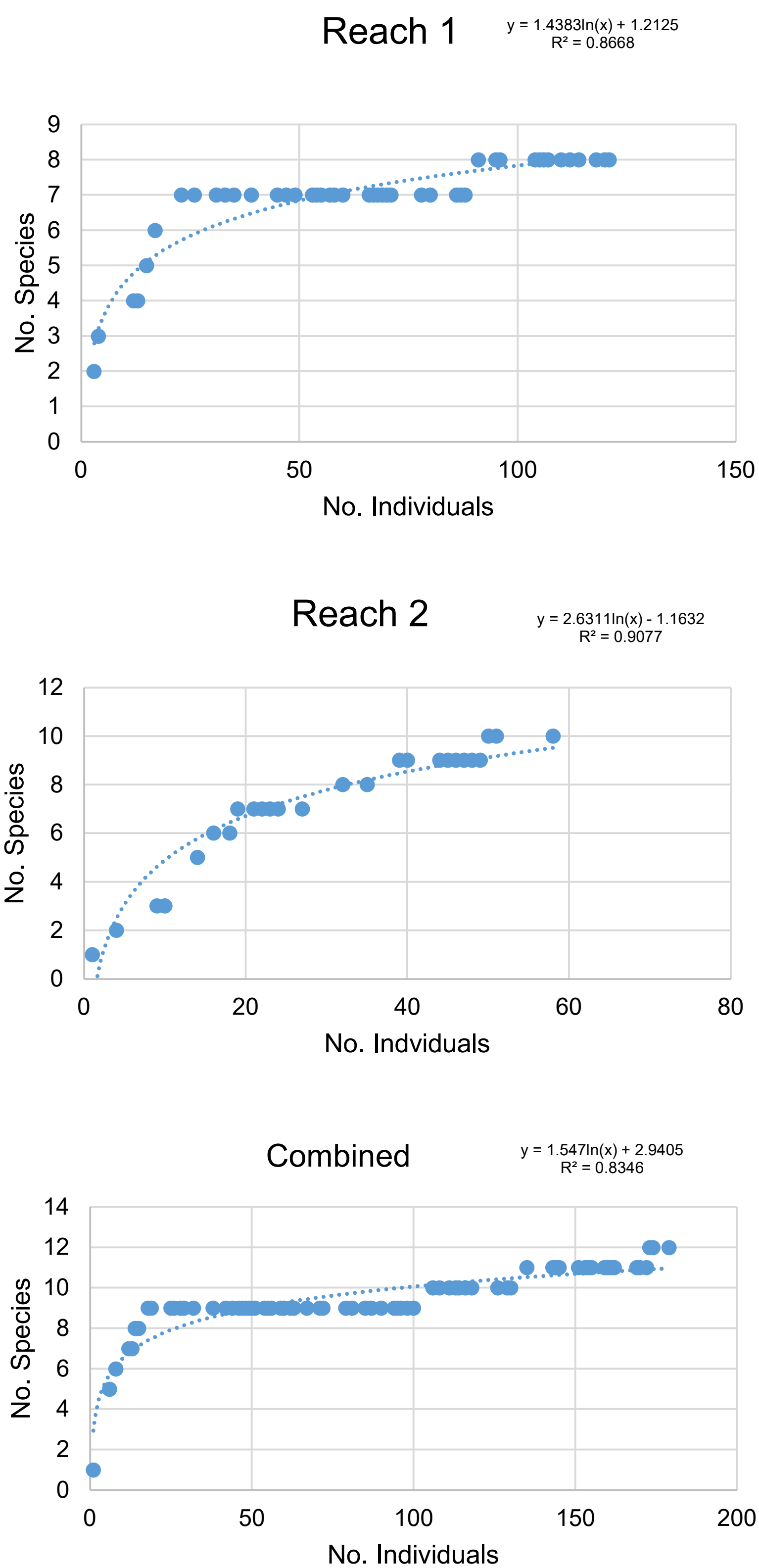
Date: 11/2/2020 Path: C:\Users\Anna Giordano\Desktop\GIS_13335\Map4b_Distribution.mxd

Basemap courtesy of Esri.

Figure 5. Species Richness Curves



Appendix A

Project Survey
Plan, Approval and Agency Communications, and
Applicable Scientific Collection Permit

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Tony Evers, Governor
Preston D. Cole, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

August 9, 2019

Becca Winterringer
521 Sycamore Drive
Euclid, OH 44132

Subject: WI E/T Permit Enclosed

Dear Ms Winterringer:

Enclosed is your Wisconsin Endangered and Threatened Species (E/T) Permit **#1164**. Please sign this permit and keep it with you when engaging in permitted activities.

Your permit is valid for five years and will expire on 1/31/2015 but may be renewed before this date with approval. It is the permit holder's responsibility to ensure that the permit they have on file has not expired, and that the permit reflects the current activities they need coverage for. Please note that your permit has conditions, which are listed on the page following your approved permit.

Conditions include an Annual Report on work performed under your permit, which will be due January 15th each year. Instructions on Annual Reporting can be found by visiting the link listed in Condition 2. Please review these instructions to ensure you record appropriate data. Reporting is your responsibility as the permit holder, not the responsibility of your client(s) or partner(s). Failure to submit complete and timely reports or follow any other condition of your permit may result in revocation of your permit.

You may request to amend your permit to reflect an addition or change in activities/species. You may also close your permit prior to the expiration date, if you stop working with listed species.

Please contact Naomi Rivers (Naomi.Rivers@wisconsin.gov or (608) 261-6449) if you have any questions about your permit.

Thank you for your efforts on behalf of Wisconsin's endangered resources.

Sincerely,

Naomi Rivers

E/T Permit Coordinator
Bureau of Natural Heritage Conservation

State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921

Endangered and Threatened Species Permit

Form 1700-002 (R 3/06)

The below named person is authorized by the Wisconsin Department of Natural Resources, pursuant to section 29.604, Wis. Stats., and Chapter NR 27, Wis. Adm. Code, to conduct the described activities for scientific or educational purposes.

DNR Permit Number	DNR Metal Tag Number
1164	
Date DNR Permit Issued	**Date DNR Permit Expires**
08/08/2019	01/31/2025
Federal Permit Number	**Date Federal Permit Expires**
TE72093B-0	12/31/2020

Permittee Information

Last Name	First
Winterrigner	Becca

Street or Route	City	State	ZIP Code

Phone Number	Email Address	Date of Birth	Eye Color	Hair Color	Weight	Height

Species or Study Information

County(ies) of Activity

Chippewa

Name and Number of Specimens or Description of Study

Bullhead - Plethobasus cyphyus (FE, SE), Purple Wartyback - Cyclonaias tuberculata (SE), Round Pigtoe - Pleurobema sintoxia (SSC), Spectacle Case - Cumberlandia monodonta (FE, SE)

Source of Species or Area of Study	Where Species or Item Will Be Kept
Chippewa River	N/A
Method of Taking and/or Transporting	**During the Following Period of Time**
Hand collection	

Purpose for Obtaining or Collection

To determine the presence or probable absence of freshwater mussel resources located within the impact area associated with the Cornell Hydro Riprap Replacement site.

Final Disposition of Specimens

All live unionids will be returned to the wild near collection point.

Scientific Qualification of Permittee

Additional Conditions of This Permit

See attached conditions.

Permittee Certification

I hereby certify that I have read, am familiar, and agree to comply with the regulations described herein. This permit is not transferable and must be exhibited to any authorized agent of the Department of Natural Resources on demand.

Permittee Signature	Date Signed

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
For the Secretary

By: ______________________ Date: 8/8/2019

CONDITIONS
Wisconsin Endangered and Threatened Species Permit #1164

1. This permit is not valid unless signed by both parties.

2. An annual report documenting activities conducted under the authority of this permit is due annually by January 15th. Annual reports can be submitted electronically by visiting http://dnr.wi.gov/topic/EndangeredResources/permits.html, selecting the "Endangered and threatened species permits" drop down, and selecting the "Annual permit report" link.

3. Sub-permittees are not allowed for E/T permits. Anyone working with state listed threatened or endangered species must obtain their own valid E/T permit, unless working under direct supervision of the permit holder.

4. If any information listed on this permit (name, address, etc.) changes, please contact us within one week to update our records.

5. Requests for changes to anything authorized by this permit (species, activities, area of study, etc.) should be sent in writing to the E/T Species Permit Coordinator. Such requests are subject to review and may require an amendment to the permit or a new permit.

6. This permit may be renewed on or before the expiration date, and if all conditions are met.

7. Permit holder is responsible for obtaining and maintaining any other permits, licenses, or authorizations that may be required to conduct the above activities.

8. Permit holder is responsible for obtaining trespass permission from landowners/managers and notifying them of all planned activities (if applicable).

Becca Winterringer

From: Ryan Schwegman
Sent: Friday, September 11, 2020 1:13 PM
To: Becca Winterringer
Subject: FW: Response Requested FW: Cornell Mussel Survey, study plan and budget

Ryan Schwegman

EnviroScienceInc.com
"Excellence in Any Environment"

From: Ryan Schwegman
Sent: Thursday, April 23, 2020 1:00 PM
To: Becca Winterringer <bwinterringer@enviroscienceinc.com>
Subject: FW: Response Requested FW: Cornell Mussel Survey, study plan and budget

Ryan Schwegman

EnviroScienceInc.com
"Excellence in Any Environment"

From: Kitchel, Lisie E - DNR <Lisie.Kitchel@wisconsin.gov>
Sent: Monday, April 13, 2020 9:45 PM
To: Ryan Schwegman <rschwegman@enviroscienceinc.com>
Subject: RE: Response Requested FW: Cornell Mussel Survey, study plan and budget

Thanks Ryan!

Lisie Kitchel
Cell Phone: 608-220-5180

From: Ryan Schwegman <rschwegman@enviroscienceinc.com>
Sent: Thursday, April 9, 2020 8:13 AM
To: Kitchel, Lisie E - DNR <Lisie.Kitchel@wisconsin.gov>; Weinzinger, Jesse J - DNR <Jesse.Weinzinger@wisconsin.gov>
Subject: RE: Response Requested FW: Cornell Mussel Survey, study plan and budget

Thanks Lisie and Hi Jesse!

See my comments below and let me know if you have any more questions, I would happy to help or make adjustments to better fit your needs.

- I will have the *P. sintoxia* language removed from the proposed scope.

- In each reach we have proposed 5 transects and total search area will be dictated by the river width. Using aerial imagery we assumed and average of 180m for each transect, so the total search area should be in ballpark of 900m2 in each reach. With two reaches proposed we will sampling around 1800m2.
- Using the equations found in *Survey design for detecting rare freshwater mussels* (Smith, 2006), an estimated 900m of transect would result in a probability of detection of approximately 83.4%. An estimated/ assumed conservative mussel density of 0.01/m^2 was used to calculate an estimated abundance. A conservative estimate of search efficiency of only 0.2 (meaning we are only finding 20% of the mussels actually present on a given transect segment) was applied to the equation due to limited visibility and the constraints of using surface supplied air diving equipment when sampling for mussels.
  - We use this to determine how much transect we should be proposing and we always assume a lower than expected efficiency and a low density. We want to ensure we are collecting enough data. Typically we find that the conditions and efficiency are better than assumed and densities are higher than assumed, which results in the reported probability of detection in >90% range.

RS

Ryan Schwegman
Manager Marine Services

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Office: (330) 688-0111 / **Toll-Free:** (800) 940-4025 / **Cell:** (513) 839-0123 / **24h Emergency:** (888) 866-8540
5070 Stow Road, Stow, OH 44224

From: Kitchel, Lisie E - DNR <Lisie.Kitchel@wisconsin.gov>
Sent: Thursday, April 9, 2020 2:44 AM
To: Ryan Schwegman <rschwegman@enviroscienceinc.com>
Cc: Weinzinger, Jesse J - DNR <Jesse.Weinzinger@wisconsin.gov>
Subject: RE: Response Requested FW: Cornell Mussel Survey, study plan and budget

Ryan, Jesse is the other mussel biologist here in Wisconsin and had some questions about the proposal for the Chippewa project
Rather than try to answer and in case he had more questions I though it more efficient just to put you two in contact.

Lisie Kitchel
Cell Phone: 608-220-5180

From: Weinzinger, Jesse J - DNR <Jesse.Weinzinger@wisconsin.gov>
Sent: Friday, April 03, 2020 4:37 PM
To: Kitchel, Lisie E - DNR <Lisie.Kitchel@wisconsin.gov>; Laatsch, Cheryl - DNR <Cheryl.Laatsch@wisconsin.gov>; Rowe, Stacy A - DNR <Stacy.Rowe@wisconsin.gov>
Subject: RE: Response Requested FW: Cornell Mussel Survey, study plan and budget

I do have a couple of comments or questions with the proposal:

- Round Pigtoe *(Pleurobema sintoxia)* is no longer a mussel SGCN.

- Can they provide an estimated search area at each river reach? They note 1x10m transect segments covering bank to bank, but I do not see an overall search area.
- How did they calculate an 83.4% probability without a documented search area or known abundance or density?

Have a good weekend,
Jesse

We are committed to service excellence.
Visit our survey at http://dnr.wi.gov/customersurvey to evaluate how I did.

Jesse Weinzinger
Conservation Biologist - NHC
Wisconsin Mussel Monitoring Program
Wisconsin Department of Natural Resources
Phone: (608) 397-0198
Jesse.Weinzinger@Wisconsin.gov

From: Kitchel, Lisie E - DNR <Lisie.Kitchel@wisconsin.gov>
Sent: Friday, April 03, 2020 2:26 AM
To: Laatsch, Cheryl - DNR <Cheryl.Laatsch@wisconsin.gov>; Rowe, Stacy A - DNR <Stacy.Rowe@wisconsin.gov>
Cc: Weinzinger, Jesse J - DNR <Jesse.Weinzinger@wisconsin.gov>
Subject: RE: Response Requested FW: Cornell Mussel Survey, study plan and budget

I am fine with the survey as proposed, they should inform us if the modify it based on sites conditions. The 1,000 feet might be a bit much, but I am fine if they want to cover that much of the river, better to much than too less.

Lisie Kitchel
Cell Phone: 608-220-5180

From: Laatsch, Cheryl - DNR <Cheryl.Laatsch@wisconsin.gov>
Sent: Thursday, April 2, 2020 2:01 PM
To: Kitchel, Lisie E - DNR <Lisie.Kitchel@wisconsin.gov>; Rowe, Stacy A - DNR <Stacy.Rowe@wisconsin.gov>
Cc: Weinzinger, Jesse J - DNR <Jesse.Weinzinger@wisconsin.gov>
Subject: Response Requested FW: Cornell Mussel Survey, study plan and budget
Importance: High

Hi - Please review the attached documents and let me know as soon as possible if you have any concerns or edits for the mussel sampling. This action is part of the Cornell relicensing on the Chippewa Rv.

We are committed to service excellence.
Visit our survey at http://dnr.wi.gov/customersurvey to evaluate how I did.

Cheryl Laatsch
Statewide FERC Coordinator
Bureau of Environmental Analysis and Sustainability
Wisconsin Dept of Natural Resources
N7725 Hwy 28
Horicon WI 53032
(T) 920-387-7869 (Fax) 920-387-7888
Cheryl.laatsch@wisconsin.gov

dnr.wi.gov

From: Miller, Matthew J <Matthew.J.Miller@xcelenergy.com>
Sent: Thursday, April 02, 2020 1:57 PM
To: Laatsch, Cheryl - DNR <Cheryl.Laatsch@wisconsin.gov>
Cc: Shawn Puzen <Shawn.Puzen@meadhunt.com>; Crotty, Scott A <scott.a.crotty@xcelenergy.com>; Darrin Johnson <Darrin.Johnson@meadhunt.com>
Subject: FW: Cornell Mussel Survey, study plan and budget
Importance: High

Hello Cheryl,

Attached is our consultant's proposal for the Cornell Mussel Survey which was developed in consultation with Lisie Kitchel. Please let me know if the DNR approves of the proposal so we can move forward with the contract.

From: Chris Turner <cturner@glec.com>
Sent: Tuesday, March 31, 2020 7:46 AM
To: Miller, Matthew J <Matthew.J.Miller@xcelenergy.com>
Subject: Cornell Mussel Survey, study plan and budget

CAUTION EXTERNAL SENDER: Stop and consider before you click links or open attachments.
Report suspicious email using the 'Report Phishing/Spam' button in Outlook.

Hi Matt:
Attached please find a proposed study plan and budget for the 2020 Cornell mussel survey. ES worked with Lisie at WDNR to develop the plan but WDNR has not "officially" reviewed it. The requirements led to just two sample reaches (one below the dam and one in the upper riverine area).

The work (pending approval) is planned for 4 days in 2020, yet to be scheduled.

Let me know if you have any questions.

____

Chris Turner
Principal Research Scientist
Great Lakes Environmental Center, Inc.
715-829-3737
cturner@glec.com

Appendix B

Photographic Record

Photo 1. View of the Chippewa River in the upstream survey reach facing east from the right descending bank at Transect 1.

Photo 2. View of the Chippewa River in the upstream survey reach facing south from the right descending bank at Transect 1

Photo 3. View of the Chippewa River in the downstream survey reach facing northeast (upstream) from mid-channel along Transect 1.

Photo 4. View of the Chippewa River in the downstream survey reach facing southwest (downstream) from mid-channel along Transect 1.

Photo 5. View of the Chippewa River in the downstream survey reach facing northeast (upstream) from the right descending bank at Transect 2.

Photo 6. View of the Chippewa River in the downstream survey reach facing south (downstream) from the right descending bank at Transect 2.

Photo 7. View of the Chippewa River in the downstream survey reach facing northeast (upstream) from the left descending bank at Transect 3.

Photo 8. View of the Chippewa River in the downstream survey reach facing southwest (downstream) from the left descending bank at Transect 3.

Photo 9. View of the Chippewa River in the downstream survey reach facing northeast (upstream) from the left descending bank at Transect 7.

Photo 10. View of the Chippewa River in the downstream survey reach facing northwest across the channel from the left descending bank at Transect 7.

Photo 11. Representative photo of Mucket collected from the Chippewa River in the upstream survey reach.

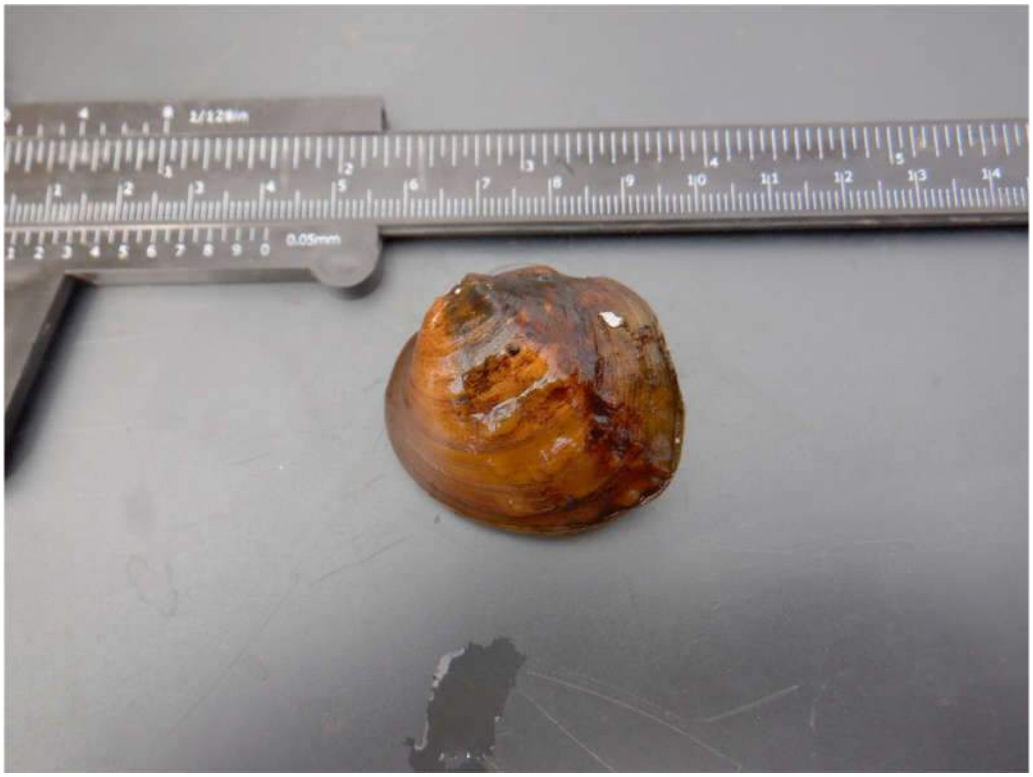

Photo 12. Representative photo of Pimpleback collected from the Chippewa River.

Photo 13. Representative photo of Purple Wartyback from the Chippewa River in the downstream survey reach (insets: dorsal views).

Photo 14. Representative photo of Spike from the Chippewa River (inset: dorsal view).

Photo 15. Representative photo of Wabash Pigtoe collected from the Chippewa River in the downstream reach.

Photo 16. Representative photo of Plain Pocketbook collected from the Chippewa River.

Photo 17. Representative photo of Fatmucket collected from the Chippewa River in the downstream reach River.

Photo 18. Representative photo of Fluted-shell collected from the Chippewa River in the downstream reach.

Photo 19. Representative photo of Black Sandshell collected from the Chippewa River.

Photo 20. Representative photo of Hickorynut collected from the Chippewa River (inset: juvenile).

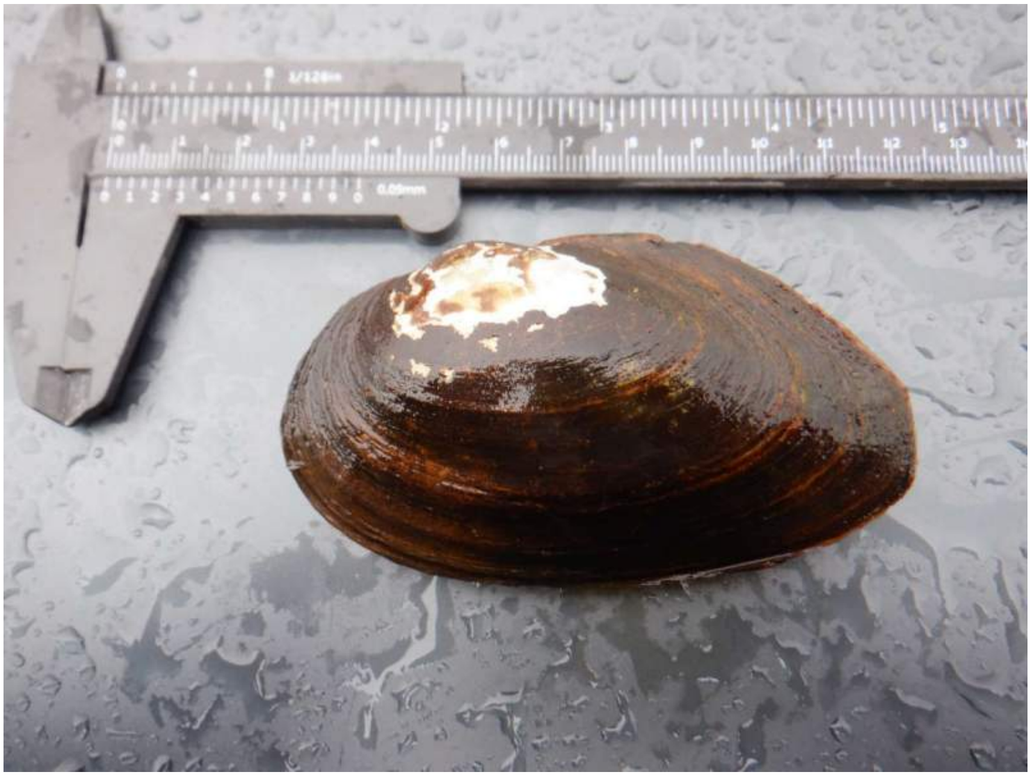

Photo 21. Representative photo of Giant Floater collected from the Chippewa River.

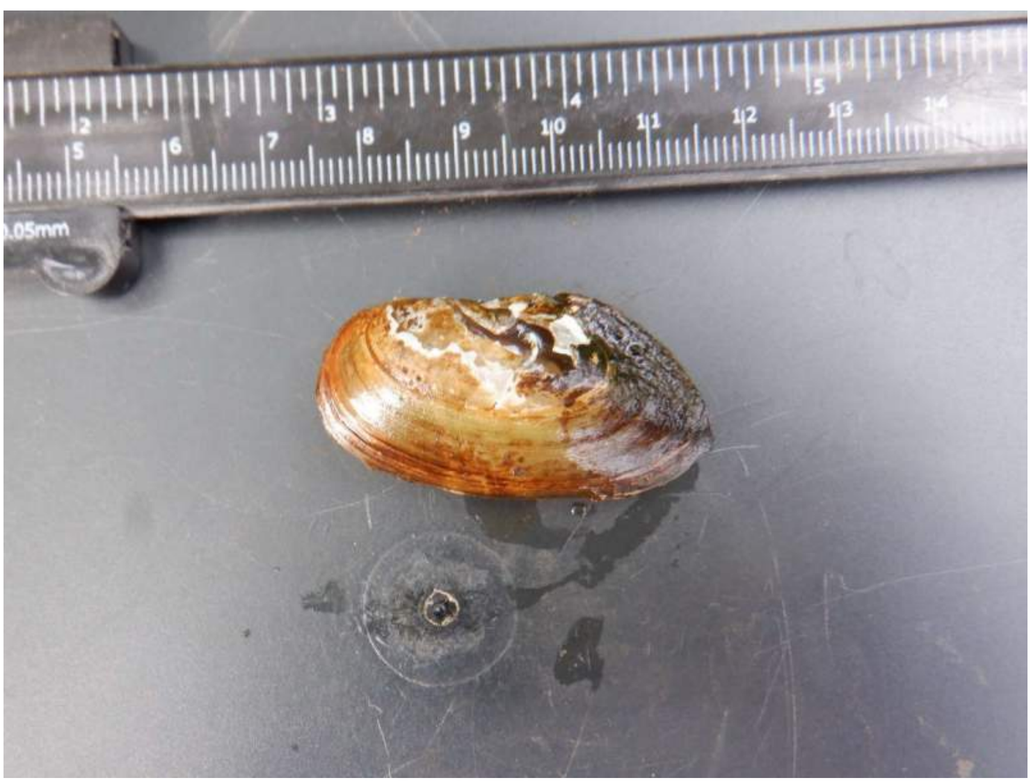

Photo 12. Representative photo of Paper Pondshell from the Chippewa River in the downstream survey reach.

Appendix C

Scanned Field Sheets

Date 09242020
Page 1 of 3

Habitat Data Sheet

Project Name/No.: 13335 / 6LEC
Crew: (BW) RW, AS, CR, RTB

River/Stream Name: Chippewa R.
County: Chippewa
Coordinates: UP: 45.200767 / -91.152133
Location/Town: Cornell
Weather: Ptly Cloudy
Air Temp: 58 °F
Water Quality (T, pH, Flow, Cond, DO): Water T 68.2 vis 30" Gage 03655000 : 2,500 cfs / 3.70 ft
Survey Type (Semi-quan/Qual/Quan/Reconn): Semi Quant Transects
Comments: 11 possible T's : picked 5 using RNT : 2, 3, 6, 7, 9

	T/Q/Site[A]	Rep[B] X	Y	Time	Depth	Br	Bo	Cb	Gr	Sd	St	Md	Cl	Other
1	UP - T3	180	170	1121	7					20	80			RDB st. 1121
2		170	160	TX2	7			20	50	30				
3		160	150	AS	7			20	50	30				
4		150	140	+RT	9			20	50	30				
5		140	130	136	8			20	40	40				
6		130	120		8			30	40	30				
7		120	110		8		10	40	30	20				
8		110	100		8		20	30	30	20				
9		100	90		10		10	40	40	10				
10		90	80		9		20	30	20	10				
11		80	70	1200	10		40	30	20	10				
12		70	60	1204	10		40	40	10	10				
13		60	50	1216	12		30	30	20	20				
14		50	40	1220	12		20	30	30	20				
15		40	30	1226	13		20	20	30	30				
16		30	20	1228	13		20	20	30	30				
17		20	10		12		20	20	30	30				
18		10	0	1235	8		20	20	20	30	10			
19		0	Shore	→	3					90	10			end @ LDB
20	UP-T2	180	170	1241	3-8					20	80			RJ / AS
21		170	160	1256	10					90	10			Time X2
22		160	150	1305	10					90	10			LDB st.
23		150	140	1312	10			20	40	40				
24		140	130	1315	7		10	30	30	30				
25		130	120	1310	7		10	30	30	30				
26		120	110	1323	7		10	30	40	20				
27		110	100	1328	8		10	30	30	30				
28		100	90	1331	9		20	20	40	20				
29		90	80		10		40	30	20	10				
30		80	70	1339	10		50	30	10	10				
31		70	60	1342	12		50	30	10	10				
32		60	50	1346	15		10	40	20	30				
33		50	40	1353	14		10	40	30	20				
34		40	30	1356	12		40	10	20	20				
35		30	20	1401	8		50	10	20	20				
36		20	10	1406	7		40	20	20	20				
37		10	0	1411	4		30	20	20	30				
38		0	Sh		3					90	10			end @ DB
39	UP-T7	180	170	1430	3		5			95				st RDB
40		170	160	1436	8			10	10	80				

Notes (A = Site (ADI, DSB etc). B = X - Cell, Transect; Y - Replicate or Quadrat)

X = Max dist Y = min dist

Date 09242020
Page 2 of 3

Habitat Data Sheet

Project Name/No.: 13335/GLEC
Crew:

	T/Q/Site[A]	Rep[B] X	Y		Depth	Br	Bo	Cb	Gr	Sd	St		Cl	Other
1	UP T7 CONT'D	160	150	1445	10		-	40	30	30				Time
2		150	140	1448	11			40	30	30				x2
3		140	130	1451	13		10	30	30	30				
4		130	120	1454	10			20	50	30				
5		120	110	1458	10		20	20	20	40				
6		110	100	1503	10		40	30	10	20				
7		100	90		10		20	40	20	20				
8		90	80		10		20	30	30	20				
9		80	70	1509	11		10	30	30	30				
10		70	60		10		50	30	10	10				
11		60	50		12		10	20	20	20				
12		50	40	1520	12		10	30	30	30				
13		40	30		11		10	30	30	30				
14		30	20		10		10	30	30	30				
15		20	10		9		20	20	30	30				
16		10	0	1541	3		10	80			10			
17		0	SH	end										end LDB
18	UP-T6	180	170	1548	8			40	40	20				
19		170	160		9			20	40	40				
20		160	150		8			30	40	30				
21		150	140		9			20	40	40				
22		140	130		8		20	40	20	20				
23		130	120		8		20	30	30	20				
24		120	110		9		10	30	30	30				
25		110	100		10		10	30	30	30				
26		100	90	1617	11		20	30	20	30				
27		90	80		12		20	20	30	30				
28		80	70		11		30	30	20	20				
29		70	60		11		10	20	40	20				10 LWD
30		60	50		12		20	50	30					
31		50	40		13			40	40	20				
32		40	30		10		20	10	40	30				
33		30	20		12		20	10	40	30				
34		20	10		8		10	40	40	10				
35		10	0	1658	4			30	40	30				RDB end
36		0	shore		2									
37	UP-T9	180	170	1705	4		10	70	10	10				LDB st
38		170	160		7			10		90				
39		160	150		7		10	40	30	20				
40		150	140		10		20	30	30	20				
41		140	130		10		20	30	30	20				
42		130	120		13		20	30	20	30				
43		120	110		13		10	40	30	20				
44		110	100		10		20	30	30	20				
45		100	90		10		30	30	20	20				

A = Transect Number, Quadrat Number or Site ID

Date 09242020
Page 3 of 3

Habitat Data Sheet

Project Name/No.: 13335/GLEC
Crew:

	T/Q/Site[A]	Rep[a] X	Y	Depth	Br	Bo	Cb	Gr	Sd	St		Cl	Other
1	UP T9	90	80	10		40	30	20	10				
2	Cont'd	80	70	12		40	30	20	10				
3		70	60	11		30	30	20	20				
4		60	50	11			30	50	20				
5		50	40	8		30	20	30	20				
6		40	30	10		20	30	30	20				
7		30	20	10		10	30	30	30				
8		20	10	8			30	40	30				
9		10	0	3			30	40	30				
10		0	shore	1800 end Time									end ERPB
11													
12													
13		end 09/24											
14													
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42													
43													
44													
45													

A = Transect Number, Quadrat Number or Site ID

180-150 Ø working from 150

UNIO DATA

UPSTREAM Transects

QUALITATIVE CELL #2,3,6,7,9

Project Name/Number: 13335 / GLEC

Date: 09242020

Malacologist: BW

Data Recorder: BW

Locality Notes: Cornell, WI

T3 Y 150 130 110 100 90 80 40 30 20 10 0

	Diver	Cell	Time	Species	Condition	Sex	A/J	L	H	W	Notes
1	T3	~~150~~		EUDI	7 L		A				LRB and
2		~~140~~		LASI	1 L	F	A				
3		10		EUDI	5 L						
4		20		LIRE	1 L	M					
5				LASI	1 L	M					
6				LASI	2 L	F					
7				CYPU	1 L						
8		30		EUDI	1 L						
9		L		LASI	1 L	M					
10		40		CYPU	1 L						
11		L		LIRE	1 L	M					
12		50		LACA	1 L	F					
13		90		LACA	1 L	F					
14		100		LASI	1 L	F					
15		L		LASI	1 L	M					
16		110		CYPU	1 L						
17		L		LASI	1 L	M					
18				LASI	1 L	F					
19		130		LIRE	1 L	F					
20		L		ACU	1 L						
21		150		LASI	1 L	F					RDB
22	T2	~~140~~		CYPU							
23		50		LACA	1 L	F					
24				CYPU							
25		60		LIRE	1 L	M					
26		90		LASI	1	M					
27		L		LASI	1	F					
28				LIRE	1	F					
29		100		LIRE	1	FG					
30		110		EUDI							
31		140		LACA	1 L	F					
32		150		CYPU	1 L		J				LDB
33		L		LIRE	1 L	F					working
34		30		CYPU	2 L						to RDB
35		20		EUDI	6 L						150 → 0
36				LASI	1	F					
37				CYPU	1						
38		10		CYPU	1						
39				EUDI	1						
40				LASI	1	F					
41				LASI	1	M	J				
42		0		LIRE	1	M					RDB
43				EUDI	2						
44				CYPU	1						
45				LASI	1	M					
46				PIGA	1						
47											
48											
49											
50											

RJ orange
AS Blue

T2 Bags 2 0 Y 10 20 30 40

Bags 1 150 Y 140 110 100 90 60 50 40

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UNIO DATA				Project Name/Number: 13335 / GLEC						
UPSTREAM TS 2,3,6,7,9				Date: 09242020				Malacologist: BW		
QUALITATIVE CELL				Data Recorder: BW				Locality Notes: Cornell, WI		

	Diver	Cell	Time	Species	Condition	Sex	A/J	L	H	W	Notes
1	T7	70		LACA	1L	F					
2		80		LOVA	1L	F					
3		100		LASI	1L	F					
4		120		CYPU	2L						
5				LACA	1	M					
6				EUDI	1						X
7		140		LACA	1	M					RDB working
8				EUDI	1						to LBB
9		~~0~~		EUDI	6						180-70
10		10		LIRE	1	M					
11				EUDI	1						
12				CYPU	2						
13				LACA	1	M	J(5)				
14		20		EUDI	4						
15		40		LASI	1	F					
16	T6	~~0~~		LACA	1	F					RDB
17				CYPU	2						
18		10		EUDI	4						
19				LASI	1	M					
20				LACA	1	F					
21		20		CYPU	1						
22				EUDI	1						
23		30		LIRE	1	F					
24		60		LASI	2	F					
25		70		LASI	2	F					working
26		90		CYPU	1						
27				LACA	1	M					
28		140		CYPU							
29				FUFL	1						
30		170		CYPU							
31				EUDI							LBB
32	T9	~~0~~		EUDI	4						RDB st
33		10		EUDI	1						
34		60		LACA	1	F					
35		80		LIRE	1	M					working
36		130		LACA	1	F					
37		150		ACLI	1						
38				LASI	1	M					LDB
39											
40		— end 09242020 —									
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											

T6 Y
~~170~~
~~140~~
~~90~~
~~70~~
~~60~~
~~30~~
~~20~~
~~10~~
~~0~~

T9 Y
~~150~~
~~130~~
~~80~~
~~60~~
~~10~~
~~0~~

T7 Bag 2
~~0~~
~~10~~
20
40

Bag 1 T7 ~~140~~
~~120~~
~~100~~
~~80~~ ~~70~~

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Date 09252020
Page 1 of 4

Habitat Data Sheet

Project Name/No.: 13335/GLEC
Crew: BW RW CR RJB AS

River/Stream Name: Chippewa
County: Chippewa
Coordinates: DS @ is 45.151665/-91.168024
Location/Town: Cornell, WI
Weather: sunny 60
Air Temp:
Water Quality (T, pH, Flow, Cond, DO): vis: 46" USGS: 0365500 3230/4.21 water T: 67.4
Survey Type (Semi-quan/Qual/Quan/Reconn): Semi Quan.
Comments: Plan modified, cannot get thru rapids @ is to shallow per LK, OK to survey near IS area.

	Rep[B]				Hab/Substrate (%)								
T/Q/Site[A]	X	Y	Time	Depth	Br	Bo	Cb	Gr	Sd	St	Md	Cl	Other
1 PN T1	0	sh/10	1114	2				90		10			RDB st.
2	10	20		4			20	40	40				
3	20	30		4		10		40	50				
4	30	40		4		10	10	40	40				
5	40	50		5		20	20	30	30				
6	50	60		5		10	20	40	30				
7	60	70		5		10	20	40	30				
8	70	80		5		10	30	30	30				
9	80	90		5		30	20	30	20				
10	90	100		5		30	20	30	20				
11	100	110		5		50	20	20	10				
12	110	120		5		40	20	20	20				
13	120	130		5			30	30	40				
14	130	140		4		10	20	30	40				
15	140	150		5		10	30	30	30				
16	150	160		3		70	10	10	10				
17	160	170		3		80	10			10			
18	170	180	1158	2		70	10			20			@ is. sh.
19 QNT2	0	10	1228	2		60	30			10			RDB st
20	10			3		70	30						
21	20		RS	5		20	30	30	20				
22	30		CR	5		25	25	25	25				
23	40			5		25	25	25	25				
24	50			7		25	25	25	25				
25	60			6		10	30	30	30				
26	70			5		10	30	30	30				
27	80			3			40	40	20				
28	90		1316	3			20	40	40				@ is head
29 QN T3	0	10	1410	2			80		10	10			on LDB
30 LD of is	10	20		2			80		20				
31	20	30	RS	3		50	50						
32	30	35		3		50	50						
33	35	—	1426	3		50	50						is LDB
34 QNT4	0	10	1410	3	20	70			10				on LDB
35	10	20		5	20	70			10				
36	20	30		6	10	50			40				
37	30	40	R	6	10	40	10	25	15				
38	40	50		6	10	40	10		40				
39	50	bnk	1438	3		25	50		25				is LDB
40													

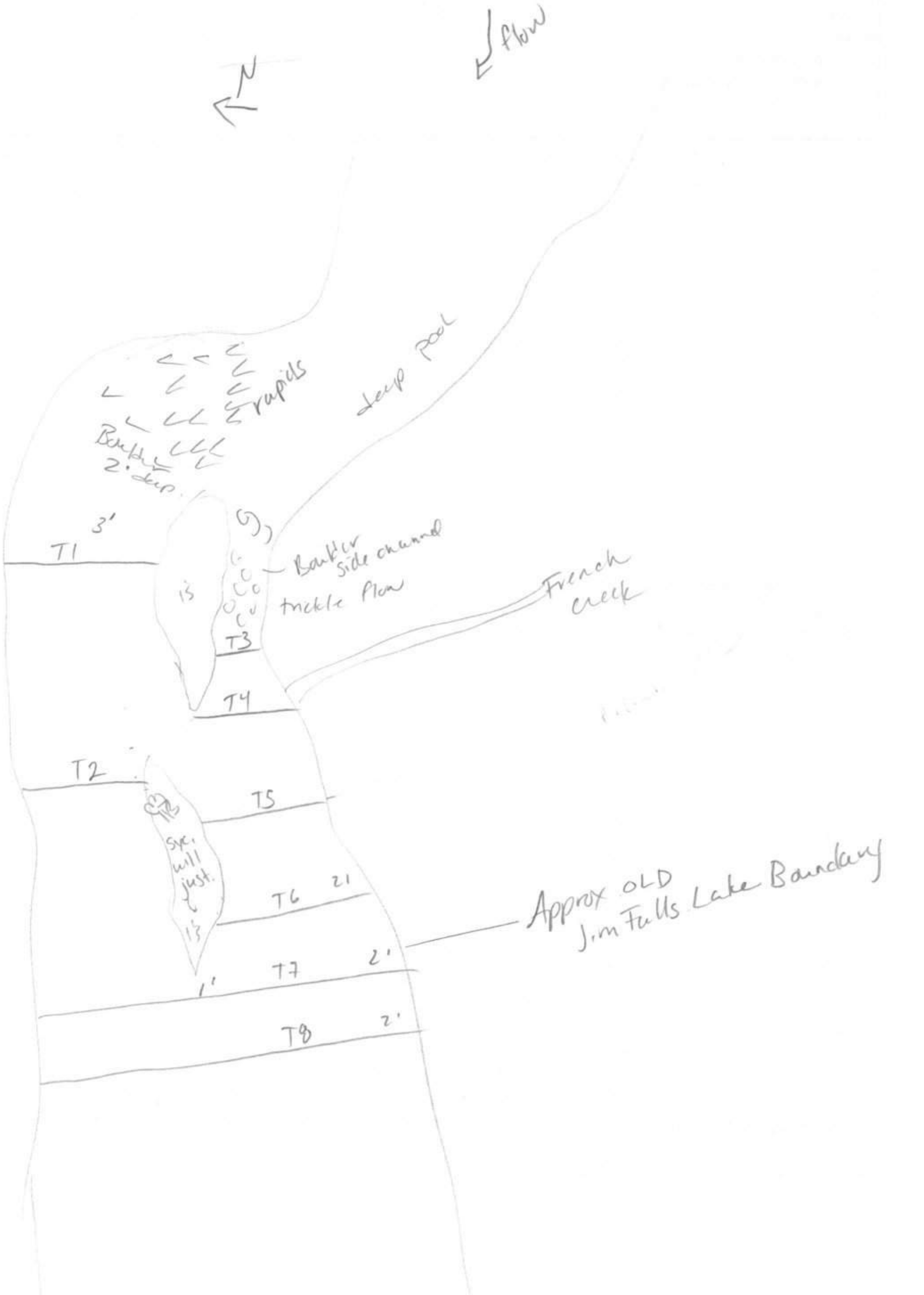
Notes (A = Site (ADI, DSB etc), B = X - Cell, Transect; Y - Replicate or Quadrat)

see drawing for T locations

2/4

Site Drawing

13335 /6LCC



Date 09252020
Page 3 of 4

Habitat Data Sheet

Project Name/No.: 13335/GLEC
Crew: (BW) RW, RJB, AS, CR

See pg 1

	T/Q/Site[A]	Rep[B] X	Y		Depth	Br	Bo	Cb	Gr	Sd	St		Cl	Other
1	DN T5	0	10	1500					20	80				RD is
2	CR	10	20						40	60				Start
3		20	30						50	50				
4		30	40					10	50	40				
5		40	50					10	50	40				
6		50	60					10	50	40				
7		60	70					10	50	40				
8		70	80				25	25	25	25				
9		80	90				10	10	40	40				
10		90	100	1531			25	25	25	25				
11		100	110				50	40		10				
12	DN T6	0		1500						100				at 15 RD
13	RJ	10								100				
14		20						10	45	45				
15		30					10	25	25	40				
16		40					10	25	25	40				
17		50					10	25	25	40				
18		60					80	10	5	5				
19		70					80	10	10					
20		80	bnk	1548			10	10	40	20	20			LDB
21	DN T7	0		1600	2		100							LDB
22		10			3		75	25						
23		20					60	40						
24		30					10	40	40	10				
25	JR	40						30	35	35				
26		50						same						
27		60						same						
28		70						same						
29		80			2				40	20				
30		90			1				50	60				
31		100			1				50	50				
32		110			1.5				50	50				
33		120			2			25	25	50				
34		130			4		10	40	40	10				
35		140			4		10	40	40	10				
36		150			4		10	30	40	10				
37		160			3		10	30	40	20				
38		170			4		20	20	40	20				
39		180	190		2				10	80	10			
40		190	end Bnk	1738	2			75	10	15		LWD		RDB
41	DN T8	0			3		50	50						LDB St
42		10			3		50	20	15	15				
43	RJB	20			3									
44		30			3									
45		40			3			same						

A = Transect Number, Quadrat Number or Site ID

Date 09252020
Page 4 of 4

Habitat Data Sheet

Project Name/No.: 13335 / GLEC
Crew: BW RW, RJB, CR, AS

	T/Q/Site^A	Rep° X	Y		Depth	Br	Bo	Cb	Gr	Sd	St			Cl	Other
1	ONT8	50	60		3		25	50	10	15					
2	cont'd	60	70		3			SAME							
3	RJB	70	80		3										
4		80	90		3										
5		90	100		3										
6		100	110		3										
7		110	120		3										
8		120	130		3										
9		130	140		4										
10		140	150		4										
11		150	160		4										
12		160	170		5										
13		170	180		5										
14		180	190		6										
15		190	200	1730	3			10	40	40	10				
16		200	at bnk												
17															
18		end 09/25/2020													
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
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36															
37															
38															
39															
40															
41															
42															
43															
44															
45															

A = Transect Number, Quadrat Number or Site ID

See pg 1

120
40
10

UNIO DATA				Project Name/Number: 13335							
Downstream Transects				Date: 09252020				Malacologist: BW			
QUALITATIVE CELL				Data Recorder: BW				Locality Notes:			

#	Diver	Cell	Time	Species	Condition	Sex	A/J	L	H	W	Notes
1	T1	120		CYPU	1L		A				
2		40		LACA	1L	M					
3		10		OBOL	1L	M					
4				LACA	1L	M					
5				LASI	1L	M	J				
6	T2	30		LIRE	1L	M					
7	T3	40		EUDI	1L		J (5)				
8	T4	20		LIRE	1L	F					
9				CYPU	1L		J				
10	T6	30.		LIRE	F						
11		40		LASI	F						
12		70		CYPU (CYTUB)	confirmed			1 CYTU			
13	T5	50		LIRE	3L						
14		60		EUDI	1L						
15		70		LACA	1L	F					
16		~~20~~		OBOL	1L						
17		~~90~~									
18		20		LACA	1L	M					
19		90		LACA	2	M					
20					1	F					
21				EUDI	1						
22	T7	170		LIRE	5	M					
23					2	F					
24		140		FUFL	1	L	[illegible]				
25				LACA	1	F					
26					1	M					
27		130		OBOL	1	J	J				
28		120		CYPU	4	→		(CTUB)			
29		70		LASI	1	F					
30		60		FUFL	1	A					
31	T8	140		LACA	2	M					
32		120		LACA	3	F					
33				OBOL	1						
34		110		LIRE	2	F					
35				LIRE	3	M					
36		40		LASI	1	M					
37		20		A. FSDR	? 1						
38				CYPU	2	(CTUB)		identified			
39		10		LSCS	1						
40											
41			—	end —							
42											
43											
44											
45											
46											
47											
48											
49											
50											

modified approch, see email + pg 1 Hub bank sheet

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APPENDIX E-24 2020 Purple Loosestrife Monitoring Report

Xcel Energy®
RESPONSIBLE BY NATURE®

1414 West Hamilton Avenue
PO Box 8
Eau Claire, WI 54702-0008

October 29, 2020

VIA Electronic Filing

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Subject: **Annual Purple Loosestrife Monitoring Report**
Holcombe Hydro (P-1982), Cornell Hydro (P-2639), Jim Falls Hydro (P-2491), Wissota Hydro (P-2567), Chippewa Falls Hydro (P-2440) and Dells Hydro (P-2670)

Dear Secretary:

Enclosed is the Annual Purple Loosestrife Monitoring Report for the above-referenced hydro projects. Pursuant to Appendix M of the 2001 Lower Chippewa River Settlement Agreement, Northern States Power Company – Wisconsin (NSPW, licensee) is required to annually monitor for the presence of loosestrife at each impoundment and eradicate pioneering plants on company-owned shoreline.

The length of shoreline infested on Lake Holcombe increased modestly from last year despite a decrease in the overall number of loosestrife sites. Cornell Flowage saw a modest increase in both the number of loosestrife sites and overall shoreline coverage. There was a slight increase in loosestrife sites on Lake Wissota compared to last year, however, the amount of shoreline infested decreased slightly. Loosestrife was documented on Chippewa Falls Flowage for the first time since surveys began in 2003 and consisted of a single plant. A single plant was also observed on Dells Pond, similar to past surveys.

Should you have any questions regarding this report, please contact Matthew Miller at (715) 737-1353 or at matthew.j.miller@xcelenergy.com.

Sincerely,

Scott Crotty
Digitally signed by Scott Crotty
Date: 2020.10.29 15:17:41 -05'00'

For: James M. Zyduck
Director, Hydro Plants

Enclosure

c: Nick Utrup - USFWS (via e-mail)
Cheryl Laatsch – WDNR (via e-mail)
Brian Guthman – Lake Holcombe Improvement Association (via e-mail)
Jeanette Kelly – Beaver Creek Reserve (via e-mail)
Project Files

PURPLE LOOSESTRIFE ASSESSMENT – 2020

Dells Pond, Chippewa Falls Flowage, Lake Wissota, Old Abe Flowage, Cornell Flowage, Holcombe Flowage, and Jim Falls Spillway Channel

Prepared for:

Xcel Energy
P.O. Box 8
Eau Claire, WI 54702

Prepared by:

GLEC
Great Lakes Environmental Center
739 Hastings Street
Traverse City, MI 49686

Principal contact:
Christopher J. Turner
Ph.: 715-829-3737
Email: cturner@glec.com

October 29, 2020

INTRODUCTION

Purple loosestrife (*Lythrum salicaria* L.) is an erect, herbaceous perennial of Eurasian origin that became established in the estuaries of northeastern North America by the early 1800's. Since then, this highly invasive species has spread throughout much of the United States, including most of Wisconsin's counties. As purple loosestrife expands its local distribution and becomes more widespread, it poses a serious threat to native emergent vegetation in shallow-water marshes and shorelines by displacing native food and cover plants in the waterways.

As part of the 2001 Lower Chippewa River Settlement Agreement, Xcel Energy agreed to annually monitor for the presence and spread of purple loosestrife at its six Lower Chippewa River hydroelectric projects. The surveys are to take place each year in the late summer when loosestrife blooms are easily detectable. Additionally, Xcel Energy committed to treating small clusters of pioneering plants which occur on company-owned property with an approved aquatic herbicide.

In 2010, Xcel Energy partnered with Beaver Creek Reserve to introduce European beetles (*Galerucella calmariensis* and/or *Galerucella pusilla*) into the main spillway channel adjacent to the Jim Falls Hydro. Beetles were again introduced into the same area during the summer of 2011. The beetles are commonly referred to as "Cella" foliage beetles or purple loosestrife bio-control beetles and they feed specifically on purple loosestrife plants. Their use has shown to be successful at decreasing the overall population of purple loosestrife. The locations and density of loosestrife within the Jim Falls spillway channel are therefore being monitored to determine the success of the beetle introduction.

METHODS

Following the same approach as previous surveys, an inspection of the entire shoreline of Dells Pond, Chippewa Falls Flowage, Lake Wissota, Old Abe Flowage, Cornell Flowage and Holcombe Flowage was performed by boat. The surveys were conducted between August 17 and September 14, 2020. The surveyor motored slowly around the shoreline looking for purple loosestrife plants. When loosestrife was discovered, the location was marked on a map and coordinates were entered into a handheld GPS unit. Loosestrife infestations were classified as either "present" or "abundant" and marked on the map with a specific color. "Present" was defined as a few plants that sparsely inhabited an area but did not comprise a large percentage of the overall vegetation in that area. "Abundant" indicated that denser loosestrife growth existed and that the loosestrife made up a significant portion of the shoreline's overall vegetative cover.

By referencing the location of purple loosestrife plants with land ownership maps provided by Xcel Energy, the surveyor determined if the plants were on company-owned property. If the plants were on Xcel Energy property, and if it was only a minor infestation, the plants were sprayed with Rodeo® (an aquatic herbicide) from a backpack sprayer. From past work, it has been determined that herbicide application can be used as an effective treatment for small loosestrife populations, however, it is much less effective at controlling larger infestations. If major infestations were noted on Xcel Energy property, they were not to be treated, but documented for the possibility of a different eradication method in the future.

Using GPS coordinates and notations made by the surveyor, the locations of purple loosestrife infestation were noted on field maps and catalogued in a spreadsheet. The locations were then digitized onto GIS base maps (Wisconsin DNR 24K Hydrography version 6 and ESRI StreetMap USA). Locations of purple loosestrife are depicted on the maps using green for present and red for abundant. Due to the scale of the maps, locations covering less than 20 feet of shoreline are denoted by a dot while areas covering 20 feet of shoreline or greater are denoted by a line drawn to scale. Through the combined use of GPS, laser rangefinder, visual estimates, and GIS, the total length of shoreline infested by purple loosestrife was calculated for each flowage (Table 1). Appendix A includes survey maps for each flowage infested with loosestrife along with a corresponding catalog of each loosestrife location.

A survey of purple loosestrife was also conducted in the Jim Falls spillway channel adjacent to the downstream powerhouse. This area has been known to contain purple loosestrife in locally high densities which prompted the introduction of purple loosestrife bio-control beetles. A comprehensive mapping effort of the area began in 2010 to monitor the spread of loosestrife and the success of the beetle introduction. This portion of the fieldwork was completed on foot using GPS and maps to identify the locations and densities of the loosestrife within the channel.

RESULTS AND DISCUSSION

The number of purple loosestrife locations and the total length of shoreline infested for each flowage over the last three years are summarized below in Table 1. A standardized approach used to calculate abundance and shoreline coverage allows for a direct comparison from year-to-year. This year's survey revealed an increase in purple loosestrife infestation on Holcombe Flowage and Cornell Flowage and a decrease on Old Abe Flowage and Lake Wissota. The same single loosestrife plant previously documented on Dells Pond was again observed this year, while a single loosestrife plant was noted on Chippewa Falls Flowage (marking the first time loosestrife was noted on this impoundment). Collectively, the length of shoreline infested by loosestrife on the six flowages increased from last year, yet remains below 2018 levels. Table 2 includes a summary of the number of loosestrife infestations and the total length of shoreline infested for all six impoundments over the past three years.

Table 1. Summary of Purple Loosestrife Infestations (2018-2020).

	Number of purple loosestrife locations						Shoreline Affected (ft)					
	Present			Abundant			Present			Abundant		
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
Holcombe	152	157	123	1	1	2	704	456	518	40	55	180
Cornell	20	13	27	0	0	0	72	23	63	0	0	0
Old Abe	42	45	31	0	0	0	176	139	107	0	0	0
Wissota	5	7	12	0	0	0	16	34	29	0	0	0
Chippewa Falls	0	0	1	0	0	0	0	0	2	0	0	0
Dells	1	1	1	0	0	0	2	3	3	0	0	0

Table 2. Total Purple Loosestrife Infestations (2018-2020).

	2018	2019	2020
Total number of loosetrife points at Impoundments	221	224	197
Total feet of shoreline affected in Impoundments	1010	710	902

Holcombe Flowage again contained the most purple loosestrife among the six impoundments surveyed. There were 123 locations categorized as present and two locations categorized as abundant (see Holcombe Flowage Map 1). While this represents a decrease in the number of infestations from the previous year, the overall length of shoreline infested actually increased from 2019. While a few new plants were found during the survey, the majority of the infested areas were documented in previous years. New infestations are generally associated with areas where the native vegetation has been disturbed. This disturbance can come from urbanization (clearing for home sites, swimming areas or fishing areas), road improvements, or erosion. It is also common to have plants grow only during select years. This may be the case on Holcombe Flowage, with new plants growing this year, while previously observed plants did not. One area of significant growth is the island in the middle of Poverty Bay. This area of infestation has been increasing over the years and is now classified as abundant for the first time.

The majority of plants on Holcombe Flowage were again found in the areas on and near Pine Island and along Highway 27. The infestation in these areas was similar to that documented in the previous two years, with the exception of the area immediately adjacent to the west side of Highway 27 which a showed a decrease in loosestrife growth (see Holcombe Map 2). Several small infestations were again found just to the east of the Highway 27 Bridge. This area had a similar degree of infestation last year. The second area classified as abundant this year was also classified as abundant in the previous two surveys. The length of infested shoreline in this area increased from 40 feet in 2018 to 55 feet in 2019 and 60 feet in 2020. No purple loosestrife was found on the Pine Lake or Cranberry Lake areas of Lake Holcombe.

Several plant clusters were found scattered along the north and south shorelines of the main flowage (see Holcombe Maps 3 and 4) with many of these plants having been documented in the past. The large islands near the south shoreline of the main flowage also contained several plants. Overall, the plant density in the main basin increased modestly from last year.

The upstream reaches of the flowage (see Holcombe Maps 5 and 6) contained a number of purple loosestrife plants that were noted in past surveys. The overall plant density in these areas was noticeably less than what was documented in 2019.

In total, approximately 698 feet of shoreline was found to contain purple loosestrife on Lake Holcombe compared to 511 feet in 2019 and 744 feet in 2018. As stated above, all infestations but two were classified as present.

Cornell Flowage includes 27 infestations classified as present and none as abundant (see maps of Cornell Flowage). Many of the infested sites were noted in previous surveys, however, several new plants were found in the upper reaches of the flowage. An area once classified as abundant, located in a low lying area on an island just upstream from the State Highway 64 Bridge, has been classified as present in the last few years. Both the number of loosestrife sites and the length of infested shoreline increased from 2019.

Thirty-one areas of loosestrife infestation were found on Old Abe Flowage (see map of Old Abe Flowage), all of which were classified as present. This is lower than the plant abundance from last year. Most of the locations consisted of single plants or a few plant clusters, many of which had been documented in past surveys. The total amount of shoreline infested by purple loosestrife this year was approximately 107 feet. This compares to 139 feet in 2019.

The number of purple loosestrife sites found on Lake Wissota increased from seven in 2019 to twelve in 2020. These locations are all minor infestations comprised of small plant clusters (see map of Lake Wissota). The length of shoreline infested on Lake Wissota, however, decreased from 34 feet in 2019 to 29 feet in 2020. Very little variability has been documented over the last three years.

Loosestrife was documented for the first time on Chippewa Falls Flowage since the surveys began. This single plant cluster amounted to two feet of affected shoreline.

A single loosestrife plant was again documented on Dells Pond in 2020 (the same location as found in 2019). This single plant amounted to just three feet of infested shoreline.

The minimum flow channel at Jim Falls Hydro remains infested with a relatively high concentration of purple loosestrife plants. A significant decrease in the number of plants was noted from 2011 to 2012, followed by a rebound in 2013 and 2014. A decline in 2015 and was followed by yet another increase in 2016. In 2017, the amount of loosestrife decreased again and remained essentially unchanged the following year. In 2019, the area again saw a rebound, although modest, only to be followed once again by a decrease this year (Table 3).

This year, loosestrife was found scattered throughout the channel, with the lower third being moderately infested (see maps of Jim Falls Spillway Channel).

Historically, the area of greatest loosestrife concentration at Jim Falls occurred just upstream from the County Highway Y Bridge (see Jim Falls Spillway map 2), however, loosestrife coverage in this area has steadily decreased from approximately 5,431 square feet in 2017 to 3,600 square feet in 2018 and 2,556 square feet in 2019. Loosestrife coverage in this area continues to decline with only 1,602 square feet infested this year (Table 4). The number of loosestrife sites and length of infected shoreline in both the upper and lower portions of the spillway channel decreased significantly from last year. Collectively, these locations accounted for 202 feet of infested shoreline versus 329 feet in 2019. Most of these locations were comprised of small plant clusters infesting between one and ten feet of shoreline, with a few more significant areas of infestation.

Ten years have passed since the introduction of the bio-control beetles into the Jim Falls minimum flow channel. While it is difficult to make a determination as to their success, the fact that the density of loosestrife in the lower area of the spillway channel continues to decrease, and the fact that loosestrife infestation in the remaining portion of the channel appears to be stabilizing, is encouraging.

Table 3. Purple Loosestrife Infestations in the Jim Falls Spillway Channel (2018 – 2020).

	2018	2019	2020
Total number of loosetrife points at Jim Falls Spillway	43	67	39
Sq feet of Fim Falls Spillway infestation near Hwy Y	3,600	2,556	1,602
Total other shoreline affected at Jim Falls Spillway	262	329	202

Table 4. 2020 Summary of Purple Loosestrife Infestations in Jim Falls Spillway Channel

Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
JF1	Present	Multiple	2556 sq ft
JF2	Present	Multiple	20 ft
JF3	Present	Multiple	5 ft
JF4	Present	Single	3 ft
JF5	Present	Multiple	10 ft
JF6	Present	Multiple	6 ft
JF7	Present	Single	4 ft
JF8	Present	Single	3 ft
JF9	Present	Multiple	16 ft
JF10	Present	Multiple	24 ft
JF11	Present	Single	4 ft
JF12	Present	Single	2 ft
JF13	Present	Single	6 ft
JF14	Present	Single	3 ft
JF15	Present	Single	2 ft
JF16	Present	Single	1 ft
JF17	Present	Single	3 ft
JF18	Present	Single	4 ft
JF19	Present	Multiple	12 ft
JF20	Present	Multiple	6 ft

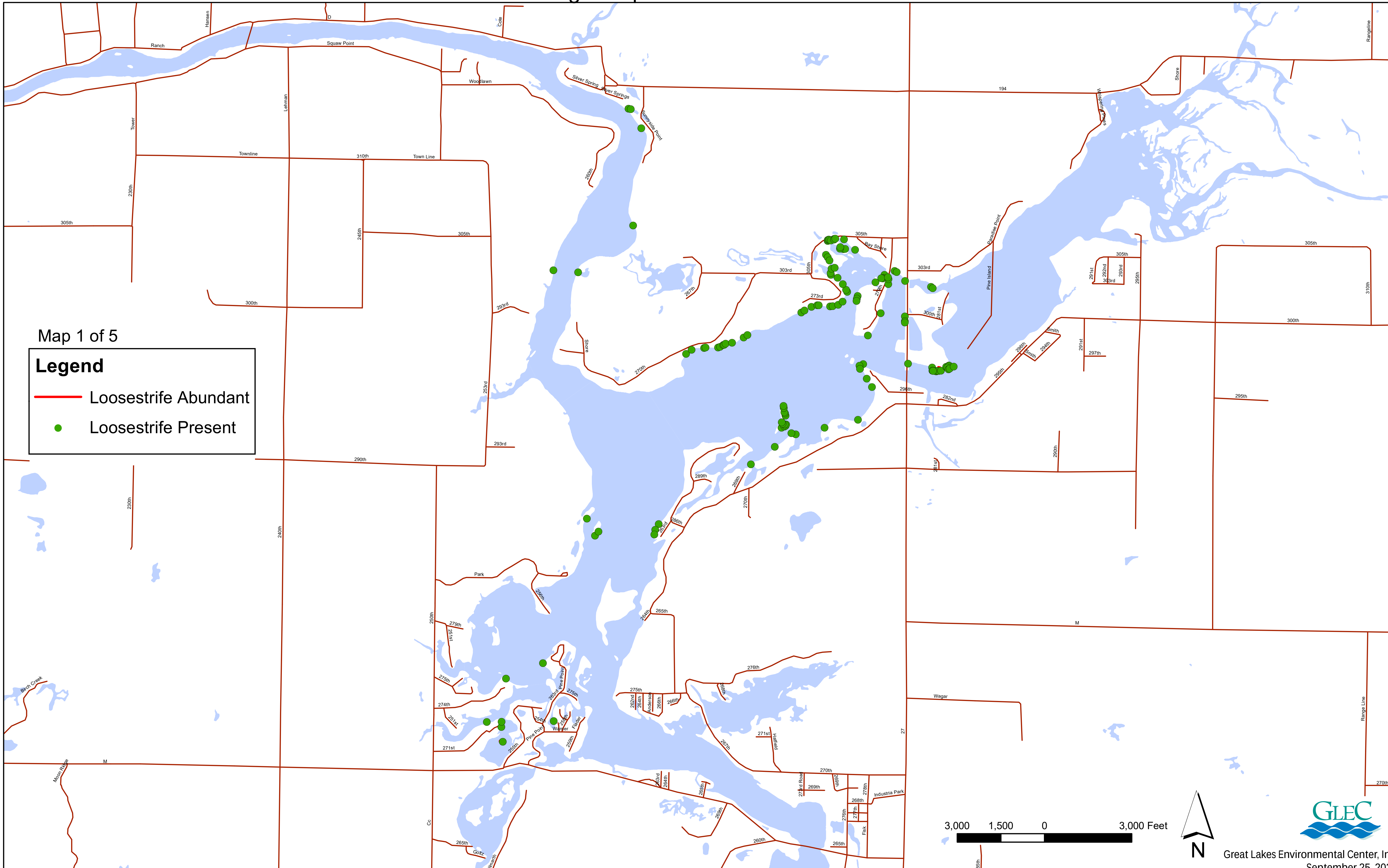
Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
JF21	Present	Single	1 ft
JF22	Present	Single	2 ft
JF23	Present	Single	3 ft
JF24	Present	Single	2 ft
JF25	Present	Multiple	4 ft
JF26	Present	Multiple	5 ft
JF27	Present	Multiple	11 ft
JF28	Present	Multiple	2 ft
JF29	Present	Single	5 ft
JF30	Present	Single	1 ft
JF31	Present	Multiple	6 ft
JF32	Present	Single	2 ft
JF33	Present	Single	4 ft
JF34	Present	Single	3 ft
JF35	Present	Single	2 ft
JF36	Present	Multiple	8 ft
JF37	Present	Multiple	3 ft
JF38	Present	Single	3 ft
JF39	Present	Single	1 ft

Appendix A

Survey Maps and Catalog of Purple Loosestrife Locations at Surveyed Flowages

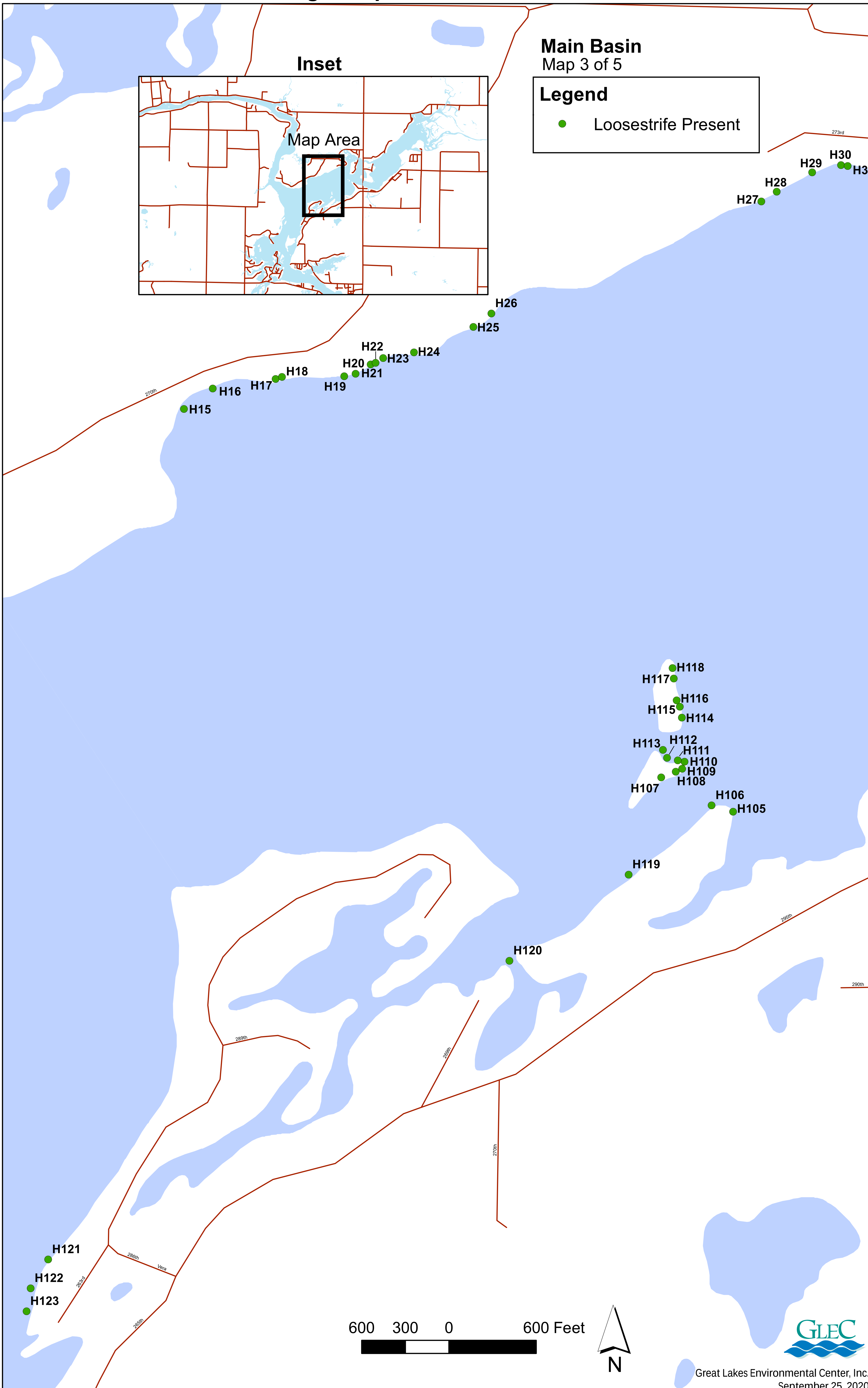
2020

Holcombe Flowage Purple Loosestrife Assessment - 2020

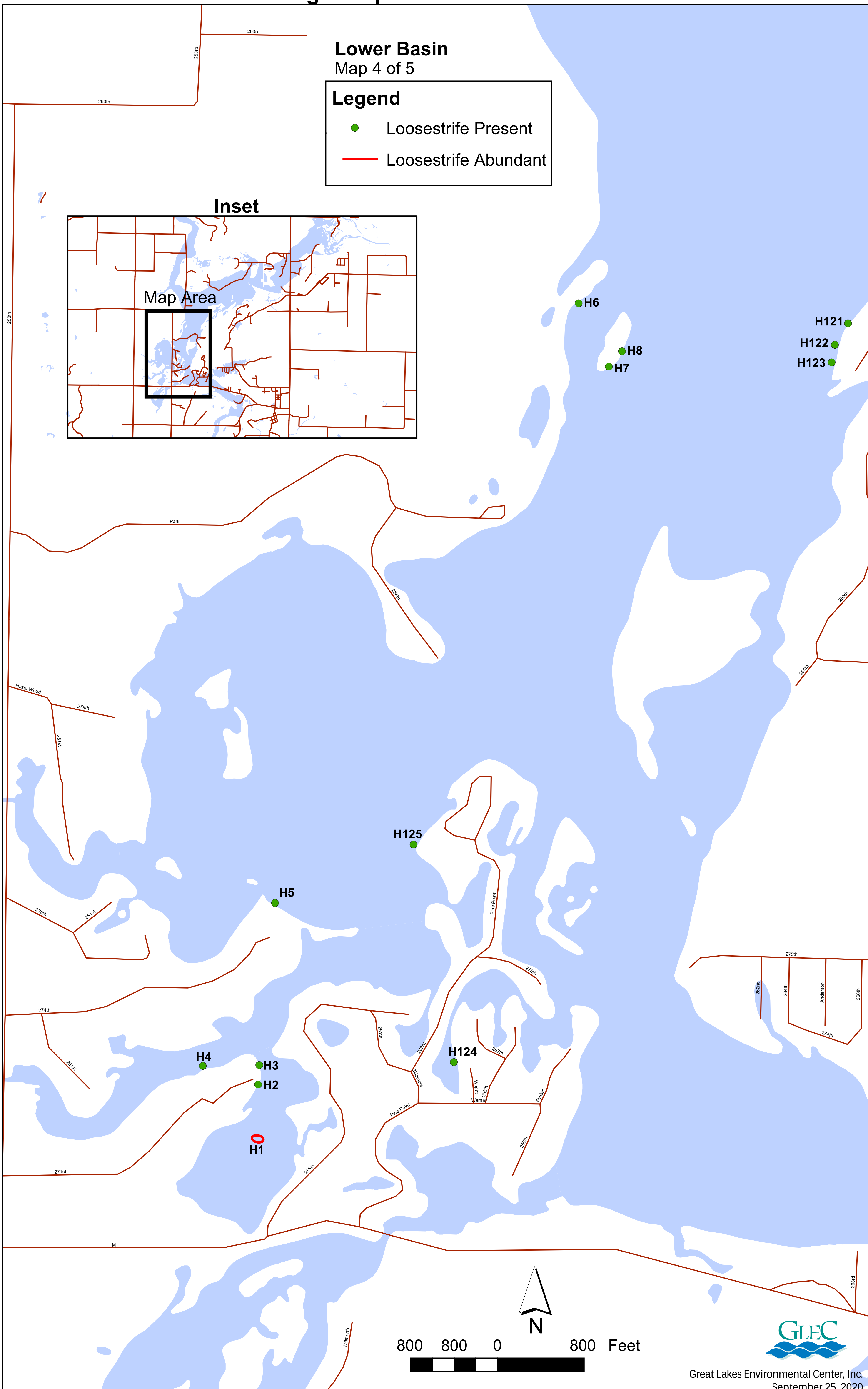


Holcombe Flowage Purple Loosestrife Assessment - 2020

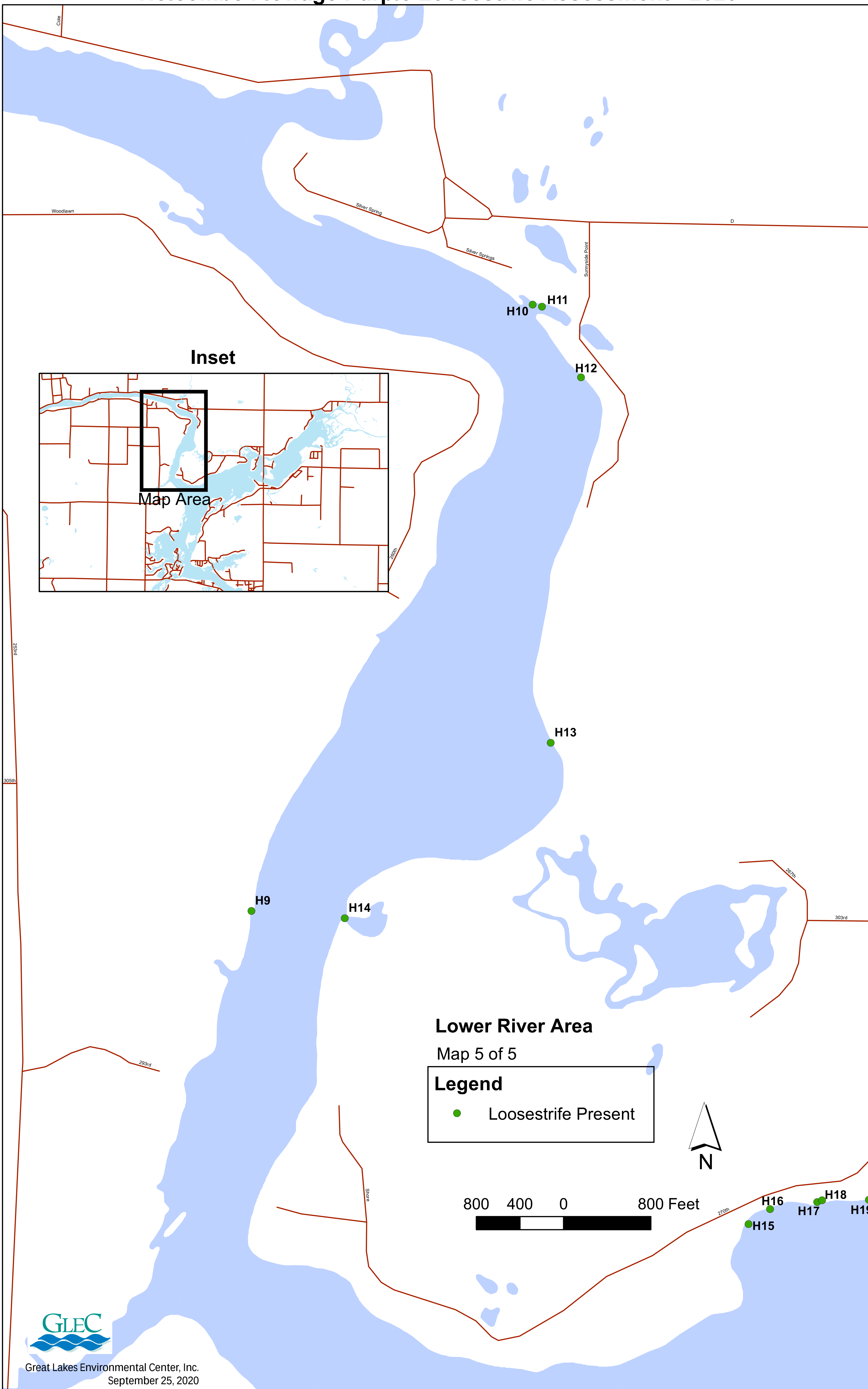
Holcombe Flowage Purple Loosestrife Assessment - 2020



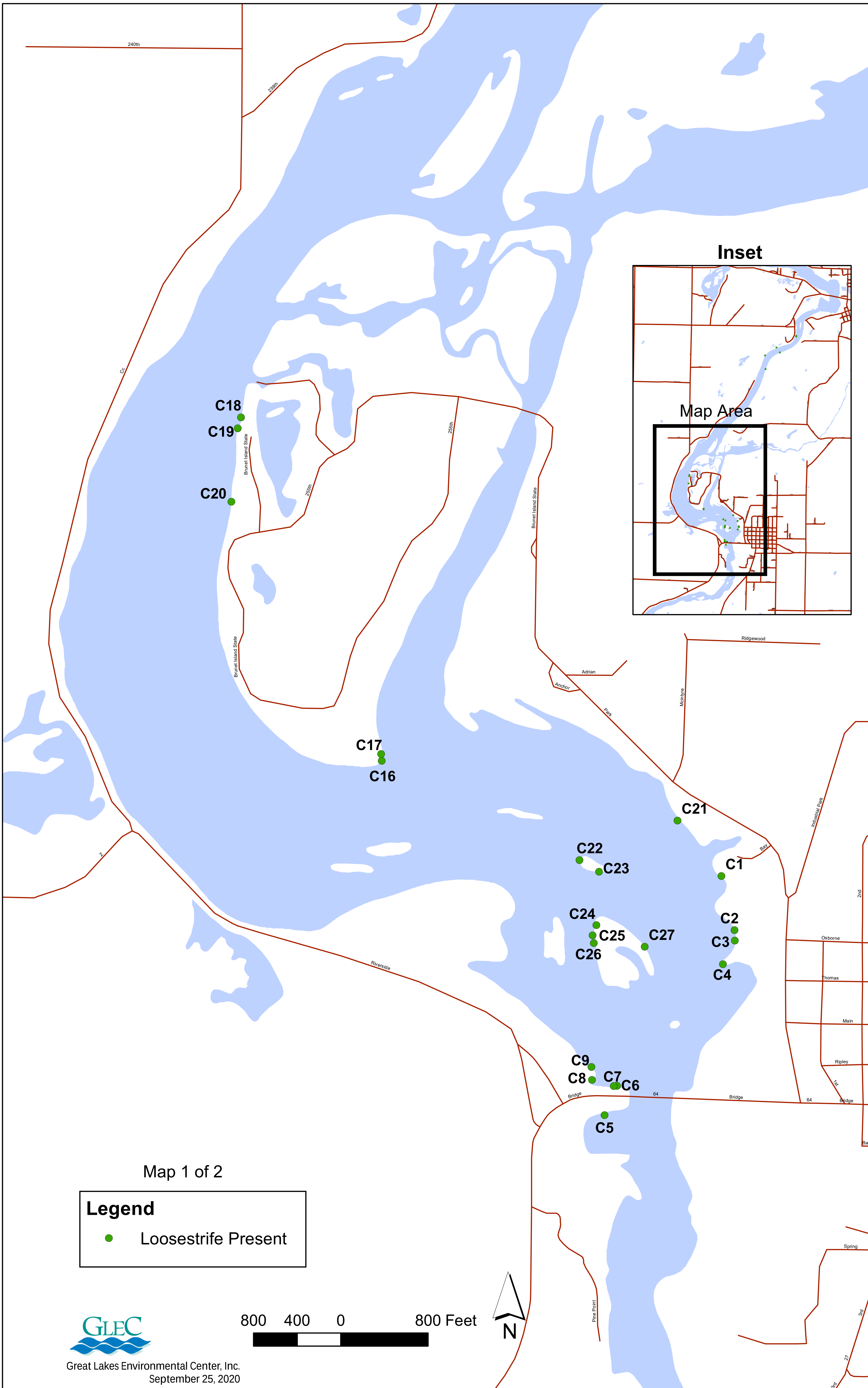
Holcombe Flowage Purple Loosestrife Assessment - 2020



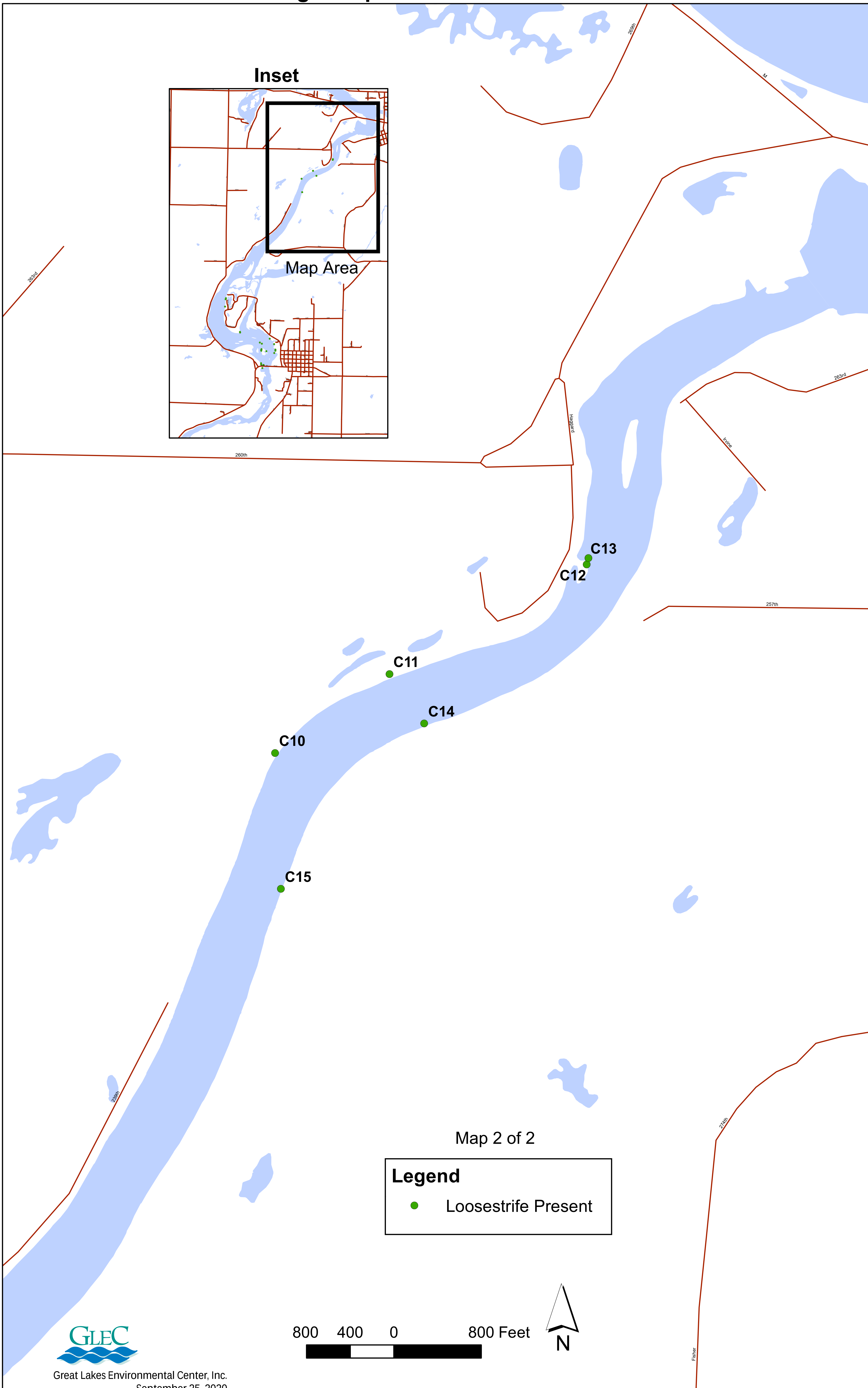
Holcombe Flowage Purple Loosestrife Assessment - 2020



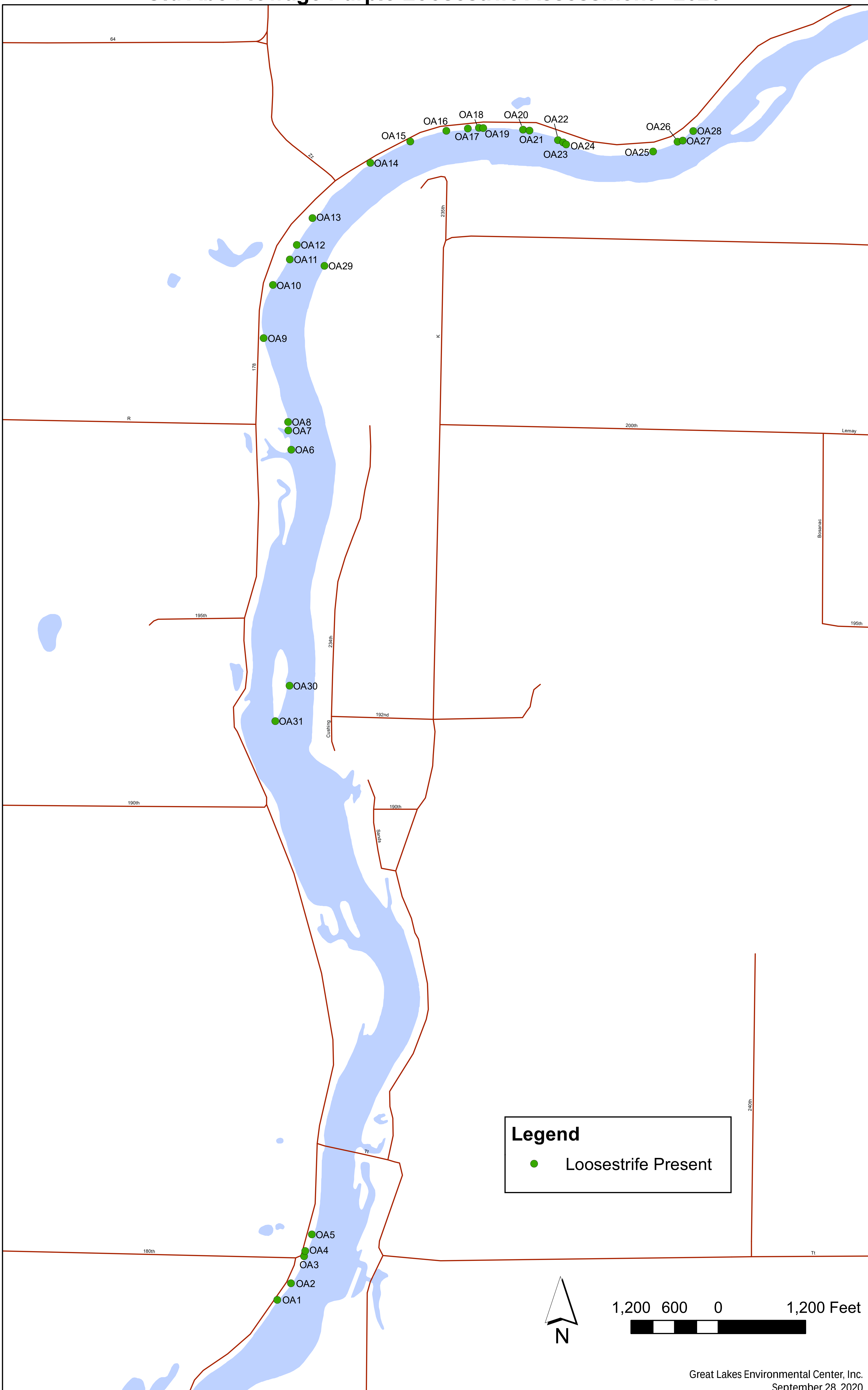
Cornell Flowage Purple Loosestrife Assessment - 2020



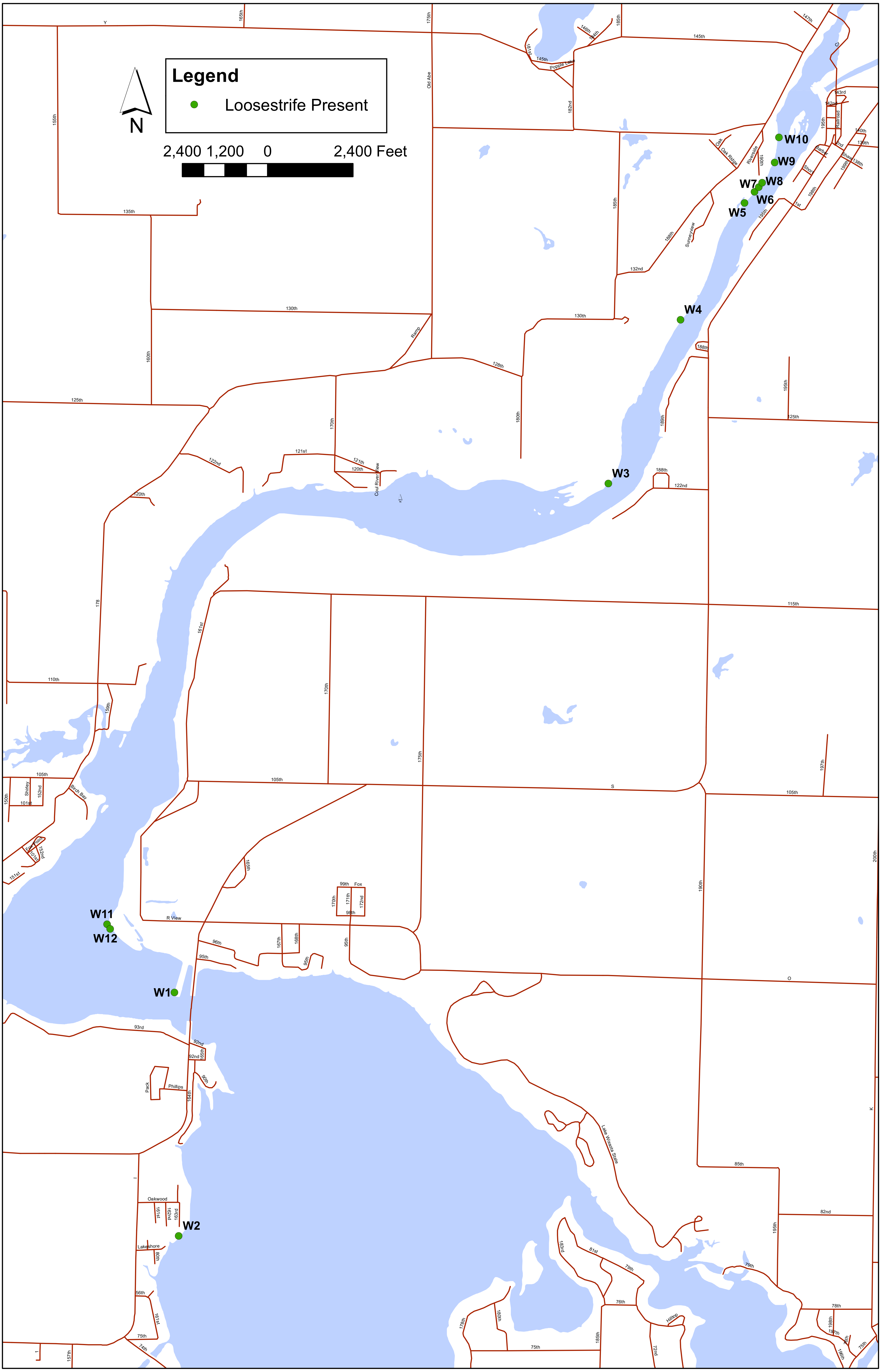
Cornell Flowage Purple Loosestrife Assessment - 2020



Old Abe Flowage Purple Loosestrife Assessment - 2020

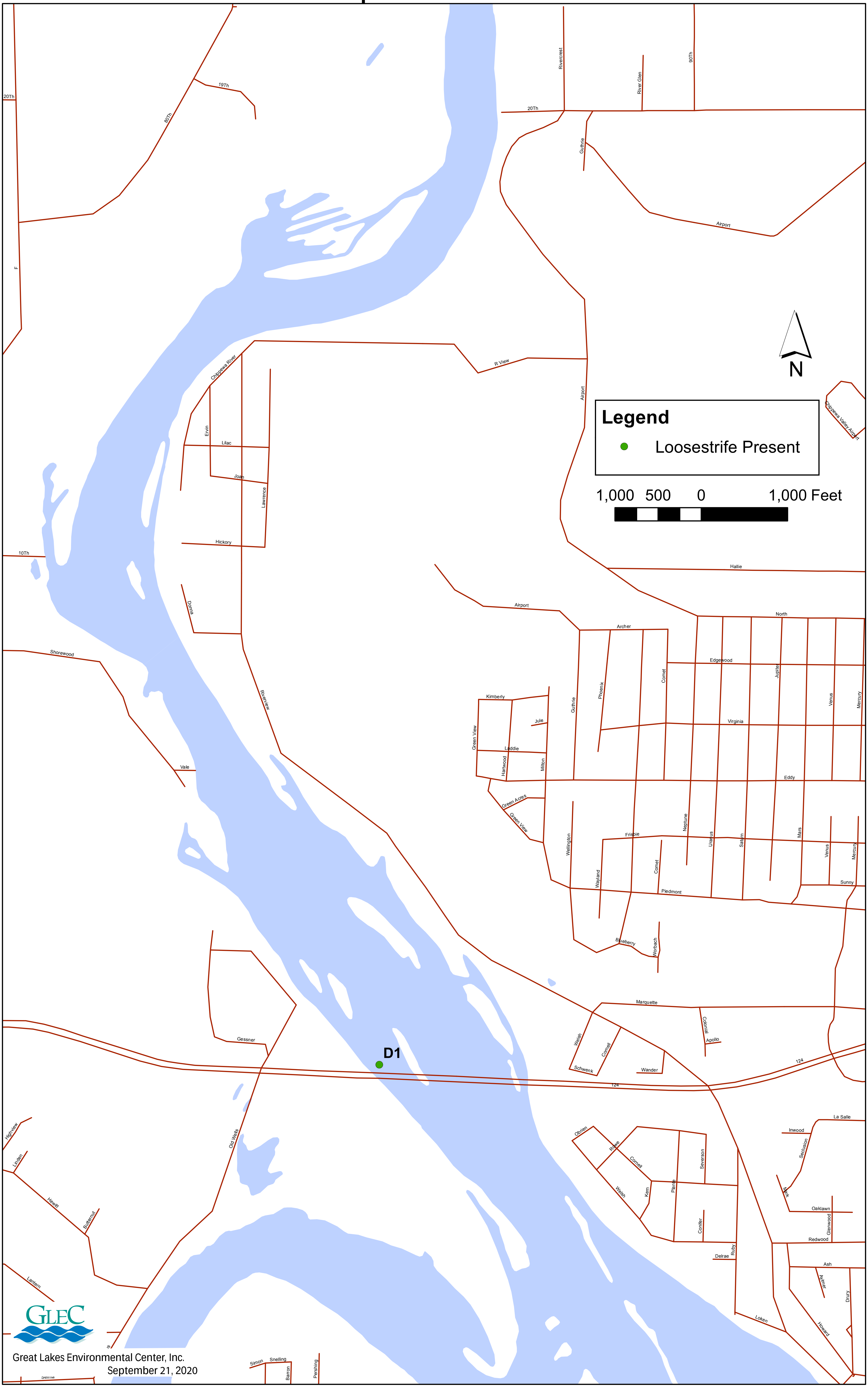


Lake Wissota Purple Loosestrife Assessment - 2020



Chippewa Falls Purple Loosestrife Assessment - 2020

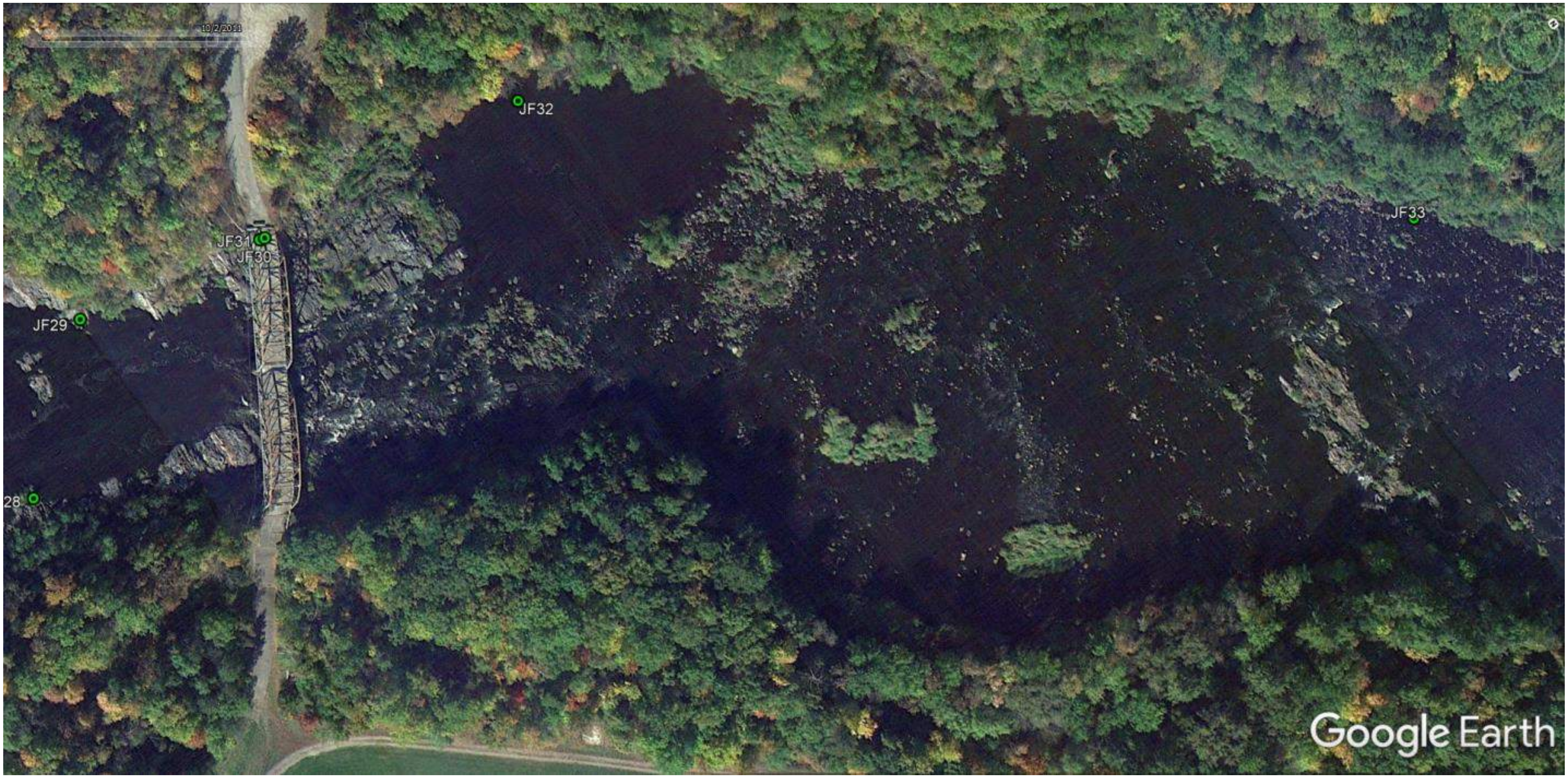
Dells Pond Purple Loosestrife Assessment - 2020



Jim Falls Spillway Channel Purple Loosestrife Assessment – 2020 (Map 1 of 4)

Jim Falls Spillway Channel Purple Loosestrife Assessment – 2020   (Map 2 of 4)

Jim Falls Spillway Channel Purple Loosestrife Assessment – 2020 (Map 3 of 4)



Jim Falls Spillway Channel Purple Loosestrife Assessment – 2020 (Map 4 of 4)

XCEL PURPLE LOOSESTRIFE LOCATIONS
2020
HOLCOMBE FLOWAGE

Location #	Degree of Infestation	Single / Multiple	Coverage (ft)	Location #	Degree of Infestation	Single / Multiple	Coverage (ft)	Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
H1	**Abundant**	Multiple	120	H43	**Present**	Multiple	12	H85	**Present**	Single	1
H2	**Present**	Single	1	H44	**Present**	Single	2	H86	**Present**	Multiple	5
H3	**Present**	Single	3	H45	**Present**	Single	2	H87	**Abundant**	Multiple	60
H4	**Present**	Single	3	H46	**Present**	Single	2	H88	**Present**	Multiple	18
H5	**Present**	Single	1	H47	**Present**	Multiple	8	H89	**Present**	Multiple	12
H6	**Present**	Multiple	2	H48	**Present**	Multiple	4	H90	**Present**	Multiple	9
H7	**Present**	Single	1	H49	**Present**	Multiple	6	H91	**Present**	Multiple	5
H8	**Present**	Multiple	4	H50	**Present**	Multiple	5	H92	**Present**	Single	2
H9	**Present**	Multiple	4	H51	**Present**	Multiple	7	H93	**Present**	Single	2
H10	**Present**	Single	1	H52	**Present**	Multiple	7	H94	**Present**	Multiple	5
H11	**Present**	Single	1	H53	**Present**	Multiple	4	H95	**Present**	Single	2
H12	**Present**	Single	2	H54	**Present**	Multiple	10	H96	**Present**	Single	2
H13	**Present**	Multiple	4	H55	**Present**	Multiple	8	H97	**Present**	Single	2
H14	**Present**	Single	2	H56	**Present**	Multiple	4	H98	**Present**	Multiple	3
H15	**Present**	Single	1	H57	**Present**	Multiple	10	H99	**Present**	Multiple	5
H16	**Present**	Single	2	H58	**Present**	Multiple	14	H100	**Present**	Multiple	12
H17	**Present**	Single	2	H59	**Present**	Single	3	H101	**Present**	Single	2
H18	**Present**	Multiple	7	H60	**Present**	Multiple	7	H102	**Present**	Single	2
H19	**Present**	Single	1	H61	**Present**	Multiple	4	H103	**Present**	Single	3
H20	**Present**	Single	3	H62	**Present**	Multiple	6	H104	**Present**	Single	1
H21	**Present**	Multiple	5	H63	**Present**	Multiple	15	H105	**Present**	Single	1
H22	**Present**	Single	2	H64	**Present**	Multiple	4	H106	**Present**	Multiple	2
H23	**Present**	Multiple	3	H65	**Present**	Multiple	6	H107	**Present**	Multiple	4
H24	**Present**	Single	1	H66	**Present**	Single	2	H108	**Present**	Single	1
H25	**Present**	Multiple	3	H67	**Present**	Multiple	4	H109	**Present**	Multiple	3
H26	**Present**	Multiple	2	H68	**Present**	Single	1	H110	**Present**	Multiple	9
H27	**Present**	Multiple	6	H69	**Present**	Single	2	H111	**Present**	Single	3
H28	**Present**	Multiple	3	H70	**Present**	Single	1	H112	**Present**	Multiple	2
H29	**Present**	Single	2	H71	**Present**	Multiple	13	H113	**Present**	Single	2
H30	**Present**	Multiple	2	H72	**Present**	Single	4	H114	**Present**	Single	2
H31	**Present**	Single	1	H73	**Present**	Multiple	10	H115	**Present**	Single	1
H32	**Present**	Single	1	H74	**Present**	Multiple	3	H116	**Present**	Multiple	4
H33	**Present**	Single	2	H75	**Present**	Multiple	5	H117	**Present**	Single	1
H34	**Present**	Single	1	H76	**Present**	Single	1	H118	**Present**	Single	1
H35	**Present**	Multiple	5	H77	**Present**	Single	3	H119	**Present**	Single	1
H36	**Present**	Multiple	10	H78	**Present**	Single	3	H120	**Present**	Single	1
H37	**Present**	Multiple	14	H79	**Present**	Single	4	H121	**Present**	Single	3
H38	**Present**	Multiple	6	H80	**Present**	Single	5	H122	**Present**	Multiple	8
H39	**Present**	Single	2	H81	**Present**	Multiple	6	H123	**Present**	Multiple	4
H40	**Present**	Single	1	H82	**Present**	Multiple	8	H124	**Present**	Single	2
H41	**Present**	Multiple	8	H83	**Present**	Multiple	7	H125	**Present**	Multiple	2
H42	**Present**	Multiple	8	H84	**Present**	Single	3				

XCEL PURPLE LOOSESTRIFE LOCATIONS
2020
CORNELL FLOWAGE

Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
C1	Present	Single	1
C2	Present	Single	1
C3	Present	Single	1
C4	Present	Single	1
C5	Present	Single	2
C6	Present	Single	3
C7	Present	Single	1
C8	Present	Single	3
C9	Present	Single	2
C10	Present	Single	2
C11	Present	Single	1
C12	Present	Single	2
C13	Present	Multiple	2
C14	Present	Single	1
C15	Present	Single	3
C16	Present	Multiple	3
C17	Present	Single	1
C18	Present	Single	1
C19	Present	Multiple	4
C20	Present	Single	2
C21	Present	Single	1
C22	Present	Single	1
C23	Present	Single	2
C24	Present	Multiple	6
C25	Present	Multiple	3
C26	Present	Multiple	12
C27	Present	Single	1

XCEL PURPLE LOOSESTRIFE LOCATIONS
2020
OLD ABE FLOWAGE

Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
OA1	Present	Multiple	4
OA2	Present	Single	2
OA3	Present	Multiple	3
OA4	Present	Single	1
OA5	Present	Multiple	6
OA6	Present	Single	2
OA7	Present	Single	1
OA8	Present	Single	2
OA9	Present	Single	1
OA10	Present	Single	3
OA11	Present	Single	2
OA12	Present	Multiple	2
OA13	Present	Single	3
OA14	Present	Multiple	5
OA15	Present	Single	1
OA16	Present	Single	1
OA17	Present	Single	2
OA18	Present	Single	1
OA19	Present	Multiple	3
OA20	Present	Multiple	4
OA21	Present	Single	1
OA22	Present	Multiple	8
OA23	Present	Multiple	4
OA24	Present	Multiple	5
OA25	Present	Multiple	9
OA26	Present	Multiple	10
OA27	Present	Multiple	6
OA28	Present	Multiple	7
OA29	Present	Single	2
OA30	Present	Single	1
OA31	Present	Multiple	5

XCEL PURPLE LOOSESTRIFE LOCATIONS
2020
LAKE WISSOTA

Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
W1	Present	Single	1
W2	Present	Single	2
W3	Present	Multiple	3
W4	Present	Single	2
W5	Present	Single	3
W6	Present	Single	2
W7	Present	Single	1
W8	Present	Single	2
W9	Present	Multiple	7
W10	Present	Single	2
W11	Present	Single	2
W12	Present	Single	2

XCEL PURPLE LOOSESTRIFE LOCATIONS
2020
CHIPPEWA FALLS FLOWAGE

Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
CF1	**Present**	Single	2

XCEL PURPLE LOOSESTRIFE LOCATIONS
2020
DELLS POND

Location #	Degree of Infestation	Single / Multiple	Coverage (ft)
D1	**Present**	Single	3

Document Content(s)

APPENDIX E-25 2015 WDNR SWIMS Data

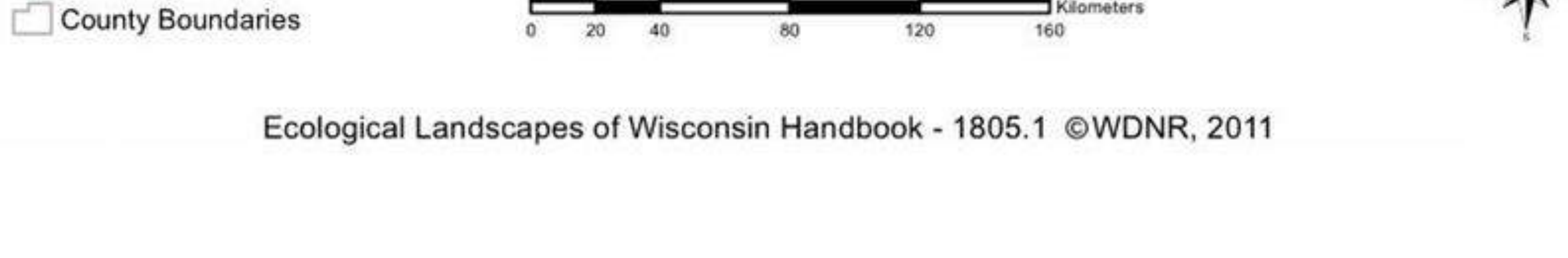
91288	SWIMS	Did you look for Banded mystery snails?	Yes		9/8/2015 8:00	
91872	SWIMS	Did you look for asiatic clam (Corbicula)?	Yes		9/8/2015 8:00	
91164	SWIMS	Did you look for Eurasian Water-Milfoil?	Yes		9/8/2015 8:00	
91163	SWIMS	Did you look for Brazilian waterweed?	Yes		9/8/2015 8:00	
91162	SWIMS	Did you look for Hydrilla?	Yes		9/8/2015 8:00	
91161	SWIMS	Did you look for Flowering Rush?	Yes		9/8/2015 8:00	
91159	SWIMS	Did you look for phragmites?	Yes		9/8/2015 8:00	
91158	SWIMS	Did you look for purple loosestrife?	Yes		9/8/2015 8:00	
91901	SWIMS	Did you look for Fishhook Waterfleas?	Yes		9/8/2015 8:00	
91900	SWIMS	Did you look for Spiny Waterfleas?	Yes		9/8/2015 8:00	
91873	SWIMS	Did you look for rusty crayfish?	Yes		9/8/2015 8:00	
91157	SWIMS	Did you look for Japanese Knotweed?	Yes		9/8/2015 8:00	
91896	SWIMS	Did you look for Yellow Flag Iris?	Yes		9/8/2015 8:00	
91899	SWIMS	Did you look for Water Chestnut?	Yes		9/8/2015 8:00	
91167	SWIMS	Did you look for Didymo?	Yes		9/8/2015 8:00	
91895	SWIMS	Did you look for Water Lettuce?	Yes		9/8/2015 8:00	
91894	SWIMS	Did you look for Water Hyacinth?	Yes		9/8/2015 8:00	
91893	SWIMS	Did you look for Parrot Feather?	Yes		9/8/2015 8:00	
91892	SWIMS	Did you look for Fanwort?	Yes		9/8/2015 8:00	
91891	SWIMS	Did you look for European frogbit	Yes		9/8/2015 8:00	
91287	SWIMS	Did you look for Chinese mystery snails?	Yes		9/8/2015 8:00	
91171	SWIMS	Did you look for Red Swamp Crayfish?	Yes		9/8/2015 8:00	
91172	SWIMS	Did you look for Faucet Snails?	Yes		9/8/2015 8:00	
91170	SWIMS	Did you look for New Zealand Mudsnails?	Yes		9/8/2015 8:00	
91169	SWIMS	Did you look for Zebra Mussels?	Yes		9/8/2015 8:00	
91168	SWIMS	Did you look for Quagga Mussels?	Yes		9/8/2015 8:00	
91166	SWIMS	Did you look for Yellow Floating Heart?	Yes		9/8/2015 8:00	
91165	SWIMS	Did you look for Curly-Leaf Pondweed?	Yes		9/8/2015 8:00	
90881	SWIMS	Total Paid Hours Spent	6	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
49701	DNR_STORET	SECCHI DEPTH - FEET	1 FEET	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40028	SWIMS	Did you collect a sample and bring it to a DNR office? If so, which offic	Jodi Lepsch	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.1739	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1721	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40039	SWIMS	Water Flea Tow Method	horizontal tows (near surface)	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91846	SWIMS	Depth Sampled	1 METERS	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40040	SWIMS	Diameter of zooplankton net opening	50cm	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91376	SWIMS	Has Ethanol been added to the sample?	YES	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40071	SWIMS	Have you consolidated all of your samples into one composite bottle?	YES	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91847	SWIMS	Sample sent to, Date	########	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.1739	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1721	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40039	SWIMS	Water Flea Tow Method	horizontal tows (near surface)	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91846	SWIMS	Depth Sampled	1 METERS	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40040	SWIMS	Diameter of zooplankton net opening	50cm	AIS Early D	9/8/2015 8:00	9/8/2015 8:00

91376	SWIMS	Has Ethanol been added to the sample?	YES	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40071	SWIMS	Have you consolidated all of your samples into one composite bottle?	YES	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91847	SWIMS	Sample sent to, Date	########	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.1739	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1721	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40039	SWIMS	Water Flea Tow Method	horizontal tows (near surface)	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91846	SWIMS	Depth Sampled	1 METERS	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40040	SWIMS	Diameter of zooplankton net opening	50cm	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91376	SWIMS	Has Ethanol been added to the sample?	YES	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40071	SWIMS	Have you consolidated all of your samples into one composite bottle?	YES	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91847	SWIMS	Sample sent to, Date	########	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Meander Survey 1	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.1742	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1619	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
20043	SWIMS	Species Name	Eurasian Water-Milfoil	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91197	SWIMS	Density of Aquatic Invasive Species (1)	2-one or a few plant beds or color	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91942	SWIMS	Was the aquatic invasive species found live or dead?	Live	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91888	SWIMS	Did you collect a specimen sample?	YES	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91889	SWIMS	Did you take a photo?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Boat Landing 1	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.17201	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1545	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Meander Survey 2	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.16876	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1555	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Search Site 1	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.16543	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1572	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
20043	SWIMS	Species Name	Purple Loosestrife	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91197	SWIMS	Density of Aquatic Invasive Species (1)	1-a few plants or invertebrates	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91942	SWIMS	Was the aquatic invasive species found live or dead?	Live	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91888	SWIMS	Did you collect a specimen sample?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91889	SWIMS	Did you take a photo?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Search Site 2	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.17363	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.17	AIS Early D	9/8/2015 8:00	9/8/2015 8:00

91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Search Site 3	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.17399	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1778	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
20043	SWIMS	Species Name	Eurasian Water-Milfoil	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91197	SWIMS	Density of Aquatic Invasive Species (1)	2-one or a few plant beds or color	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91942	SWIMS	Was the aquatic invasive species found live or dead?	Live	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91888	SWIMS	Did you collect a specimen sample?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91889	SWIMS	Did you take a photo?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91198	SWIMS	Species Name (2)	Rusty Crayfish	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91199	SWIMS	Density of Aquatic Invasive Species (2)	1-a few plants or invertebrates	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91943	SWIMS	Was the aquatic invasive species found live or dead? (2)	Live	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91932	SWIMS	Did you collect a specimen sample? (2)	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91935	SWIMS	Did you take a photo? (2)	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Search Site 4	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.18837	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1634	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Search Site 5	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.18837	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1604	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
20043	SWIMS	Species Name	Eurasian Water-Milfoil	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91197	SWIMS	Density of Aquatic Invasive Species (1)	2-one or a few plant beds or color	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91942	SWIMS	Was the aquatic invasive species found live or dead?	Live	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91888	SWIMS	Did you collect a specimen sample?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91889	SWIMS	Did you take a photo?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91196	SWIMS	Site Number	Boat Landing 2	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40056	SWIMS	Latitude of sample	45.18018	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40057	SWIMS	Longitude of sample	-91.1644	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91360	SWIMS	Did you snorkel the search sites?	NO	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
91631	SWIMS	If you did not snorkel, why not?	Stained	AIS Early D	9/8/2015 8:00	9/8/2015 8:00
40072	SWIMS	Volume of sample that was analyzed (ml)	30 ML		9/8/2015 8:00	9/8/2015 8:00
40073	SWIMS	Date sample was analyzed	1/8/2016		9/8/2015 8:00	9/8/2015 8:00
40074	SWIMS	Name of plankton sample analyst	Gina LaLiberte		9/8/2015 8:00	9/8/2015 8:00
20001	SWIMS	SPINY WATER FLEA	No		9/8/2015 8:00	9/8/2015 8:00
20000	SWIMS	FISHHOOK WATER FLEA	No		9/8/2015 8:00	9/8/2015 8:00

APPENDIX E-26: Ecological Landscapes of Wisconsin Map

Wisconsin was divided into 16 ecoregions with similar ecology and management opportunities. Each of these ecoregions is called an Ecological Landscape. The Ecological Landscapes are based on the National Hierarchical Framework of Ecological Units (NHFEU; Cleland et al. 1997). There were too many NHFEU Subsections and too few NHFEU Sections to be useful for management purposes. Ecological Landscapes use the same boundaries as NHFEU Sections or Subsections. However, some NHFEU Subsections were combined to reduce the number of geographical units in the state to a manageable number. Therefore, Ecological Landscapes are at a size (scale) between NHFEU Sections and Subsections.

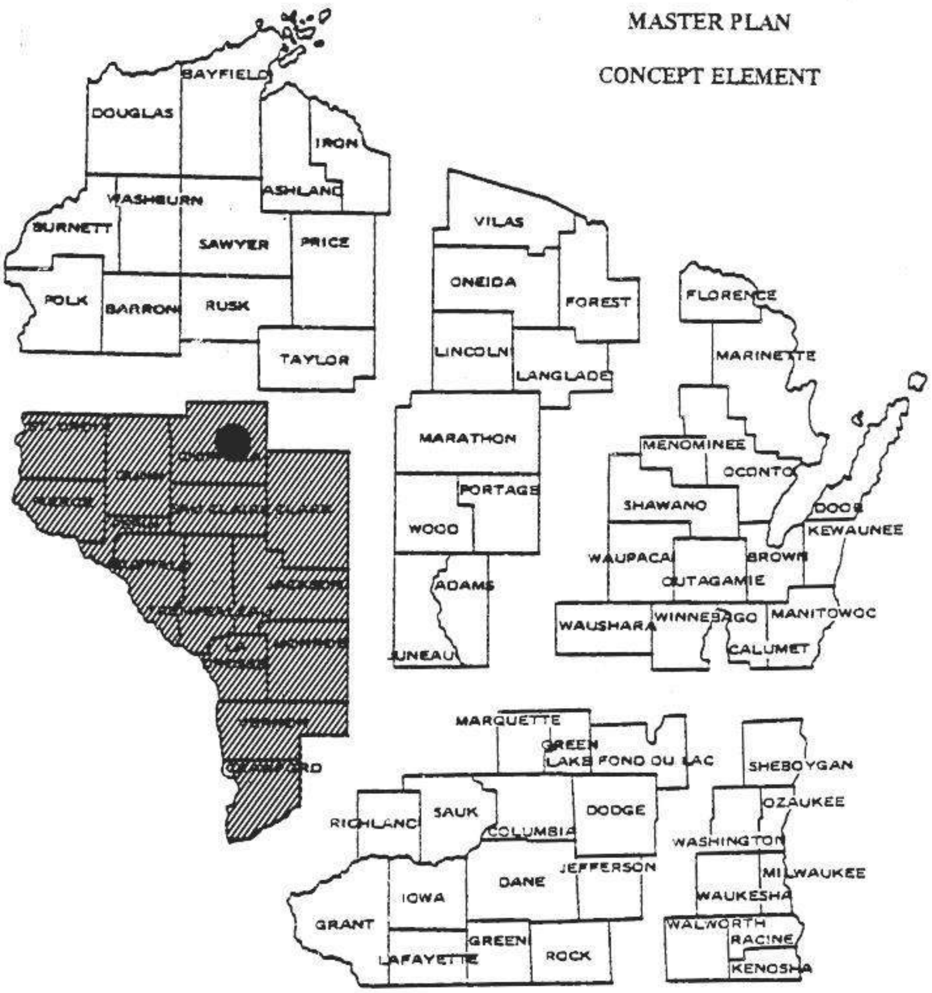


APPENDIX E-27 Brunet Island State Park Master Plan

BRUNET ISLAND STATE PARK

MASTER PLAN

CONCEPT ELEMENT



Property Task Force

Leader: Mike Ries, Park Planner
Ed Ferber, Park Manager
Larry Moussette, Park Ranger
Brian Marinello, Forest Manager
Rolland Nesbit, Wildlife Manager
Doug Erickson, Fish Manager
Gary Olson, Real Estate
Tom Harris, Warden

Approved By: MRB

Date: 3/27/86

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
MADISON, WISCONSIN

Table of Contents

SECTION I - ACTION

A. GOAL, OBJECTIVES, AND ADDITIONAL BENEFITS

Goal

To provide a scenic state park which will serve the recreational, educational, and nature experience needs of the property visitor, while preserving and protecting the resource for present and future generations.

Annual Objectives

1. Provide and maintain recreational facilities to accommodate 180,000 picnickers, swimmers, and other day users.

2. Provide a quality recreational experience for 23,000 campers by maintaining family camping facilities.

3. Provide and maintain trails to accommodate 10,000 hikers and cross-country skiers.

4. Provide and maintain self-guided nature trails, interpretive displays, and programs for 10,000 users.

5. Provide boat and canoe access to the Chippewa and Fisher Rivers for 2,500 watercraft.

6. Manage and maintain the property's scenic and natural qualities by restoring and maintaining a diversity of vegetative cover types for the life of the property.

7. Accommodate individuals who are handicapped through the proper design, construction, and management of the property and its facilities.

Additional Benefits

1. Provide for other recreational and educational uses including bird watching, wildlife observation, gathering of nuts, berries, and mushrooms, and photography.

2. Protect a bald eagle nest site.

B. RECOMMENDED MANAGEMENT AND DEVELOPMENT PROGRAM

Moderate additional development on existing state-owned land calls for providing facilities such as: a shower building, upgrading the north and south campgrounds, constructing a group camp, and replacement of facilities and furnishings as needed. In addition, hiking and ski trails will be upgraded, and the roads and parking areas will be resurfaced. Shelters will be constructed in the various day use areas, and a permanent contact station will be constructed at the park entrance.

This alternative is desirable in that it will ensure the maintenance of a high-quality recreational facility and maximize user enjoyment. This also allows for moderate increase in use.

It is proposed to transfer fire control and law enforcement personnel and equipment from the Cornell Ranger Station to Brunet Island State Park to increase operational efficiency for the Department and to provide better public service. This consolidation effort involves moving four fire control workers and one conservation warden to the park. To accomplish this, it will be necessary to construct a storage shed for heavy equipment and to provide additional office space. Added utilities will be needed as well as the construction and revamping of the present parking lot and road system near the office. The existing shop roof should also be rebuilt to eliminate ice buildup during the winter months. Funding for this $167,000 project will come from fire control and other affected programs.

All areas proposed for development will be examined for the presence of endangered or threatened animals and plants. If such species are found, development will be suspended until the District Endangered and Nongame Species Coordinator is consulted, the site evaluated, and appropriate protective measures taken. In addition, prior to any major ground disturbing activities within the park, the Department will consult the State Historical Society to determine whether archaeological or historical testing is necessary.

1. Development

Over the next 10 years, minimal new development and a number of major building maintenance items are proposed for Brunet Island State Park.

Phase 1 development will provide for the construction of a toilet-shower building located near the south campground. This facility will serve campers from both the north and south campgrounds. A four-unit, combination vault toilet will be constructed to more adequately serve day visitors in adjacent use areas and campers when water is shut off in the flush building during periods of freezing temperatures. The garage at the park residence is in poor condition and therefore will be replaced with a new two-stall garage.

Campsites will be rehabilitated in the north and south campgrounds. Spurs will be regraveled and camp pads will be leveled and reseeded as needed. A variety of tree and shrub species will be planted to provide both shade and screening. Finally, the south campground road will be asphalted and the north campground road sealcoated.

A rustic group camp (maximum capacity 100) is proposed for an area located east of the Fisher River and approximately 600 feet north of the existing park office. There is increasing demand from church, civic, and scouting groups for this type of facility at Brunet Island. Youth groups canoeing the Chippewa River have to use the family campground for overnight accommodations. The proposed group camp will serve these types of users.

Development of the group camp will include an 8-unit pit toilet, a well and hand pump, a shelter, site preparation and campsite furnishings. A 10-stall parking lot will be located near the trailer dumping station for group camp user vehicles. Additional parking, if needed, will be provided for in the office parking lot. Walk-in and limited vehicle access to the site for dropping off campers and supplies will be via an existing combination hiking-cross country ski trail/service drive. The overhead electric line paralleling the hiking-cross country ski trail will be buried in conjunction with the group camp and trail development work. In addition, the Club Moss Nature Trail will be surfaced with limestone screenings or similar material.

Miscellaneous actions will include resurfacing the park roads and parking lots, asphalting the boat launch parking lot, revision of the beach area parking lot, and painting and striping the roads. Grills, tables, fire rings, and three water fountains in the day use area will be replaced as needed. A park entrance sign will be constructed near the contact station to replace the existing deteriorated sign. A combination of riprap, retaining wall structures, and stairways will be constructed to repair erosion caused by park users cutting paths down the steep banks to get to the water' edge. General landscape planting, vista clearing, grouping and screening of garbage cans will take place to maximize park aesthetics. Boundary signing and a survey of the southwest portion of the property will be done to better define the park boundary. Finally, a sand blanket will be placed on the beach to cover the sharp gravel, stones, and small rocks that are working their way to the surface.

Phase 2 will include the construction of a permanent contact station to replace the present temporary structure. The hiking and cross country ski trails will be improved as needed, a shelter will be constructed in the day use area near the ball field, and an amphitheater will be built in the use area across from the south campground. Picnic tables, grills, fire rings, and other furnishings will also be replaced as warranted. Landscape planting in the intensive and extensive use areas will continue as needed.

During Phase 3, three four-unit pit toilets will be constructed in the north campground to replace the present facilities which are nearing the end of their useful life. A shelter will be built in the boat mooring picnic area and playground equipment (new and replacement) will be provided in the various day use areas. Any addition to the existing storage building would also occur during Phase 3 development. Finally, this phase will see the continuation of intensive area landscaping and the renovation and/or replacement picnic tables, grills, and other furnishings and facilities.

Total estimated development costs based on 1985 figures is $500,000. All proposed development will be dependent upon available funds and statewide priorities. Additional and/or up-to-date justification will also be required.

2. Management

   a. Facility

      The park is presently operated on a seven-month basis with a seasonal park ranger and a manager who is also in charge of the Cornell ranger station. In addition, approximately 11 limited-term employees (LTE's) are hired during the summer months with responsibility for sticker sales, maintenance, lifeguarding, and law enforcement.

      A limited term naturalist is also hired from Memorial Day to Labor Day at 20 hours per week. The log pavilion is used for evening programs and a 3/4-mile self-guided nature trail is available for interpretive purposes.

      If the park again becomes a year-round park, the parks program budget will not be expected to carry the additional financial burden.

      Options for keeping the park in operation through the winter can be investigated such as using existing personnel out of the Cornell Ranger Station, a local unit of government, or a service group by agreement.

      As a unit of the Wisconsin State Park system, Brunet Island has been developed and managed under Chapter 27, Laws of Wisconsin; specifically, Section 27.01, which governs state parks. The property is also managed under the provisions of Wisconsin Administrative Code 45, which contains the rules of the Wisconsin Department of Natural Resources pertaining to the conduct of visitors at state parks, state forests, and other properties under the jurisdiction of the Department.

      Presently, fire protection for the park is provided by the Cornell Fire Department for the buildings and by the Cornell Ranger Station for the natural areas of the property.

b. Vegetative Management (Fig. 4)

The vegetative management goal will be to maintain the health, vigor and diversity of the park's vegetation. To achieve this goal the following steps will be taken in accordance with Manual Code 2532.

Of the 208 acres of hemlock-hardwoods, two areas of five acres each are proposed for regeneration and maintenance of the hemlock type. The two areas will be carefully scarified and seeded with hemlock seed. Follow-up planting with hemlock transplants will provide supplemental stocking of the two areas. A fence will be constructed around each area to exclude deer. Progress of the project will be monitored at least once a year to observe results and determine the need for more seeding or planting. The procedure will be educational.

The park contains 163 acres of nearly pure stands of aspen. Of this acreage, approximately 23 acres of very high quality bigtooth aspen will be managed by cutting to maintain the vigor of this type for diversity and wildlife habitat. Aspen not managed will be left to decline in vigor and be replaced by red maple and eventually sugar maple.

Of the 66 acres of white birch at Brunet Island, 10 acres will be managed to maintain this aesthetically pleasing type. Management practices will include thinning to a prescribed density and scarification to expose bare mineral soil for a seed bed. Thinning will continue every ten years to promote big trees and growth of the birch seedlings and saplings.

Initially, the 22-acre fir-spruce plantation will be thinned to remove some hardwoods, tall trees and small, suppressed white spruce. Thinning will continue at ten-year intervals to promote vigorous large diameter trees. Better hardwoods in the stand like yellow birch will be left for diversity.

There are 17 acres of red pine plantation. Stands will be selectively marked and commercially thinned to promote rapid growth of large, healthy, natural looking pine trees.

Eight acres of the ten-acre 1977 tornado blow-down site will be planted to large seedlings or small saplings of red oak, white ash, sugar maple plus white pine transplants. Two acres will remain as is without any type of planting or management to serve as a comparison for educational and interpretive purposes.

In total, about 13 percent of the park's forested acreage will receive some type of vegetative management.

Since a complete biological inventory of the property does not exist, it is recommended that an inventory be conducted as funds permit or be undertaken though the voluntary efforts of the local university system.

c. Wildlife Management

There is no specific management proposed for the fauna or amphibian species on the property other than maintaining the status quo. However, in an effort to add to the learning experience, a variety of songbird and wood duck houses may be constructed and placed in strategic locations with appropriate explanatory signs. The active bald eagle nest and any others that may be constructed on park property will be protected per guidelines established by the Department. Vegetative management will provide habitat for a wide variety of wildlife species which, in turn, will add to the experience of park users.

The deer herd is in balance with the range and no thinning of the herd is necessary.

d. Fish Management

The Cornell Flowage is currently managed for the major game fish species: walleye, musky, small south bass, catfish, and sturgeon, as well as bluegill, black crappie, perch, and rock bass. Muskellunge is the only species that has been stocked annually in recent years, however, this practice will be reduced to biennial stocking. Artificial habitats should be installed for panfish and forage fish to promote the increase in numbers of these species. This will provide anglers increased fishing opportunities and expand the forage base for predators, particularly walleyes. Stocking of bluegills and/or perch should be encouraged when they are available. No regulation changes are recommended at this time.

A variety of length, season, and bag limits have regulated fishing in the flowage over the years. There is currently no length limit on any game fish species except muskellunge (32 inches) and sturgeon (45 inches). The open season for walleye, northern pike, large and small mouth bass currently runs year-round. For muskellunge, the open-season runs from the fourth Saturday in May through November, and for sturgeon, there is a special season in September. The daily bag limit for walleye, large and small mouth bass, and northern pike is 5 per day; for muskellunge - 1 per day; sturgeon - 1 per year; for panfish and suckers - 50 aggregate; for catfish - 10 per day. For further detailed information, please reference the fishery studies undertaken on the Cornell Flowage in 1983.

e. Revenue Potential

The 1985-86 operations budget for Brunet Island was $58,392. With 1985 revenue at $34,528, the percent of revenue to operations cost is about 59 percent.

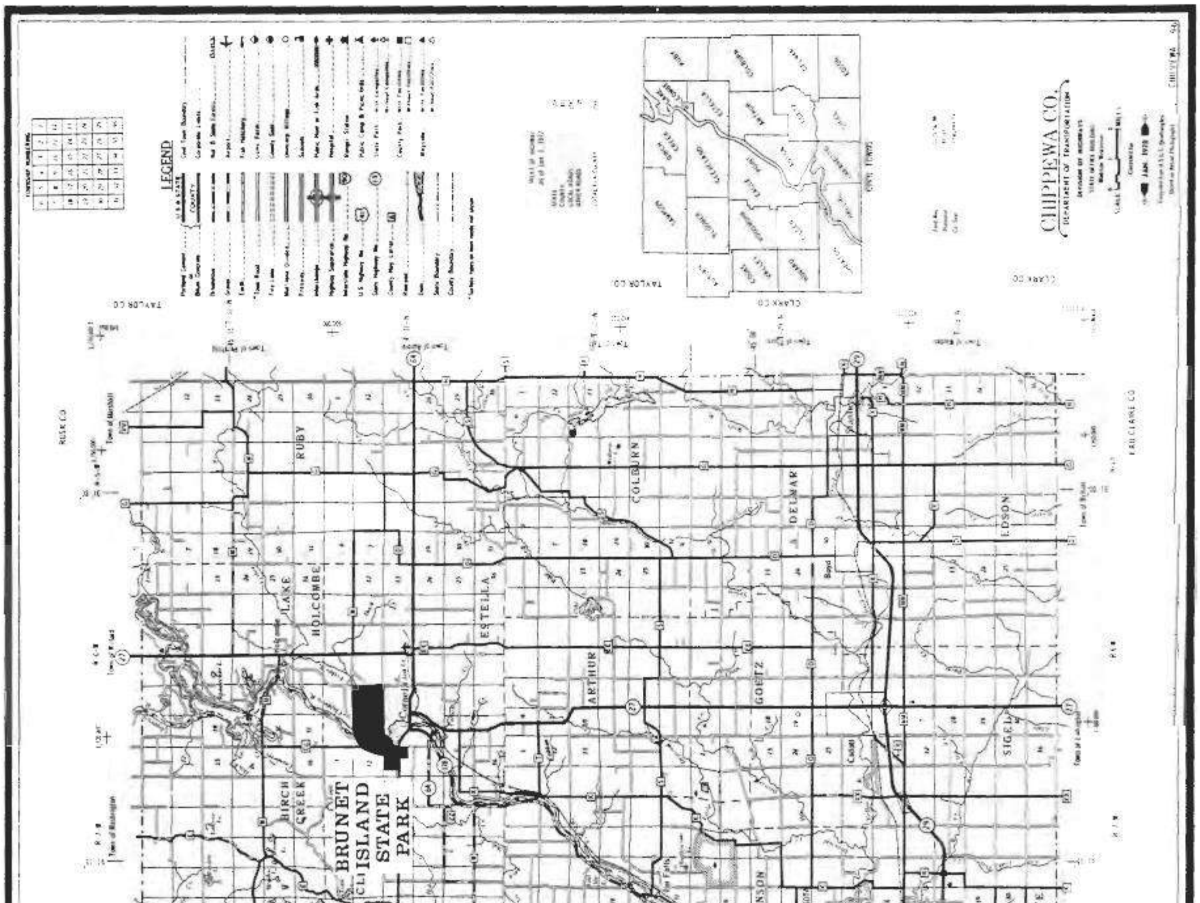
f. Roads, Entrances, and Private Inholdings

Brunet Island is a one-entrance park. A temporary park entrance/visitor station was placed on the entrance road in 1983. Park personnel provide services to the visiting public, collect vehicle admission sticker fees, and dispense park information to the visitor. Since placing the temporary contact station at the entrance, the number of annual resident stickers sold increased 4% while daily resident stickers sold increased 23% over 1982 figures. Camper registration is taken care of at the campsite or at the park office which is located in a building that also houses the shop/maintenance facility. For more efficient management, a permanent contact station should be erected so that sticker sales, camper registration, and general office work can be done in one location during the peak use seasons.

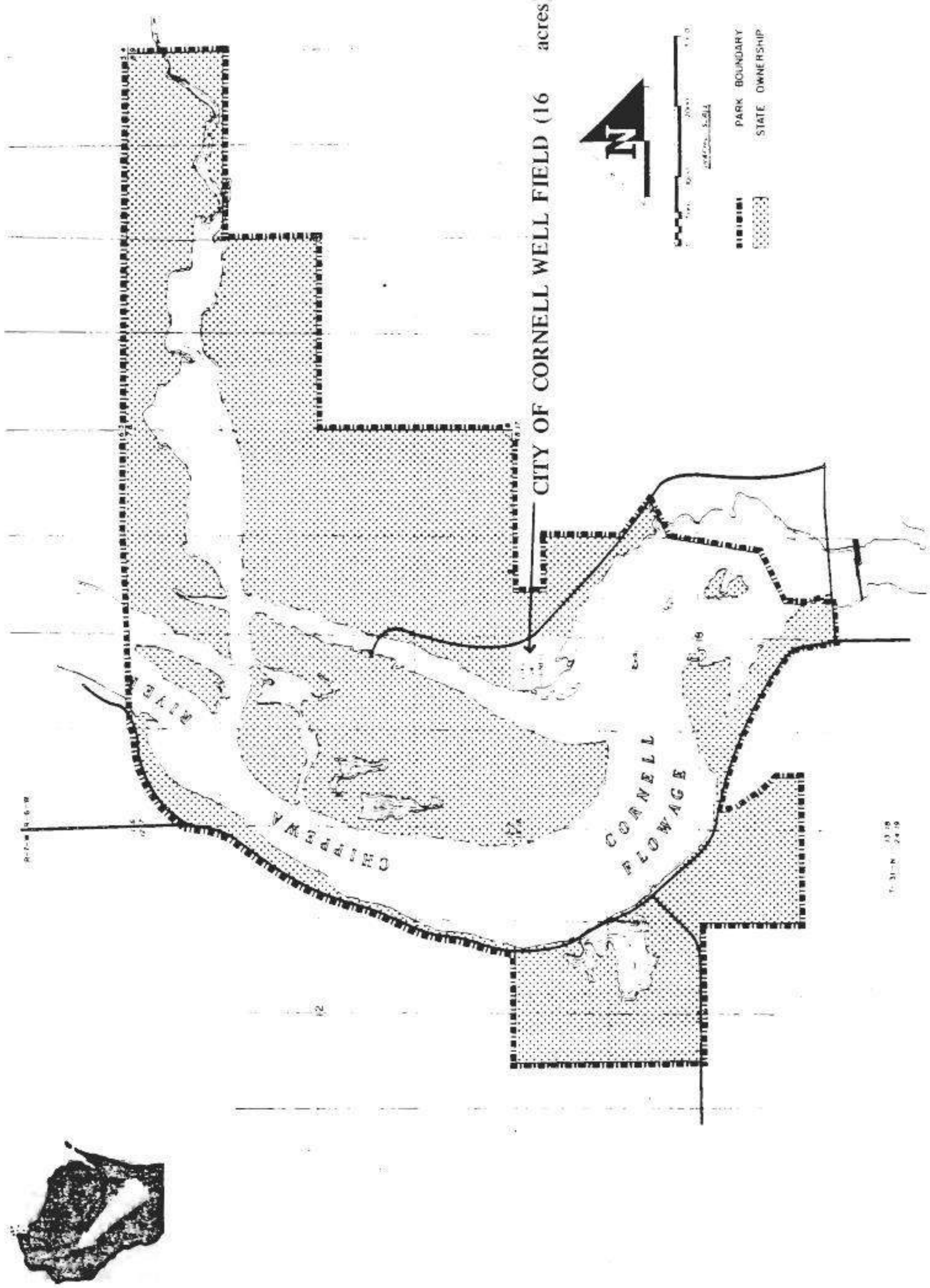
There is one private inholding on the property (city well field) but this does not affect the Department's ability to operate the property.

3. Land Acquisition

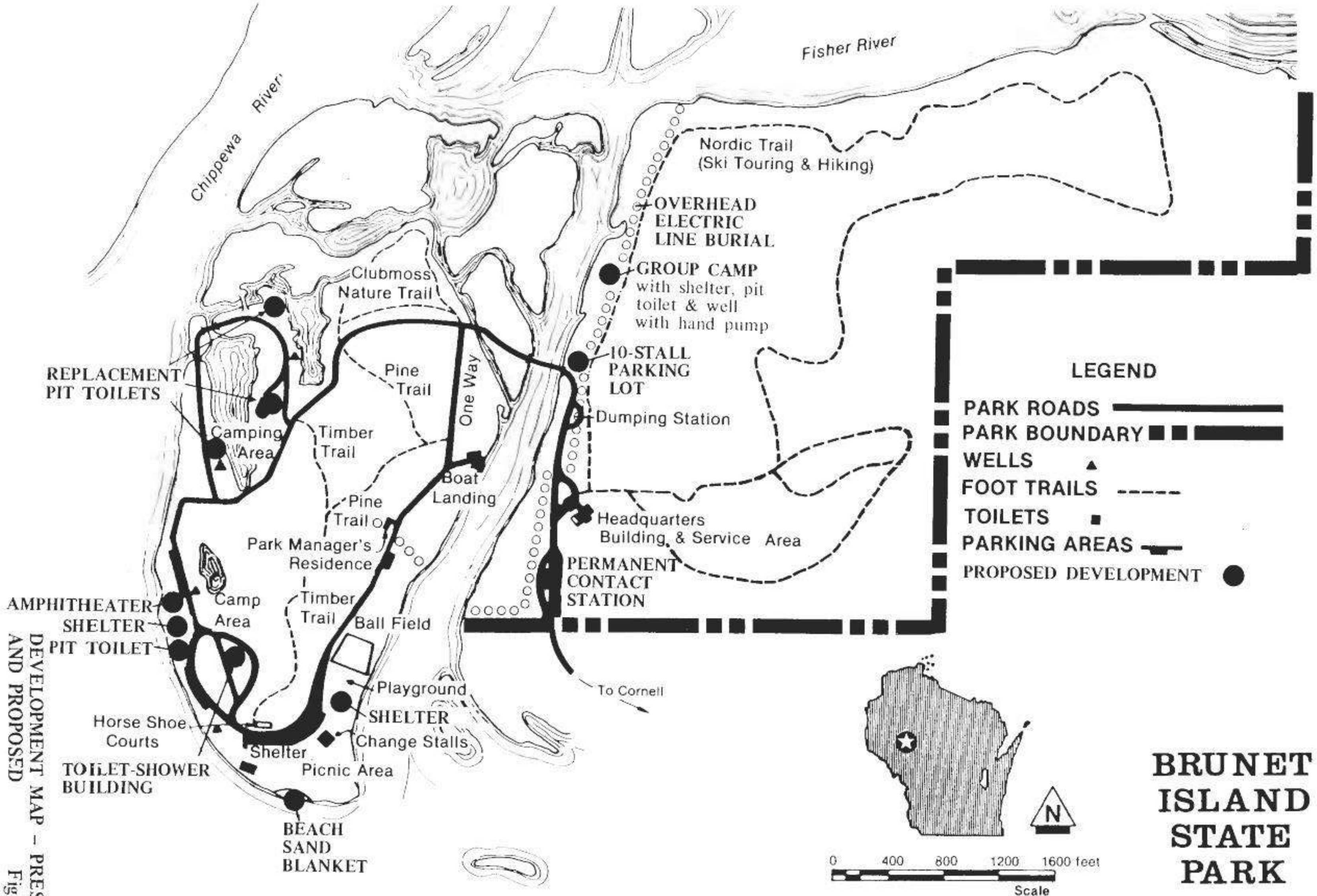
The original acreage goal of 1,032 acres at Brunet Island has been met. The new acreage goal will be increased to 1,048 acres to include a 16-acre parcel of city land (well field) within the park boundary should the parcel be available in the future.



COUNTY LOCATOR MAP   Figure 1

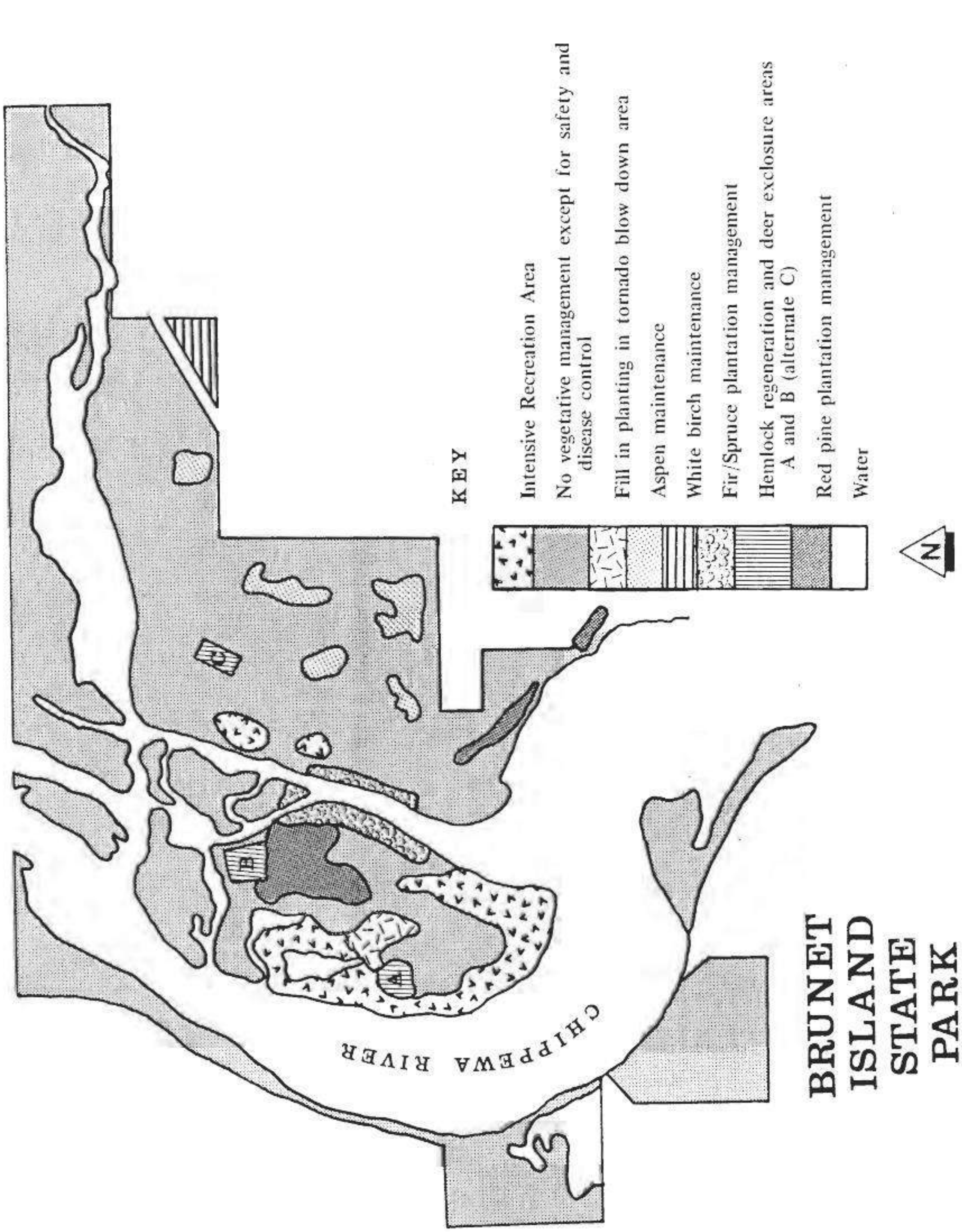


ACQUISITION MAP Figure 2

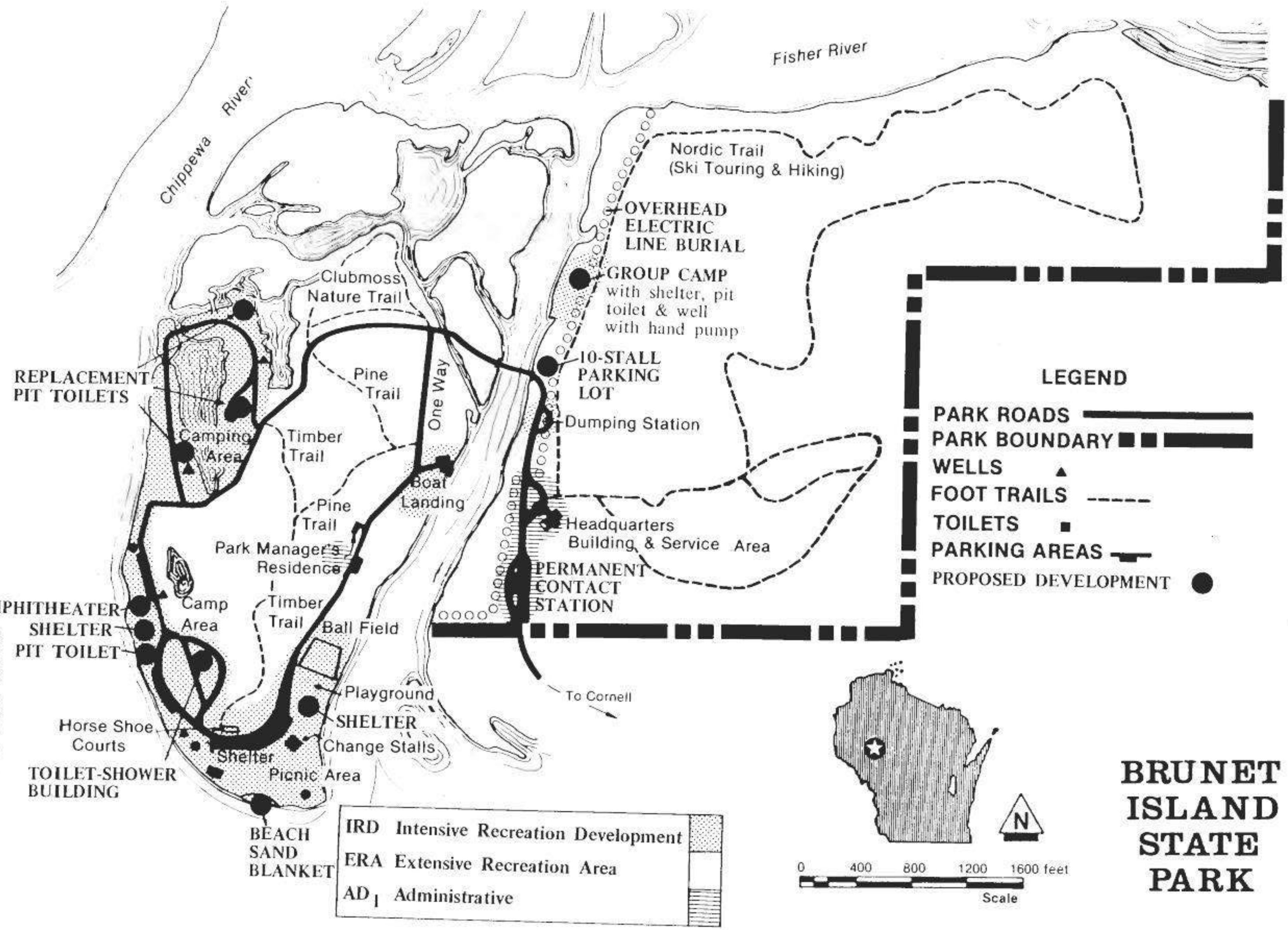


DEVELOPMENT MAP – PRESENT AND PROPOSED

Figure 3



VEGETATIVE MANAGEMENT MAP Figure 4



LAND USE CLASSIFICATION MAP
Figure 5

SECTION II - SUPPORT DATA

A. BACKGROUND INFORMATION

1. Location

The park is located within Estella and Cleveland Townships, Chippewa County. It is approximately 40 miles from the Eau Claire-Chippewa Falls area and about a two-hour drive from the heavily populated Minneapolis-St. Paul metropolitan area. Primary access to the park is provided by State Trunk Highways 64 and 27.

The City of Cornell is nestled on the banks of the Chippewa River adjacent to Brunet Island State Park.

2. History of the Area

One hundred years or more before the American Revolution, French fur traders had explored the upper reaches of the Chippewa River and laid the foundation for an extensive fur industry. Their diaries and reports recorded this as a land rich in furs, timber, and potential water power.

Brunet Island State Park bears the name of one of the early settlers in this area of Wisconsin. Jean Brunet was an explorer, teacher, missionary, guide, politician and engineer. He lived in the area from 1828 to 1877.

Another notable individual was Ezra Cornell who often visited the Brunet's home while looking for land for the newly founded Cornell University in Ithaca, New York. In 1867, the New York manufacturing company was organized to further his plan for a mill in town at Brunet Falls (Cornell). Mr. Cornell died before his plans could be realized and left his landholdings as an endowment to Cornell University.

The latter history of this area and the Chippewa River largely revolves around the mammoth lumbering operations which began around 1850 and lasted until the area was finally denuded. Large-scale lumbering operations came to a close in the early 1900's. After 1860, the keen competition for timber resulted in many feuds and legislative and legal clashes which kept the state in an uproar until 1875.

3. Chronology of Property's Establishment and Development

Brunet Island State Park is 1,032 acres in size. The main use area is a 179-acre island between the Chippewa River on the west and the Fisher River on the east. The park was established in 1939 as a WPA project, and it was dedicated in 1940. As noted earlier, this park was named for Jean Brunet, a Frenchman who was the first settler of Chippewa Falls and Brunet Falls, now called Cornell.

4. Past and Present Management Activities

Since its inception, the property has been managed for camping, picnicking, hiking, swimming, fishing, and general nature education, as well as a variety of other related activities. Presently, it has 87 acres of land developed for intensive recreation use. It has 20 acres of picnic area, 75 picnic tables, 24 grills, 1 shelter, a 210-foot beach, 227 parking stalls, a 3/4 mile long nature trail, 5 miles of hiking trails, 4 miles of cross-country ski trails, 69 campsites, 1 boat launch, and 2.6 miles of road. Average annual visitation for the last 2 years for day-use is approximately 150,000 and camper days is approximately 20,000.

The Cornell Archery Club has an agreement for using a portion of the park between the park road and the Fisher River as part of an archery range. The remaining portion is located on city property. The archery range is open to the public and affiliation with the club is not required.

B. RESOURCE CAPABILITIES AND INVENTORY

1. Geology

The Wisconsin Glacier was the most recent glacier to reach Chippewa County. It did not completely cover the county as did earlier ice sheets. Upon receding, it deposited debris, or till, in large quantities in the form of terminal moraines across the northeast part of the county, from the northwest corner southeast to Jim Falls and then east to the county line. The young drift area of the terminal moraine is distinct in having a typical hilly appearance, a large number of kettle holes, bogs, and irregularly shaped lakes, as well as numerous swamps.

The geological formations which underlie Chippewa County are the Pre-Cambrian (igneous) crystalline rocks in the northeastern part, from near Long Lake and south to Chippewa Falls and eastward to the county line. The bed of the Chippewa River upstream from Chippewa Falls exposes portions of this bedrock.

2. Soils

Major soils found within the property include Roshholt sandy loam, Chetek sandy loam, Menahga loamy sand, and Friendship loamy sand on the island. On the mainland, Menahga loamy sand, Alban fine sandy loam, Santiago silt loam, Amery, and Chetek sandy loam are found. Most of the soil series are well drained to excessively well-drained and have slight to moderate restrictions for dwellings with or without basement, local roads, campgrounds, picnic areas, playgrounds, and trails.

3. Climate

The climate of Chippewa County is classified as humid continental. It is characterized by moderately long, cold winters and short summers that are warm and humid. Mean temperatures drop below freezing in mid-November and freeze-up of lakes follows soon afterward. Ice cover remains until April. The average annual precipitation is 30.5 inches. Maximum precipitation occurs in June with 4.9 inches followed by August, May, and July. Summer rainfall averages 3.48 inches per month during April through October, while winter precipitation is about 8.5 inches. Near the end of November, most of the precipitation falls as snow and accumulates throughout the winter.

4. Water Resources

Brunet Island State Park lies adjacent to the Chippewa and Fisher Rivers which make up the Cornell Flowage. The flowage is approximately 864 acres in size and was created as a reservoir for hydroelectric production. Water levels continue to be maintained for this purpose and fluctuate during the year, depending on anticipated runoff and precipitation. The principal inlet is maintained by a 42-foot high dam at Holcombe; the other inlet is the Fisher River. The dam maintaining the Cornell Flowage has a head of 39 feet. Both dams are operated by Northern States Power Company. The deepest part of the flowage, 54 feet, is located near the dam at Cornell. The flowage has a relatively small percentage of developed shoreline. There are two boat landings with parking, one of which is in Brunet Island State Park. Since impoundment, there have been several surveys to determine the status of the sport fishery in the Cornell Flowage. The fish population of the flowage is dominated by walleye. Other predator species include muskellunge, northern pike, large and small mouth bass. Panfish include bluegills, perch, black crappie, rock bass, and pumpkinseed. Other species found are bullheads, white suckers, lake sturgeon, burbot, channel catfish, and quillback.

5. Vegetative Cover

The original forest cover, based on 1847-1853 survey records, was hemlock, northern hardwoods, white birch, and aspen. Currently on-the-ground evidence shows that most of the timber on the island has remained much as it was when the first land surveys of the area were made.

The following is a brief description of the present forest cover types and includes all areas outside of the intensive use areas such as beach, picnic areas, and campground.

There are 208 acres of hemlock-hardwoods. Species here include hemlock, basswood, sugar maple, white oak, and yellow birch. Most of this type is over 15 inches in diameter at 4-1/2 feet above the ground (DBH). Ages vary widely; with most falling into the 80-120 year-old range. Some of the larger hemlock are declining in vigor, but generally, the stands are still growing.

The northern hardwoods cover 186 acres and contain basswood, red oak, sugar maple, red maple, white ash, white birch, aspen, bitternut hickory, and butternut. Most of the stands (107) are 11-15 inches DBH. The remainder are pole timber and sapling stands 1-11 inch DBH. Ages vary from small seedlings to over 100 years. Most stands are still in good condition with good to excellent quality trees.

Nearly pure stands of aspen cover 163 acres. The majority of the stands are 5-11 inch DBH with an average age of 48 years. The normal age span of aspen is quite short (up to 50 years). As this was one of the original forest types within the park and because it is a vital forest type for game, these stands should be managed so that they will regenerate themselves via root sprouting.

White birch is found on 66 acres of the property. There is one stand composed mainly of white birch with some aspen, red maple, sugar maple, and red oak intermixed. Average stand diameter is 5-11 inches and averages 61 years of age. This is an interesting and aesthetically pleasing type which should be maintained for overall vegetation diversity.

There are 22 acres of the fir-spruce cover type. This stand is 47 years old and was planted by the CCC. The size of trees vary but 5-inch DBH is a good average. Most of the trees are white spruce which were planted under existing hardwoods.

Red pine plantations cover 17 acres of the park. Most of this is roadside plantings done by the CCC and averages 40-50 years of age. The stands have been thinned commercially in the past and are now entering the small sawlog size class (9-15 DBH).

White pine covers 8 acres and the trees are 5-10 inches in diameter and average 40-50 years of age. They are being suppressed by competing hardwoods and are in need of release.

Bottomland hardwoods cover 17 acres. These are isolated stands located in very wet areas and are also found on some of the small islands in the Chippewa River. Main species here are river birch, silver maple, and red maple. It is an aesthetically attractive type which is currently small in size (5-11 inches DBH) and less than 60 years of age.

There are no known rare, unique, or endangered plant communities or species present within the property boundary. However, as time and funds permit, a total vegetative inventory should be undertaken.

6. Wildlife

Common wildlife species include white-tailed deer, gray squirrel, raccoon, red fox, muskrat, mink, and beaver. Waterfowl include mallards and wood ducks. A list of amphibians, birds, mammals, and reptiles can be found in Appendix A.

There is an inactive bald eagle nest within the park. It is on the north side of the Fisher River approximately 1/4 mile east of the confluence of the Fisher and Chippewa Rivers.

7. Site Inventory

The cover type map indicates the following: Forest cover - 687 acres, picnic areas - 20 acres; campgrounds - 18 acres; trails, beach, boat launch etc. - 40 acres; parking area - 7 acres; minor streams, lakes and surface water - 145 acres; grasslands - 47 acres; lowland grass - 41 acres; lowland brush - 17 acres; and powerline right-of-way - 10 acres.

8. Land Use Inventory

Lands within the park are classified as intensive recreation development (IRD) and extensive recreation areas (ERA). The IRD land presently encompasses 84 acres. The remaining acreage is classified as extensive recreation area.

9. Historical and Archaeological Features

The State Historical Society has indicated that there are no known historical or archaeological sites in the park, but this may simply reflect the lack of a systematic survey to locate such resources in this part of Chippewa County. Surveys conducted elsewhere along the Chippewa River indicate that the river islands and terraces have a very high probability of containing archaeological sites. For this reason, they recommend that prior to undertaking any major ground disturbing activity in Brunet Island State Park, the DNR consult with their office to determine whether an archaeological survey is needed.

C. MANAGEMENT PROBLEMS

1. Sticker Sales and Revenue Collection

Prior to the 1983 use season, sticker sales were handled out of the office (located in the shop building), by park employees contacting park visitors in their vehicles at the various parking lots or by placing a sticker violation notice on the unattended vehicle. This system resulted in inefficient fee collection, loss of revenue, and wasted employee work time. The situation was corrected this past use season by placing a temporary booth on the park entrance road and staffing it with LTE and local high school work-study personnel.

This system resulted in a 4% increase in resident annual sticker sales and a 23% increase in daily resident stickers. It is apparent that the park should be sufficiently staffed to keep the contact station open during the major use season. In addition, a permanent park entrance visitor station should be constructed so that sticker sales, camper registration, and general office work can be undertaken in this single structure.

2. Shoreline Erosion

The north campground and various day use area shorelines have a history of erosion created by people walking down the steep banks to fish or moor their boats. This has been corrected in some instances by placing a retaining wall on side hills and riprapping the shoreline. In other instances, work remains to correct the erosion and guard against further bank disturbance. The use of such structures, in combination with providing stairs, stepping stones, tree and shrub plantings, and a program of user education should be utilized to eliminate this recurring problem.

D. RECREATIONAL NEEDS AND JUSTIFICATIONS

The 1981 State Outdoor Recreation Plan for Region 4 which includes Clark, Eau Claire, Dunn, St. Croix, Polk, Barron, and Chippewa Counties notes that there is need for developed campsites, primitive campsites, and pleasure walking trails. The study further indicates that there is no need for additional cross-country ski trails and snowmobile trails. At the present time, the summer campsite occupancy rate of 51% is not high enough to justify campground expansion at Brunet Island. Similarly, picnic areas are sufficient to meet demand based on day use annual visitation figures.

The Chippewa County-Community Outdoor Recreation Plan of 1977 indicates no need for developed campsites through the year 1990. It did indicate a need for an additional 259 picnic tables by 1990. Swimming area supply meets present and future needs. Additional cross-country ski trails are identified as being needed but no specific length figures were provided.

Based on public input at a master planning work shop, an additional 3/4 mile loop should be added to the existing cross-country ski trail.

E. ANALYSIS OF ALTERNATIVES

1. No Additional Acquisition and No Additional Development

This alternative would provide for no further acquisition or development. The Department would merely retain and manage the existing resource and its recreational facilities. This alternative is not desirable since the property was acquired for recreational purposes in order to meet the needs of the recreating public. No additional acquisition within the property boundary could lead to future encroachment of undesirable land uses. No additional development could lead to degradation of the resource, its facilities, and could lead to degradation of the resource, its facilities, and could lead to safety problems.

2. Reduce and Adjust Existing Acquisition Boundary

   This alternative would provide for the elimination of the 16-acre parcel of land that is presently occupied by the Cornell well field. The property could be eliminated from the park boundary with little or no impact to the park as it presently exists if we were assured that the land would be retained by the city for a well field. However, because this is not a certainty, the land should be kept within the boundary and acquired when and if it becomes available for sale. This, again, would guard against any potential future land use conflicts.

3. Moderate Additional Development on Existing State-Owned Land

   It is recommended that moderate additional development occur on existing state-owned land. Facilities include a shower building , upgrading the north and south campgrounds, constructing a group camp and replacing facilities and furnishing as needed. In addition, hiking and ski trails would be upgraded and the roads and parking areas will be resurfaced. A shelter and amphitheater will be constructed in the day use area and a permanent contact station will be built at the park entrance. This alternative is desirable in that it will ensure the maintenance of a high-quality recreational facility, maximize user enjoyment, and eliminate any potential safety problems.

   Development of a fire control storage building and office space in conjunction with the existing park office/shop complex is proposed. This consolidation would entail bringing fire control employees, a conservation warden, and park personnel into one central location and facility. This action will allow for the sharing of manpower and equipment which will be beneficial to the property.

4. Additional Large Scale Development on Lands Within Park Boundary

   Large scale development including enlarging the campground and various day use areas is possible. However, based on present and projected use figures, such action is not warranted.

DK:jm
4105L

APPENDIX A

Wildlife Species

No formal surveys to document species and numbers have been conducted. However, because of the park´s location and vegetative types, the following have been observed or encounter might be anticipated:

a. Amphibians

Chorus Frog
Common American Toad
Gray Tree Frog
Green Frog
Jefferson Salamander
Leopard Frog
Mudpuppy
Newt
Pickeral Frog
Red-barked Salamander
Spring Peeper
Wood Frog

b. Birds

American Goldfinch
Bald Eagle (Endangered)
Baltimore Oriole
Barn Swallow
Barred Owl
Belted Kingfisher
Black-Capped Chickadee
Blue Jay
Blue-Wing Teal
Brown Thrasher
Bufflehead (Migrant)
Cardinal
Catbird
Common Crow
Common Grackle
Common Loon (Migrant)
Common Nighthawk
Downy Woodpecker
Eastern Phoebe
Flicker
Great Blue Heron
Great Horned Owl
Green Heron
Goldeneye (Migrant)
Hairy Woodpecker
House Sparrow
Least Bittern
Mallard
Mourning Dove
Northern Shrike
Purple Finch

Purple Martin
Raven
Red-Breasted Nuthatch
Red-Headed Woodpecker
Red-Tailed Hawk
Red-Winged Blackbird
Ring-Necked Duck (Migrant)
Robin
Ruffed Grouse
Scaup (Migrant)
Screech Owl
Sharp-Shinned Hawk
Slate-Colored Junco
Snow Bunting
Snowy Owl (Occasional Winter Visitor)
Starling
Whip-poor-will
White-Breasted Nuthatch
Woodduck
Wood Thrush

c. Mammals

Beaver
Coyote
Eastern Chipmunk
Ermine
Flying Squirrel
Gray Squirrel
Masked Shrew
Mink
Muskrat
Porcupine
Pygmy Shrew
Raccoon
Red-Backed Vole
Red Fox
River Otter
Short-tailed Shrew
Snowshoe Hare
Thirteen-lined Ground Squirrel
Red Squirrel
Stripped Skunk
White-footed Mouse
White-tailed Deer
Woodchuck
Woodland Deer Mouse

d. Reptiles

Common Garter Snake
Common Water Snake
Eastern Hognose Snake
Eastern Ringneck Snake
Pine Snake
Five-lined Skink

Fox Snake
Painted Turtle
Red-bellied Snake
Snapping Turtle
Softshell Turtle

APPENDIX B

Fish Species

walleye (*Stizostedion vitreum vitreum*)
muskellunge (*Exos masquinongy*)
northern pike (*Exos lucius*)
largemouth bass (*Micropterus salmoides*)
smallmouth bass (*Micropterus dolomieus*)
bluegills (*Lepomis machrochirus*)
yellow perch (*Perca flavescens*)
black crappies (*Poxomoxis nigromaculatus*)
rock bass (*Amblopolites rupestris*)
pumpkin seed (*Lepomis gibosus*)
bullheads (*Ictaluris spp.*)
white suckers (*Catostomus commersoni*)
lake sturgeon (*Acipsenser fulvescens*)
burbot (*Lota lota*)
channel catfish (*Ictaluris punctatus*)
quillback (*Carpiodes cyprinus*)

MRT112

Parks + Rec.

The State of Wisconsin

SCIENTIFIC AREAS PRESERVATION COUNCIL

Box 7921
Madison, Wisconsin 53707

IN REPLY REFER TO: 1750

January 28, 1986

Mr. David Weizenicker, Director
Bureau of Parks and Recreation
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707

We have no specific natural area proposals for Brunet Island State Park; however we do want to express our concern regarding the timber management proposed in the concept master plan.

As we have stated in other state park master plan comments; tree-cutting in state parks should be limited to that required for safety of park users and as otherwise required in intensive recreation zones.

We have been informed that the tree-cutting policy for state parks has been clarified to emphasize that extensive recreation zones of parks would be left to exhibit a natural environment, that is, generally left alone. The Brunet Island Park plans suggest a new emphasis on timber harvest more typical of forests or wildlife properties. We believe that the policy of severely limiting harvest of trees has served Wisconsin's parks well. Today, the state parks provide areas where the public can readily observe natural biological processes.

We hope that Brunet Island Park Concept Master Plan will be modified following more closely the guidelines of the revised tree-cutting policy.

Cordially,

Forest Stearns

Forest Stearns
Chairman

FS:CG:ss/41460

CORRESPONDENCE/MEMORANDUM — STATE OF WISCONSIN

Date: February 24, 1986 *File Ref:* 2100-1

To: Cliff Germain-ER/4

From: D. L. Weizenicker-PR/4 JH for D. Weizenicker

Subject: SAPC Comments on Brunet Island State Park Master Plan

This is in response to the Council's comments on the vegetative management proposals in the Brunet Island Master Plan.

Since hemlock is disappearing from Wisconsin's forests, Brunet Island presents an excellent opportunity to regenerate at least 10 acres of deteriorating hemlock stands to keep a remnant of hemlock forest viewable by the public. In addition to the hemlock, both aspen and white birch require certain management practices to maintain vigor and promote regeneration.

In the draft master plan reviewed by the Council, 236 acres were recommended for vegetative management or 34 percent of the forested area of the park. The master plan to be presented to the Board for approval has been revised to recommend that 90 acres or 13 percent receive a specific type of vegetative management. This breaks down to hemlock (10 a.), aspen (23 a.), white birch (10 a.), conifer plantation (39 a.), and planting in the blow down area (8 a.). If you exclude the management of the 39 acres of conifer plantation which will be thinned occasionally, and the 8 acres of blowdown area which will be planted, only 7.6% of the naturally vegetated area of the park will be managed.

In summary, the Bureau of Parks concurs with the master plan task force that there is sufficient justification for recommending that the hemlock, aspen, and white birch timber types be perpetuated at Brunet Island only in lesser acreage. Considerations are uniqueness of hemlock stands, species diversity, aesthetics, nature interpretation and wildlife habitat.

We thank the Council for reviewing the Brunet Island Master Plan.

DJK:btM561

cc: J. Treichel-PR/4
D. Kulhanek-PR/4
J. Lissack-Eau Claire

CORRESPONDENCE/MEMORANDUM

STATE OF WISCONSIN

Date: June 6, 1985

File Ref: 2100-1/1430

~~To:~~ Dave Weizenicker - PR/4

From: Dick Lindberg - FR/4 RL

Subject: WRAC Review of Brunet Island State Park Plan

The following are the Wild Resources Advisory Council review comments on this master plan.

1. The plan is straightforward and relatively free of problems.

2. A brief overview of the property's outstanding features would have been helpful in the introduction as would a reference in the goal to their preservation and protection.

3. Adding the Cornell Ranger Station functions to this property is a good move as is the provision of the group camp and is the study of endangered and threatened plants and animals.

4. Extra effort should be exerted to complete land acquisition and obtain the desired contiguous ownership.

5. The historical support data, maps, appendices and soils and geological description were very adequate and added greatly to the plan directions and readability.

Thank you for the review opportunity.

DL:dj

CORRESPONDENCE / MEMORANDUM — STATE OF WISCONSIN

DATE: July 1, 1985 IN REPLY REFER TO: 2100-1

TO: Dick Lindberg - FR/4

FROM: Dave Weizenicker - PR/4 JT for D. Weizenicker

SUBJECT: WRAC Comments on Brunet Island State Park Master Plan

This is in response to the Council's comments on the Brunet Island master plan.

Comment #1: The plan is straightforward and relatively free of problems.

Department Response: So noted.

Comment #2: A brief overview of the property's outstanding features would have been helpful in the introduction as would a reference in the goal to their preservation and protection.

Department Response: As in most state park master plans the goal statement is kept quite general with the list of objectives providing more of the detail. From the description of the park's resources in the background information section, the hemlock, aspen, and white birch vegetative types are the only outstanding features requiring special management and protection. This is covered in Objective #6.

Comment #3: Adding the Cornell ranger station functions to this property is a good move as is the provision of the group camp and is the study of endangered and threatened plants and animals.

Department Response: The task force is to be commended, especially for recommending the transfer of Department personnel to the park to increase operational efficiency and provide better public service.

Comment #4: Extra effort should be exerted to complete land acquisition and obtain the desired contiguous ownership.

Department Response: The acreage goal at Brunet Island has been met, however, the plan recommends that the goal be increased by about 16 acres to include a parcel of city land (well field) in the park boundary should the parcel be available in the future.

Comment #5: The historical support data, maps, appendices, and soils and geological description were very adequate and added greatly to the plan directions and readability.

Department Response: So noted.

We thank the Council for reviewing the Brunet Island master plan.

cc: J. Treichel - PR/4
D. Kulhanek - PR/4
J. Lissack - Eau Claire

Form 1600-1

DEPARTMENT OF NATURAL RESOURCES

District or Bureau: WCD
Docket Number:
Type List Designation(s): NR 150.03(2)(c)4

ENVIRONMENTAL ASSESSMENT

Applicant: State of Wisconsin, Department of Natural Resources

Title of Proposal: Brunet Island State Park Master Plan/Conceptual Element

Location: Chippewa County
Township 31N, Range 7W
Sections 7, 8, and 18, Estella Township & portions of Sections 12, 13, and 18, Cleveland Township
Political Towns: Estella and Cleveland

PROJECT SUMMARY

1. General Description (brief overview)

This environmental assessment is based on the provisions of the 1985 conceptual master plan prepared for Brunet Island State Park. Basically, the plan identifies Brunet Island as a scenic state park and it shall remain thus. The management and development alternatives selected for the property allow for moderate increased use and development. It is anticipated that use will increase approximately 10-15% during the next 10-year period following approval of the master plan and subsequent development of new facilities. A wide range of traditional activities are offered including: camping, swimming, boating, fishing, picnicking, hiking, nature study, and related day-use activity.

The master plan identifies the proposed development, management, and land acquisition scheduled for the park.

Development:

Moderate additional development calls for providing facilities such as a shower building, upgrading the north and south campgrounds, constructing a group camp, and replacing facilities and furnishings as needed. In addition, hiking and ski trails will be upgraded and the roads will be resurfaced. Shelters will be constructed in the various day use areas and a permanent contact station will be built at the park entrance. It is also proposed to transfer fire control and law enforcement personnel and equipment from the Cornell Ranger Station to Brunet Island State Park to increase operational efficiency and to provide better public service. To accomplish this, it will be necessary to construct a storage shed for heavy equipment, provide additional office space, enlarge utilities, and construct and revamp the present parking lot and road system near the office.

Management:

The park is presently operated on a seven-month basis with a seasonal park ranger and manager who is also in charge of the Cornell Ranger Station. In addition, approximately 12 limited-term employees (LTE) are hired during the summer months. They are responsible for sticker sales, maintenance, lifeguarding, law enforcement, and performing naturalist duties. In the future, it is hoped that the property will be returned to a 12-month operation and be staffed accordingly.

As a unit of the Wisconsin State Park System, Brunet Island has been developed and managed under Chapter 27, Laws of Wisconsin; specifically, Section 27.01, which governs state parks. The property is also managed under the provisions of Wisconsin Administrative Code 45, which contains the rules and regulations of the Department of Natural Resources pertaining to the conduct of visitors at state parks, state forests, and other properties under the jurisdiction of the Department.

Lands within the park are classified as intensive recreation development (IRD) and extensive recreation area (ERA). The IRD land emcompasses 84 acres. The remaining acreage is classified as extensive recreation area.

Land Control:

As of December 31, 1984 state ownership of Brunet Island was 1,032.24 acres. 16.24 acres (city well field) remain to be purchased in order to reach the project acreage goal of 1,048.48 acres (see Item #17).

2. Purpose and Need (include history and background as appropriate).

Brunet Island was established as a scenic state park in 1939. The main use area is a 179-acre island between the Chippewa River on the west and Fisher River on the east. It was originally developed as a WPA project.

The master plan narrative is being prepared in accord with Natural Resources Board and Department policy. The primary purpose of this conceptual master plan is to guide the development, operation, and maintenance of the property for the next 10 years and provide recreational facilities to accommodate approximately 180,000 annual visitations for day use and 23,000 camper days.

The 1981 State Outdoor Recreation Plan (SCORP) for Region 4 which includes Clark, Eau Claire, Dunn, St. Croix, Polk, Barron, and Chippewa Counties notes that there is a need for additional family campsites, primitive campsites, and pleasure walking trails. The study further indicates that there is no need for additional cross country ski trails or snowmobile trails. At the present time, campsite occupancy figures at Brunet Island are not high enough to justify campground expansion. Similarly, picnic areas are sufficient to meet demand based on annual day-use visitation figures.

The Chippewa County Community Outdoor Recreation Plan of 1977 indicates no need for developed campsites through the year 1990. It did indicate, however, a need for an additional 259 picnic tables by the year 1990. Swimming areas meet present and future needs. Additional cross-country ski trails are identified as being needed but no specific length figures were provided. Based on public input at the master planning workshop, an additional 3/4 mile loop should be added to the park's existing cross-country ski trail.

3. Authorities and Approvals (list statutory authority and other relevant local, state and federal permits or approvals required)

   Statutory authority to initiate: Section 27.01 of Wis. State Statutes, permits or approvals required: Natural Resources Board and Governor

   All development, as identified in the master plan, will comply with applicable state and local zoning requirements. Construction of rest room facilities will be in accord with H63 and all other township or Chippewa County zoning ordinance.

   Shoreline riprap and the beach sand blanket will comply with Chapters 30-31 (see Item #5).

4. Estimated Cost and Funding Source

   The total estimated development cost, based on 1985 figures, is $500,000. ORAP, LAWCON, and other funds will be used as they become available.

PROPOSED PHYSICAL CHANGES

5. Manipulation of Terrestrial Resources (include relevant quantities - sq. ft., cu. yds., etc.)

   The proposed toilet/shower building, approximately 30' X 40' in size, will be located in the south campground. Soil excavated for footings, septic tanks, and drainfield will be disposed of on-site and the area around the building will be seeded and landscaped. It is anticipated that under 100 cubic yards of soil will be excavated. The four-unit pit toilet located in the day-use area adjacent to the south campground will be placed in a grassy open area. Soil excavated for the vault will be disposed of on-site and the area landscaped. The new two-stall garage near the residence will be located on the site of the present garage which is in bad state of repair. Campsite rehabilitation in the north and south campgrounds will include regraveling the spurs and leveling and reseeding the camp pads. Up to 200 cubic yards of gravel and up to 200 cubic yards of soil may be needed to upgrade the campsites. It is unknown how many cubic yards of asphalt will be needed to resurface and seal-coat the interior park road and parking lots. The Department's Bureau of Engineering will be initiating the study and proposal for resurfacing the road in the next few years.

The rustic group camp (maximum capacity - 100 people) is proposed for an area of northern hardwoods located east of the Fisher River and approximately 600 feet north of the existing park office. Development will include an 8-unit pit toilet, a well and hand pump, a shelter, and scattered clearing and grubbing on approximately 3 acres of land. Soils excavated for the toilet vault shelter footings and other facilities will be distributed on-site and the area graded for proper drainage and use as a group camp. The 10-stall gravel surfaced parking lot proposed for this facility will be located in an open area near the trailer dumping station. The present overhead electric line that runs parallel to the adjacent cross-country ski trail will be buried by the electric company as part of the overall development scheme.

The north campground and various day-use area shorelines have a history of erosion created by people walking down the steep banks to fish or moor their boats. This has been corrected in some instances by placing a retaining wall on side hills and riprapping the shoreline. Work still remains to correct additional erosion and guard against further bank disturbance. It is estimated that up to 100 cubic yards of rock may be needed to riprap the shoreline. In addition, up to 1,000 cubic yards of soil may be needed to reclaim areas where large gullies have formed. This material may be held in place by retaining walls, vegetative planting, and laying down and staking sod on the reclaimed areas. In some instances, stairways will be provided in these areas where park users gain access to the water's edge.

A sand blanket is proposed for the beach area to cover the sharp gravel stones and small rocks that have worked their way to the surface. A Chapter 30.12(2)b permit will be obtained for the replacement of the sand blanket.

A permanent contact station (12' X 24') will be built where the present temporary structure is located. It is anticipated that less than 20 cubic yards of soil will be disturbed for the building's footings. The material will be distributed on-site, regraded, and landscaped. Similarly, soils disturbed for the placement of the shelter in the day-use area near the ballfield will be disposed of on-site, graded, and landscaped. No earth moving is anticipated for the construction of the amphitheater.

Three four-unit vault pit toilets will be constructed in the north campground during Phase III. These will be placed in the general location of existing facilities. Approximately 120 cubic yards of soil will be excavated for the vaults and this material will be spread on-site, graded, and landscaped.

Although the concept of combining fire control, a warden and park personnel has been proposed, the specifics of additional office space needs, etc. are not known. However, it is anticipated that three-four offices will be added to the existing structure and a building approximately 40' X 60' will be needed for storing fire equipment. This construction will call for the excavation of soil for building footings, utilities, and revision of parking lots and roads.

Some tree removal and planting will take place as needed for the health, safety, and welfare of park visitors and to provide shade and screening at various campground and day-use areas. In addition, some vegetative clearing and cutting will occur to create vistas along trails and at overlooks. Extensive area vegetative management will be minimal. Approximately 80 acres of hemlock hardwoods will be managed using selective cutting to increase growth rate and to start regeneration of the species. There is a 61-acre stand of aspen and a 66-acre stand of white birch which will be cut to regenerate and perpetuate those types. The fir-spruce and red pine plantations covering 39 acres of the property will be managed to promote growth and vigor. In the remaining extensive areas, natural succession will continue to meet the objective of providing a diversity of tree species and age classes.

6. Manipulation of Aquatic Resources (include relevant quantities - cfs., acre feet, MGD, etc.)

It is proposed to place a sand blanket on the existing beach. The sand blanket would encompass an area approximately 6 inches thick by 300 feet by 100 feet. The riprap noted earlier will be placed on the shoreline and thus have some of the material in the water especially during periods of high water in the flowage. It is not anticipated that this will affect more than a few hundred lineal feet of shoreline.

7. Buildings, Treatment Units, Roads and Other Structures

The proposed toilet/shower building is approximately 30′ X 40′ in size and will be block and wood frame construction. The four 4-unit combination vault toilets consist of concrete block, poured concrete, and wood construction. Their size is approximately 11′ X 19′. The garage will be approximately 20′ X 24′ and be wood frame construction. The shelter buildings for the day-use area, boat mooring area, and rustic group camp will be approximately 24′ X 40′. They will have a cement floor and laminated wood beam construction. The permanent contact station will be about 12′ X 24′, and will have a cement floor and wood frame construction. If remodeled for fire control, a warden, and park personnel the enlarged office will be brick and masonry construction. The fire control storage building will be wood and steel construction, approximately 40′ X 60′ in size.

The 2.6 miles of park road is about 22 feet wide and will be resurfaced and/or seal-coated. In addition, there are approximately 227 parking stalls of which will be seal-coated and/or resurfaced. Finally, the new boat launch facility (approximately 100′ X 120′) will receive an asphalt surface. Upgrading the existing trails may entail minor surfacing with gravel or other material and the placement of water diversion structures to correct any erosion problems. The ampitheater will consist of wood benches, a small 12′ X 20′ stage with screen, and electric serice.

8. Emissions and Discharges

Proposed additional development and subsequent use of the property is not expected to significantly affect Wisconsin's air quality. However, some local noise and pollution might be expected during construction due to the use of heavy equipment and disruption of surface conditions. Site specific actions will be taken to guard against any erosion potential. Vehicular traffic is expected to increase about 5% into and through the area within the next 10 years and this will add to the noise and potential air pollution. These emissions, however, are not expected to significantly affect the ambient air quality. Fossil fuels and lubricants consumed by construction equipment and those used for labor activities and fabrication of materials will be consumed and will result in some discharge of emissions. Secondary emissions and discharges will be created by the fuel and electricity used to operated the facility.

9. Other Changes

Lands within the park will be classified as intensive recreation development (IRD) and extensive recreation area (ERA). Intensive recreation development will encompass an estimated 90 acres upon completion of the proposed group camp, additional trails, and other day-use facilities. The remaining 942 acres will be classified as extensive area and be managed according to guidelines found under that classification.

10. Attach Maps, Plans and Other Descriptive Material as Appropriate (list)

1. Locator Map
2. Development Map
3. Ownership Map

AFFECTED ENVIRONMENT

Information Based On (check all that apply):

__X__ Literature/correspondence
__X__ Personal Contacts (list in item 31)
Field Analysis By: __X__ Author, __X__ Other (list in item 31)
Past Experience With Site By: __X__ Author,
__X__ Other (list in item 31)

11. Physical (topography - soils - water - air - wetland amounts and types)

The topography of the park ranges from nearly level to gently rolling. The topography is the result of the Wisconsin glacier which was the most recent one to reach Chippewa County. It did not completely cover the county as did earlier ice sheets. Upon receding, it deposited debris or till in large quantities in the form of terminal moraines across the northeast part of the county from the northwest corner, southeast to Jim Falls, and then east to the county line. The young drift area of the terminal moraine was distinct in having a typical hilly appearance, a large number of kettle holes, bogs, and irregularly shaped lakes as well as numerous swamps. The geological formations which underly Chippewa County are the Cambrian crystaline rocks in the northeast part, near Long Lake and south to Chippewa Falls and eastward to the Chippewa County line. The bed of the Chippewa River upstream from Chippewa Falls exposes portions of this bedrock.

Major soils found on the property include Roshholt sandy loam, Chetek sandy loam, Menahga loamy sand, and Friendship loamy sand is found on the island. On the mainland, Menahga loamy sand, Alban fine sandy loam, Santigo silt loam, Amery, and Chetek sandy loam are found. Most of the soil series are well drained to excessively well drained and have slight to moderate restrictions for dwellings with or without basements, local roads, campgrounds, picnic areas, playgrounds and trails.

The climate of Chippewa County is classified as humid continental. It is characterized by moderately long, cold winters and short summers that are warm and humid. Mean temperatures drop below freezing in mid-November and freezeup of lakes follow soon after. Summer rainfall averages 3.48 inches per month, April through October, while the total winter precipitation is about 8.5 inches.

Brunet Island State Park lies adjacent to the Chippewa and Fisher Rivers which make up the Cornell Flowage. The flowage is approximately 864 acres in size and was created as a reservoir for hydroelectric production. Water levels continue to be maintained for this purpose and fluctuate during the year depending on anticipated runoff and precipitation. The principal inlet is being maintained by a 42-foot high dam at Holcombe. The other inlet is the Fisher River. The dam maintained at the Cornell Flowage has a head of 39 feet. The deepest part of the flowage is 54 feet and is located near the dam at Cornell. The flowage has a relatively small percentage of developed shoreline. There are two boat landings with parking, one of which is in Brunet Island State Park. There is very little wetland in or adjacent to the park. The largest amount (5 acres) lies west of County Trunk CC. Minimal wetland lies along the shoreline of the many small islands and associated backwater bays which make up the main island complex. No development will take place in these wetland areas. Air around the park meets the primary and secondary ambient air quality standards.

12. Biological

a) Flora

The original forest cover, based on 1840-1853 survey records, was hemlock, northern hardwoods, white birch, and aspen. Current on-the-ground evidence shows that most of the timber on the island has remained much as it was when the first land surveys in the area were made. The following is a brief summation of the forest cover types and includes all areas outside of the intensive use areas such as beach, picnic area, and campground. There are 208 acres of hemlock hardwoods, northern hardwoods cover 168 acres, aspen covers 163 acres, and white birch is found on 66 acres of the property. There are 22 acres of the fir-spruce cover types, red pine plantations cover 17 acres of the park, and white pine covers 8 acres. Bottomland hardwoods cover approximately 17 acres.

b) Fauna

Common wildlife species include whitetail deer, gray squirrel, raccoon, red fox, muskrat, mink, and beaver. Waterfowl include mallards and wood ducks. A list of amphibians, birds, mammals, and reptiles can be found in the master plan appendix. There is an inactive bald eagle nest within the park. It is on the north side of the Fisher River approximately 1/4 mile east of the confluence of the Fisher and Chippewa Rivers.

13. Social/Economic (include ethnic and cultural groups, and zoning if applicable)

The property is located adjacent both to urban and rural settings. The City of Cornell is located directly to the southeast of the park. The rest of the park is predominantly bounded by agricultural lands, woodlot, and farmsteads. The park is approximately 40 miles from the Eau Claire - Chippewa Falls area and about a two-hour drive from the Minneapolis - St. Paul metropolitan area. Primary access to the park is provided by State Trunk Highways 64 and 27.

All revenues collected from the sale of admission stickers and campground registration fees are remitted to a segregated fund from which operation and maintenance are partially subsidized. According to a 1980 camper survey conducted by the University of Wisconsin Recreation Resource Center Extension, "Camper spending has a very substantial economic impact on the local economy." Furthermore, the study indicates that state-owned lands are not an economic burden to local government units because the state makes payments in lieu of taxes.

14. Other Special Resources (e.g., archaeological, historical, endangered/ threatened species, scientific areas, natural areas)

The State Historical Society has indicated there are no known historical and/or archaeological sites in the park, but this may simply reflect the lack of a systematic survey to locate such resources in this part of Chippewa County. Surveys conducted elsewhere along the Chippewa River indicate that the river island terraces have a very high probability of containing archaeological sites. For this reason, they recommend that prior to any major ground disturbing activity in Brunet Island State Park, the Department consult with their office to determine whether an archeaological survey is needed.

ENVIRONMENTAL CONSEQUENCES (probable adverse and beneficial impacts including indirect and secondary impacts)

15. Physical (include visual if applicable)

Proposed new development and major building maintenance will have limited impact on the property. Use is expected to increase approximately 10-15% over the next 10-year period; however, this increase should not overtax the man-made and natural resources. Maintenance of the area, its man-made features and vegetative cover should maximize user enjoyment and perceptions, as well as provide some diversity of habitat.

Development of a group campground, trails, and other support facilities will cause some minor short-term disruption to the soil due to exposure and compaction during the construction phase. Soils may also be affected by such things as compaction caused by maintenance equipment and foot traffic. Maintenance practices will be utilized to guard against destruction of ground cover which may result in erosion or other detrimental effect to the resource.

Development plans call for additional planting of trees and shrubs for shade, screening, and space definition in areas such as campground, group camp, and day-use areas.

In the extensive areas of the property, all tree harvesting activities will be done with aesthetics in mind.

Development and use of the property is not expected to significantly affect Wisconsin's air quality. However, some local noise and air pollution might be expected during construction due to the use of heavy equipment and disruption of surface conditions. Some increase of vehicular traffic into and through the area will add to the noise and potential air pollution. These emissions, however, are not expected to significantly affect the ambient air quality. Highways 64 and 27 provide immediate access to the property. These highways, as well as the village street leading to the property, should easily accommodate the expected 3-5% increase in traffic volume over the next 10-year period.

16. Biological

The number and type of plant species at Brunet Island will change somewhat due to natural succession, interruption of succession, and the cutting and planting of various plant materials. Removal of dead and dying trees will occur to ensure a healthy timber stand adjacent to the intensive use area and ensure visitor safety. Some vegetative clearing and brushing will occur to create vistas in use areas, along trails, and at overlook sites. This will entail some tree removal, limb cutting, and occasional mowing to keep down woody growth. Timber harvest will occur on the small pine plantations and various hardwood stands as outlined earlier. As the dominant vegetation cover is removed from the cut areas, accelerated growth of the remaining vegetation is expected. In addition, disrupted land near construction sites will be reseeded and planted with native tree, shrub, and ground cover species to guard against erosion and provide the user with shade and other amenities associated with vegetative cover.

The expanded hiking - cross country ski trail and group camp east of the Fisher River will increase disturbance of those species that are timid and not well-adapted to humans. Species that would be affected include coyotes and fox. However, most species present in the Brunet Island State Park area already are adapted to human disturbance and therefore should not be noticably affected.

The Cornell Flowage is currently managed for major game species such as walleye, musky, smallmouth bass, catfish, and sturgeon. Muskellunge is the only species that has been stocked in recent years and this practice will be reduced to biennial stocking. Artificial habitat will be installed for panfish and forage species to promote increased populations. This will provide anglers increased fishing opportunity and expand the forage base for predators, particularly walleyes. Stocking of bluegills and/or perch will be encouraged when they are available. The local fish manager will take the lead in all such projects and be assisted by the park personnel when appropriate.

17. Social/Economic (include ethnic and cultural groups and zoning if applicable)

Expansion and improvement of park facilities will result in better service to the public. Providing a group camp and upgrading existing campground and day-use facilites will serve to meet some of the needs as identified in local, regional, and state outdoor recreation plans. The new shower building should increase campsite utilization and length of stay and therefore increase camping revenue. This should also mean more dollars for the local economy, based on information presented within the 1980 Wisconsin Camper Survey. Providing an amphitheater, additional nature trails, and nature programs will increase the educational mission of the property and provide the user with more information about the natural environment and Department programs being undertaken to safeguard our natural resources.

Remodeling and replacing obsolete facilities should also increase park user satisfaction and lead to increased use and duration of stay. This in turn will provide economic benefits through increased park admission sticker and campsite rental fees. It is expected that the park will continue to generate local commercial sales for such things as gasoline, picnic and camping supplies. If the proposed development projects are implemented, at least $500,000 will be put into the regional economy.

There is only one 16.24-acre parcel of land remaining to be purchased to reach the project acreage goal of 1,048.48 acres. This land is presently utilized as the city well field. The Department would be interested in the land only if it was no longer used as a city well field and would come up for sale. At the present time, the Department pays in lieu of taxes for the lands which it owns.

There are two management problems worthy of discussion:

1. Sticker sales and revenue collection.

   Prior to the 1983 use season, sticker sales were handled out of the office (located in the shop building) by park employees contacting park visitors in their vehicles at the various parking lots or by placing a sticker violation notice on the unattended vehicle. This system resulted in very inefficient fee collection, loss of revenue, and waste of employee work time. The situation was corrected the past 2 use seasons by placing a temporary booth on the park entrance road and staffing it with LTE and local high school work study personnel. This system resulted in a 4% increase in resident, annual sticker sales and a 22% increase in daily resident sticker sales in 1983. It is apparent that the park should be sufficiently staffed to keep the contact station open during the major use season. In addition, a permanent park entrance visitor station should be constructed so that sales, camper registration, and general office work can be undertaken in the same structure.

2. Shoreline erosion

   The north campground and various day-use area shorelines have a history of erosion created by people walking down the steep bank to fish or moor their boats. This has been corrected in some instances by placing a retaining wall on sidehills and riprapping the shoreline.

   Work remains to correct other eroded areas and guard against future bank disturbance. The use of riprap, retaining walls, stairs, stepping stones, and plantings will be utilized in combination with user education to eliminate this recurring problem.

18. Other Special Resources (e.g., archaeological, historical, endangered/threatened species, scientific areas, natural areas)

The State Historical Society will be informed of all major development proposals and the sites will be surveyed and evaluated prior to initiating construction in those areas.

Protection will be provided for endangered and threatened species that may be found to inhabit or migrate through the park. Guidelines of Manual Code 2028.1 will be followed.

19. Probable Adverse Impacts That Cannot be Avoided

Increased presence of man within the park may mean some interference with wildlife habitat and plant damage. The construction stage will expose some soil to water and wind erosion. Some dirt and noise will also be created during construction. Air pollution emissions to the atmosphere will increase slightly due to increased auto traffic to and through the area. Some minor grading will take place around construction; however, this will only minimally alter existing topography and drainage patterns. Some soil erosion could occur in construction sites; however, this will be minimized through the use of appropriate control techniques. Increased use will possibly increase the need for public services such as police and fire protection and medical attention. Gasoline and other fuels will be consumed by people coming to the park and by maintenance vehicles used in the park. Traffic will increase on the state trunk highways and village streets leading to the property; however, this increase is minimal and therefore is not expected to have a great effect on traffic volume.

ALTERNATIVES (no action - enlarge - reduce - modify - other locations and/or methods)

20. Identify, describe and discuss feasible alternatives to the proposed action and their impacts. Give particular attention to alternatives which might avoid some or all adverse environmental effects.

No Additional Acquisition and no Additional Development.

This alternative would provide for no further acquisition or development. The Department would merely retain and manage the existing resource and its recreational facilities. This alternative is not desirable since the property was acquired for recreational purposes in order to meet the needs of the recreating public. No additional acquisition within the property boundary could lead to future encroachment of undesirable land uses. No additional development could lead to the degradation of the resource, its facilities, and could lead to safety problems.

Reduce and Adjust Existing Acquisition Boundary

This alternative would provide for the elimination of the 16-acre parcel of land that is presently occupied by the Cornell well field. The property could be eliminated from the park with little or no impact as it presently exists if we were assured that the land would be retained by the city for a well field. However, because this is not a certainty, the land should be kept within the boundary and acquired when and if it becomes available for sale. This would guard against any potential land use conflicts.

Moderate Additional Development on Existing Stateowned Land

It is recommended that moderate additional development occur on existing state-owned land. The facilities include a shower building, upgrading the north and south campgrounds, constructing a group camp, and replacing facilities and furnishings as needed. In addition, hiking and ski trails would be upgraded and roads and parking areas will be resurfaced. A shelter building and amphitheater will be constructed in the day-use area, and a permanent contact station will be built at the park entrance. This alternative is desirable in that it will ensure the maintenance of a high quality recreational facility, maximize user enjoyment, and eliminate potential safety problems.

Development of a fire control storage building and office space in conjunction with existing park office shop complex is proposed. This consolidation will entail bringing fire control employees, a conservation warden, and park personnel into one central location and facility. This action will allow for the sharing of manpower and equipment which will be beneficial to the property.

Additional Largescale Development on Lands Within Park Boundary

Largescale development including enlarging the campground and various day-use areas is possible. However, based on present and projected use figures, such action is not warranted.

EVALUATION (discuss each category. Attach additional sheets and other pertinent information if necessary.)

21. Secondary Effects: As a result of this action, is it likely that other events or actions will happen that may significantly affect the environment? If so, list here and reference their discussion in items 15-18 as appropriate.

    Providing a group camp area will increase the use of the park to the point where park revenues will be increased and secondary economic gains will be realized by the local economy. Upgrading and enlarging the day-use facilities will also increase use and secondary economic benefits. This additional use will generate traffic into the area and increase use of local roads.

22. New Environmental Effect: Does the action alter the environment so a new physical, biological or socio-economic environment would exist? If so, list here and reference their discussion in items 5-10 or 15-18 as appropriate.

    The proposed development action will not result in a significant change to the social, physical, or biological environment of the property because similar facilities and recreational activities have been provided on the property since 1939.

23. Geographically Scarce: Are the existing environmental features that would be affected by the proposed action scarce, either locally or statewide? If so, list here and reference their discussion in items 15-18 as appropriate.

Brunet Island State Park is one of two state parks located along the Chippewa River in Western Wisconsin and therefore would not be considered scarce on a regional or statewide basis. However, the park is heavily used by local Cornell residents, as well as state and out-of-state citizens and therefore removal from the Wisconsin State Park System would have a detrimental impact on users.

24. Precedent: Does the action and its effect(s) require a decision which would result in influencing future decisions? Describe.

The action is not precedent setting as similar management practices and programs discussed throughout the master plan are being carried out on a statewide basis. There are over 50 other state parks which are being managed similarly to Brunet Island State Park.

25. Controversy: Discuss and describe concerns which indicate a serious controversy or unresolved conflicts concerning alternative uses of available resources.

This action has generated no controversy as it is not precedent setting and it has been reviewed by local citizenry and generally met with their approval.

26. Consistency With Plans: Does the action conflict with local or agency zoning or with official agency plans or policy of local, state or federal government (e.g., NR 1.95)? If so, how? Refer to applicable comments in item 31.

No conflicts are known or became evident during the initial planning and review process. This project is in accord with local, county, and state outdoor recreation plans.

27. Cumulative Impacts: While the action by itself may be limited in scope, would repeated actions of this type result in major or significant impacts to the environment?

Additional actions of this type would generally upgrade existing state park properties. Due to location of the proposed development and modification of existing buildings, there would be little significant impact on the natural environment.

28. Foreclose Future Options: Is the action irreversible? Will it commit a resource (e.g., energy, habitat, historical features) for the foreseeable future?

Some fuel, wear and tear on machinery, and depletion of resource materials is non-recoverable as is the manpower utilized in the planning, construction, and operation of the park. Fuel and other energy sources used to power vehicles to and from the park would be irretrievable. Similarly, energy used to maintain the property would be permanently committed. Funds used to develop the area would be irretrievably committed as well. For all practical purposes, roads, parking lots, and buildings will be permanently committed and the material will be basically unsalvagable. However, land covered by these facilities could be retrievable as roads are often obliterated, and revegetated. Abandoned building foundations are often also removed and, as a result, the site is often regraded and revegetated.

29. Socio-cultural Impacts: Will action result in direct or indirect impacts on ethnic or cultural groups or alter social patterns?

__X___ No, the park is open to all ethnic and cultural groups.
____ Yes, refer to item 17.

30) Other:

None.

LIST OF AGENCIES, GROUPS AND INDIVIDUALS CONTACTED REGARDING THE PROJECT (Include DNR personnel and title)

31.	Date	Contact	Comments
	2/1983-7/1/84	Ed Ferber, Park Mgr. Doug Erickson, Fish Spec. Rollie Nesbit, Wildlife Spec. Brian Marinello, Forest Spec. Larry Moussette, Park Rngr. Tom Harris, Warden	Master planning task force comments as it pertains to the various resource topics, work assignments, drafting goal and objective statements, and formulation of conceptual master plan document.
	2/10/83	Cliff Germain Chief, Natural and Scientific Areas Section	Scientific Area input for Brunet Island State Park master plan. Findings: No suitable area for scientific natural or wild area designation due to limited land base and resources.

3/31/83	J. R. Huntoon Nat. Res. Admn.	Preliminary goal and objective statements approved.
10/12/83	Public Meeting - 24 residents attended	Reviewed, discussed, and accepted comments regarding acquisition development, and management of Brunet Island State Park.
5/9/84	John DeLaMater Forestry Staff Spec.	Discussed and drew up preliminary schematic plan for fire control building and office needs in combination with the park.
8/9/84	Daniel Koich, Area WMS	Development of boat launch and processing of appropriate permits.

Dennis Kulhanek PR/4

EA 17

Project Name: Brunet Island State Park County: Chippewa

RECOMMENDATION

EIS Not Required X

Analysis of the expected impacts of this proposal is of sufficient scope and detail to conclude that this is not a major action which would significantly affect the quality of the human environment. In my opinion therefore, an environmental impact statement is not required prior to final action by the Department on this project.

Refer to Office of the Secretary . . . . :

Major and Significant Action: Prepare EIS . . . .

Request EIR . . . .

Additional factors, if any, affecting the evaluator's recommendation:

Michael L. Reit 1/3/85

Signature of Evaluator Date

X Harold D. Weigenlinden 1/17/85

Noted: Area Director or Bureau Director Date

Number of responses to public notice 1

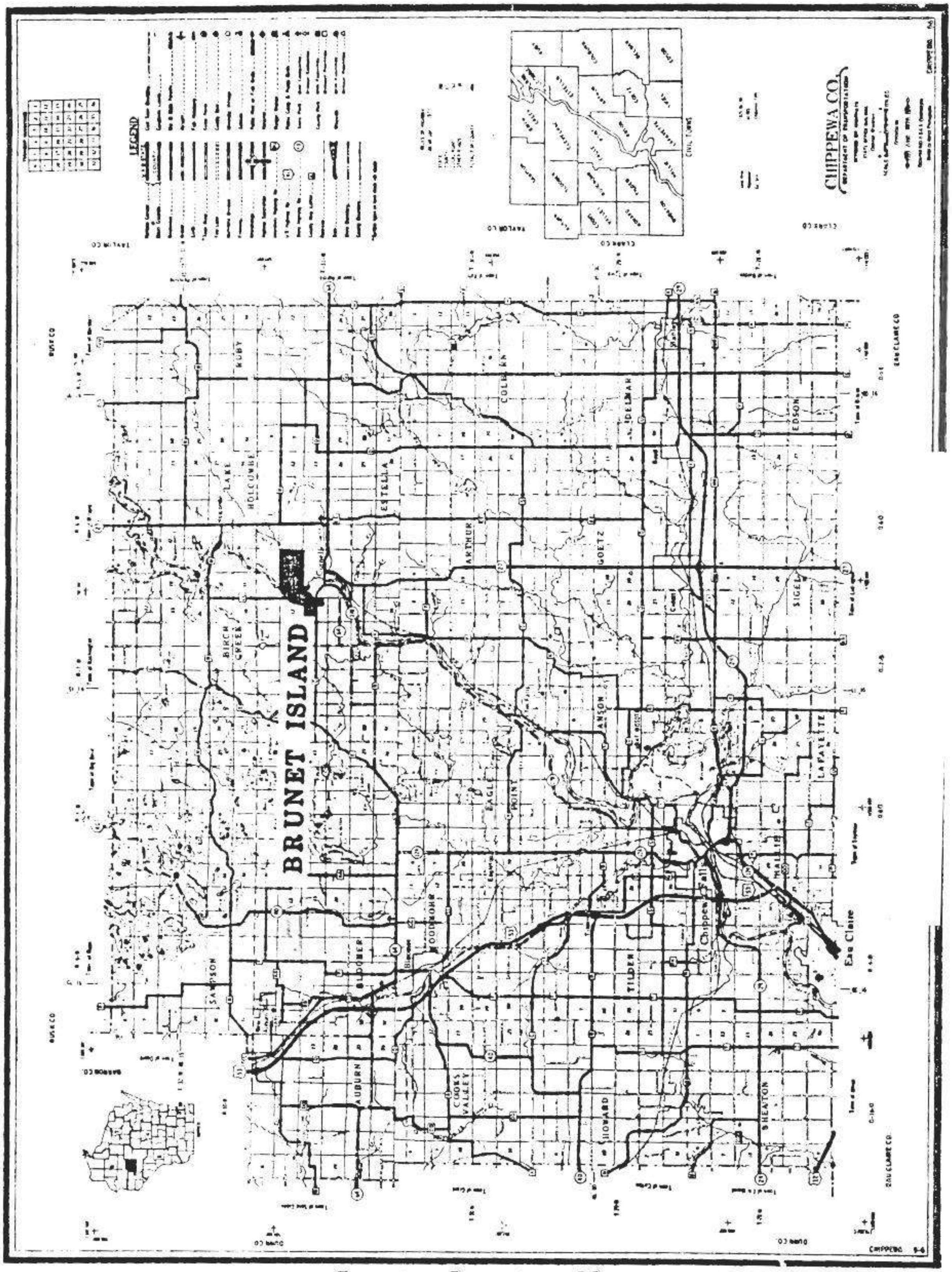
Public response log attached?....... v.c

CERTIFIED TO BE IN COMPLIANCE WITH WEPA

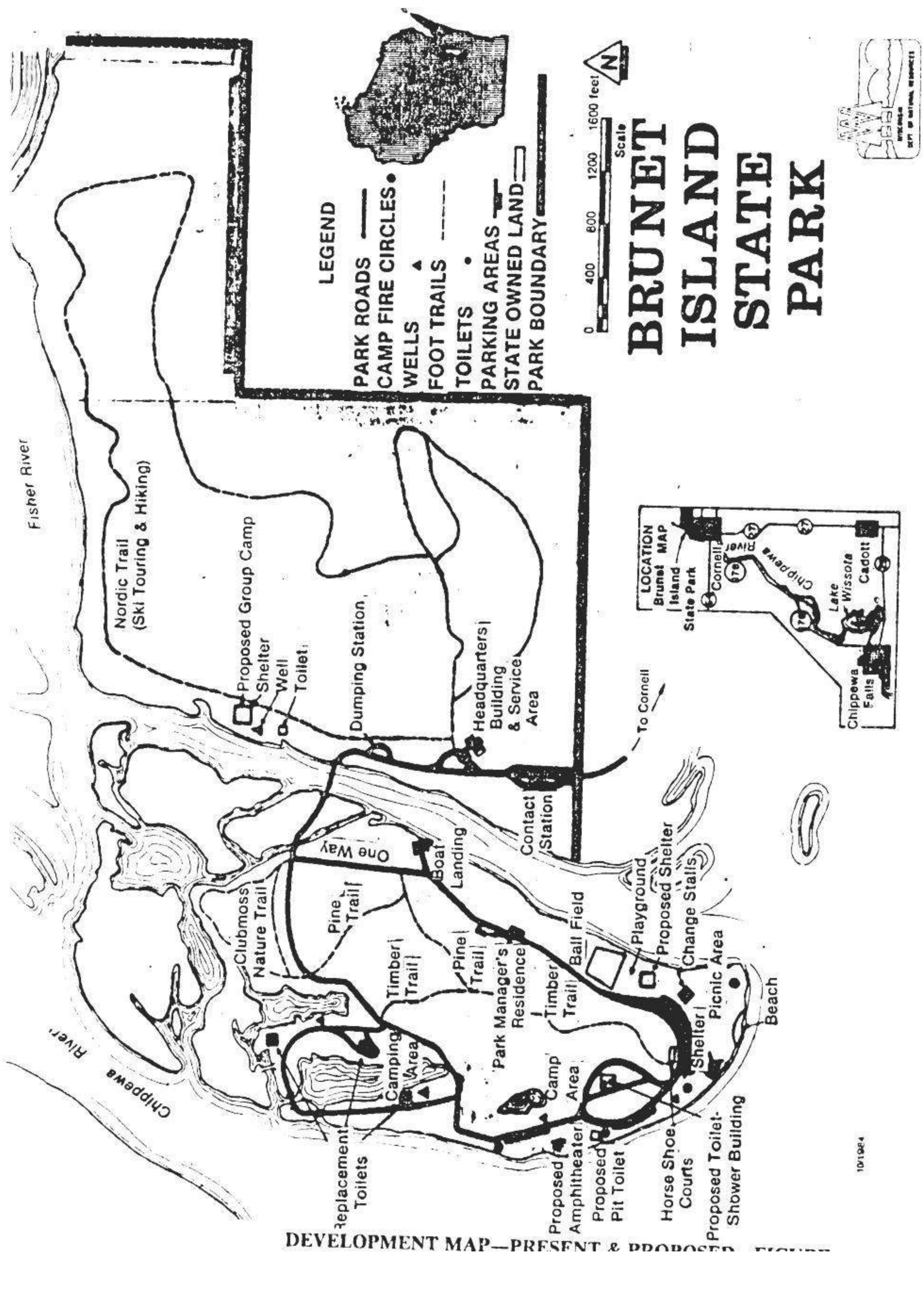
District Director or Director of BEI (or Designee) Date

Roger L. Fritz 4/30/85

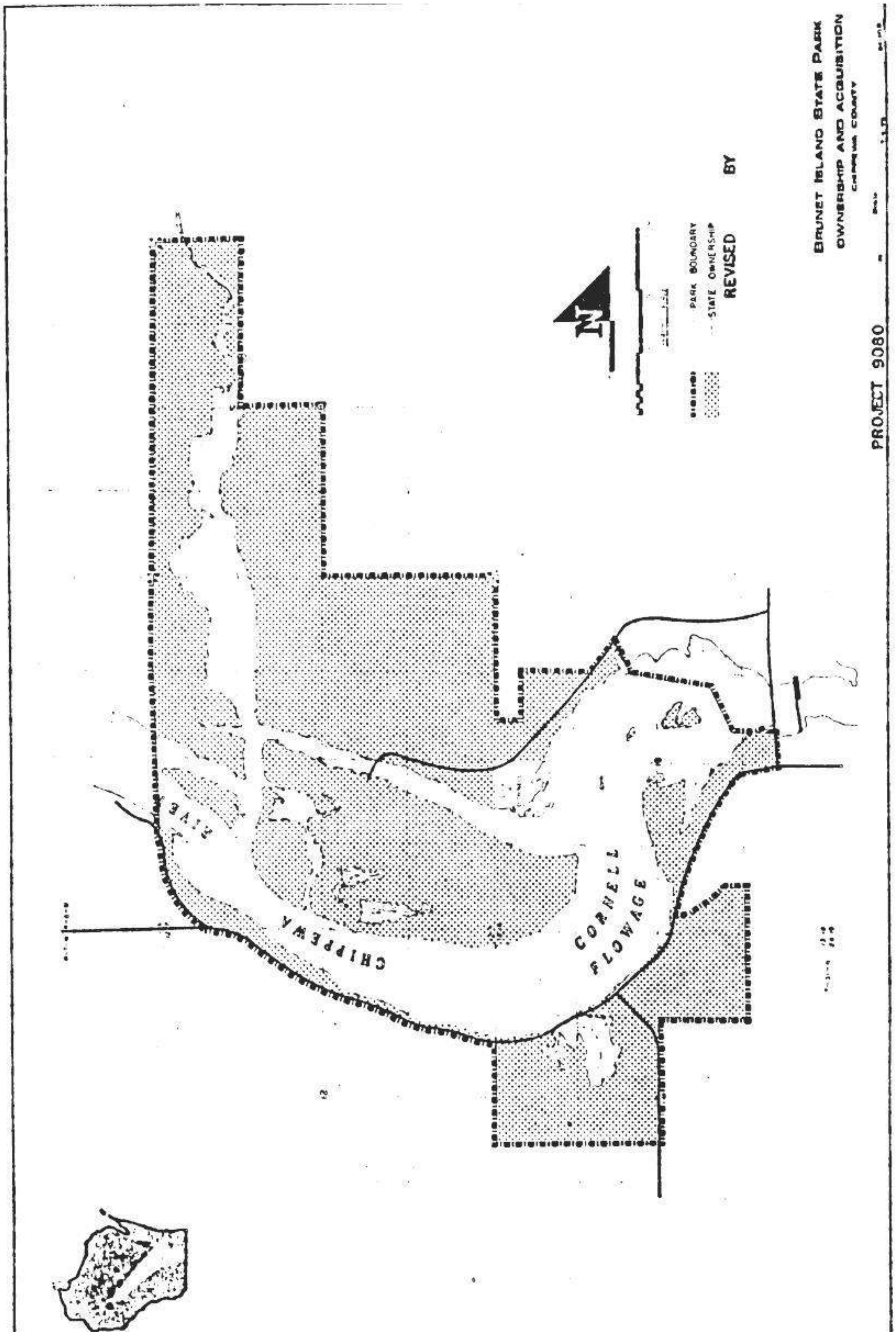
This decision is not final until certified by the appropriate District Director or the Director of BEI. If you believe you have a right to challenge this decision, you should know that Wisconsin Statutes and Administrative Codes establish time periods within which requests to review Department decisions must be filed. For judicial review of a decision pursuant to ss. 227.15 and 227.16, Stats., you have 30 days after service of the decision to file your petition for review. The respondent in an action for judicial review is the Department of Natural Resources. You may wish to seek legal counsel to determine your specific legal rights to challenge a decision. This notice is provided pursuant to s. 227.11(2), Stats.



County Locator Map **fig. 1.**



DEVELOPMENT MAP—PRESENT & PROPOSED



Acquisition Map

fig. 2

APPENDIX E-28 IPAC Official Species List

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Green Bay Ecological Services Field Office
2661 Scott Tower Drive
New Franken, WI 54229-9565
Phone: (920) 866-1717 Fax: (920) 866-1710

In Reply Refer To: February 26, 2021
Consultation Code: 03E17000-2021-SLI-0806
Event Code: 03E17000-2021-E-02783
Project Name: Cornell Hydroelectric Project Relicensing

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The attached species list identifies any federally threatened, endangered, proposed and candidate species that may occur within the boundary of your proposed project or may be affected by your proposed project. The list also includes designated critical habitat if present within your proposed project area or affected by your project. This list is provided to you as the initial step of the consultation process required under section 7(c) of the Endangered Species Act, also referred to as Section 7 Consultation.

Section 7 of the Endangered Species Act of 1973 requires that actions authorized, funded, or carried out by Federal agencies not jeopardize federally threatened or endangered species or adversely modify designated critical habitat. To fulfill this mandate, Federal agencies (or their designated non-federal representative) must consult with the Service if they determine their project "may affect" listed species or critical habitat.

Under 50 CFR 402.12(e) (the regulations that implement Section 7 of the Endangered Species Act) the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally. You may verify the list by visiting the ECOS-IPaC website http://ecos.fws.gov/ipac/ at regular intervals during project planning and implementation and completing the same process you used to receive the attached list. As an alternative, you may contact this Ecological Services Field Office for updates.

Please use the species list provided and visit the U.S. Fish and Wildlife Service's Region 3 Section 7 Technical Assistance website at - http://www.fws.gov/midwest/endangered/section7/s7process/index.html. This website contains step-by-step instructions which will help you determine if your project will have an adverse effect on listed species and will help lead you through the Section 7 process.

For all **wind energy projects** and **projects that include installing towers that use guy wires or are over 200 feet in height (*e.g.*, communication towers)**, please contact this field office directly for assistance, even if no federally listed plants, animals or critical habitat are present within your proposed project or may be affected by your proposed project.

Although no longer protected under the Endangered Species Act, be aware that bald eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*) and Migratory Bird Treaty Act *(*16 U.S.C. 703 *et seq*), as are golden eagles. Projects affecting these species may require measures to avoid harming eagles or may require a permit. If your project is near an eagle nest or winter roost area, see our Eagle Permits website at http://www.fws.gov/midwest/midwestbird/EaglePermits/index.html to help you determine if you can avoid impacting eagles or if a permit may be necessary.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Green Bay Ecological Services Field Office
2661 Scott Tower Drive
New Franken, WI 54229-9565
(920) 866-1717

Project Summary

Consultation Code: 03E17000-2021-SLI-0806
Event Code: 03E17000-2021-E-02783
Project Name: Cornell Hydroelectric Project Relicensing
Project Type: DAM
Project Description: Relicensing of the Cornell Hydroelectric Project (FERC No. 2639) under the current operational conditions. No changes to operations of the project are proposed.
Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@45.194173649999996,-91.16172587109165,14z

Counties: Chippewa County, Wisconsin

Endangered Species Act Species

There is a total of 2 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Threatened

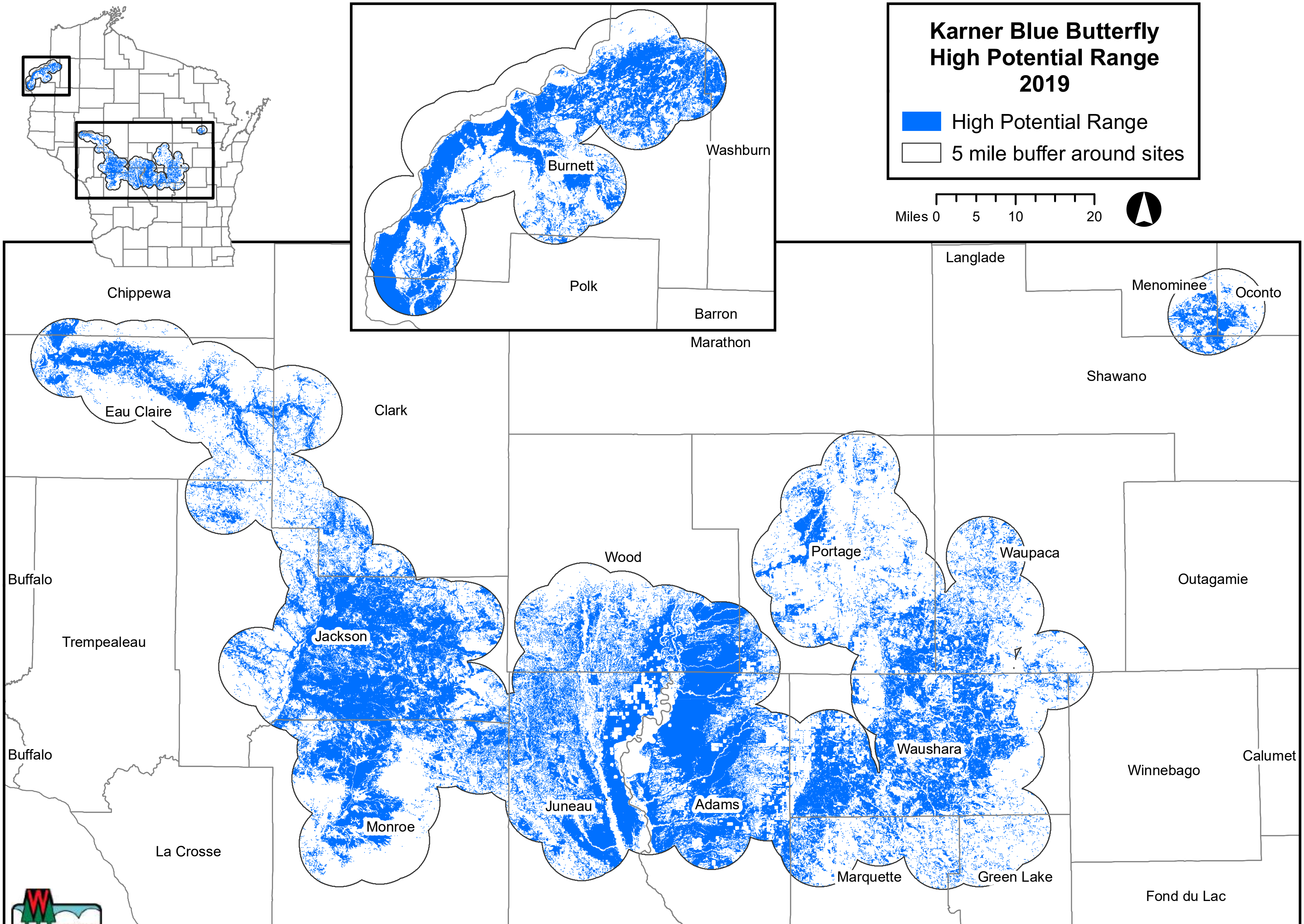
Insects

NAME	STATUS
Karner Blue Butterfly *Lycaeides melissa samuelis* There is **proposed** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/6656	Endangered

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

APPENDIX E-29 KBB High Potential Range Map



The information shown on this map has been obtained from various sources, and is of varying age, reliability and resolution. This map is not intended to be used for navigation, nor is this map an authoritative source of information about legal land ownership or public access. Users of this map should confirm the ownership of land through other means in order to avoid trespassing. No warranty, expressed or implied, is made regarding accuracy, applicability for a particular use, completeness, or legality of the information depicted on this map.

APPENDIX E-30 Public-NHI Review (ERR Log # 20-278)

The NHI Review (ERR Log # 20-278) has been filed separately with FERC as Privileged information

APPENDIX E-31 BITP/BITA for Wisconsin Cave Bats

Broad Incidental Take Permit and Broad Incidental Take Authorization for Wisconsin Cave Bats

Conservation Plan - May 2020

During this COVID-19 pandemic, there is increasing concern that symptomatic or asymptomatic humans could inadvertently pass the virus that causes COVID-19 disease in humans to mammals, including bats, during handling. As a reminder, any handling of bats by a pest control operator requires an Endangered/Threatened (E/T) Species Permit (this is not required for a landowner). In addition, please be sure to continue following disinfection protocols for any equipment used during bat removals or exclusions (see Appendix 4).

The department has issued this broad incidental take authorization (used by state agencies) and broad incidental take permit (used by non-state agencies and individuals), as provided for under s. 29.604, Wis. Stats., to allow for the incidental taking of state listed cave bats in Wisconsin that may occur as a result of specific public health concerns, bat removals, building demolitions, tree cutting, bridge demolitions, miscellaneous building repairs and wind energy development projects.

This permit and authorization cover the above activities only if the associated minimization measures are followed and take is reported (where required). These measures must be followed when a bat is present or suspected to be present (e.g., evidence of bat presence, Endangered Resources Review). Please note that the northern long-eared bat is currently listed as threatened in Wisconsin and threatened with 4(d) rule at the federal level by the United States Fish and Wildlife Service (USFWS, http://www.fws.gov/Midwest/endangered/mammals/nleb/index.html). For the activities listed above, this Conservation Plan includes both state and federal requirements. The state cannot permit or authorize take of a federally listed species, however this Conservation Plan was written to incorporate both state and federal requirements.

For activities not listed above, contact the Wisconsin Department of Natural Resources' Endangered Resources Review Program (DNRERReview@wi.gov) for more information on state and federal requirements. Please note that building demolition, tree cutting, bridge projects, miscellaneous building projects and wind energy development typically require a full Endangered Resources Review http://dnr.wi.gov/topic/ERReview/Review.html to determine impacts to other wildlife species as well.

An incidental take permit or authorization is typically issued on a project-by-project basis, however a broad incidental take permit and broad incidental take authorization were created for this situation so that neither an application nor a permit fee are required. An individual following the minimization measures listed below is automatically covered by this broad incidental take permit/authorization. Take will be minimized by following specific minimization measures and the Department has concluded that the projects covered under this permit/authorization are not likely to jeopardize the continued existence and recovery of the state population of these bats or the whole plant-animal community of which they are a part; and has benefit to the public health, safety or welfare that justifies the action.

Project Location

Statewide

Project Information

This permit/authorization cover specific public health concerns, bat removals, building demolitions, forestry activities, bridge demolitions, miscellaneous building repairs and wind energy development projects as described in *Minimization Measures.*

Species Information

This permit/authorization cover all cave bats currently listed in Wisconsin (NR 27.07, Wis. Admin. Code):

- Big brown bat (*Eptesicus fuscus*) – State Threatened
  The big brown bat is a large insectivorous bat, weighing 15.0-26.0 grams. Fur color is russet to dark brown, and the muzzle is black and hairless. In summer, big brown bats commonly roost in artificial structures such as barns, but these bats will also use crevices in trees and rock faces. Big brown bats migrate short distances to caves and mines where they will hibernate for the winter.
- Eastern pipistrelle (*Perimyotis subflavus*) – State Threatened
  The eastern pipistrelle is Wisconsin's smallest bat weighing 4.0-8.0 grams. Fur color ranges from golden brown to reddish brown, and the wing membrane is black with red forearms. The eastern pipistrelle is an insectivorous bat. In summer, these bats commonly roost in the branches of deciduous trees disguised as a leaf. This species migrates short distances to caves and mines in the fall where they hibernate over the winter.
- Little brown bat (*Myotis lucifugus*) – State Threatened
  The little brown bat is a medium-sized member of the genus *Myotis*. This insectivorous bat weighs 5.0-12.5 grams, and has tan, reddish-brown or dark brown fur. This species commonly uses artificial structures such as attics and barns as summer roosting sites, but will also roost in crevices and cavities of trees. In fall, little brown bats make local long-distance migrations of up to 279 miles to caves and mines where they will hibernate for the winter.
- Northern long-eared bat (*Myotis septentrionalis*) – State Threatened and Federally Threatened
  The northern long-eared bat is dark brown with a gray belly, weighing 5.0-8.0 grams and is insectivorous. In summer this bat roosts in trees behind loose bark and in cracks/crevices/holes along the trunk of the tree. It rarely roosts in artificial structures. Unlike most of the state's bats, this species commonly forages in forest interior. In fall the northern long-eared bat migrates to caves and mines where they will hibernate for the winter.

Likely Impact to Species

Although minimization measures to protect the big brown bat, eastern pipistrelle, little brown bat and northern long-eared bat are incorporated into this broad incidental take permit/authorization, it is not possible to fully avoid incidental take of these species in all situations. Due to the nature of activities covered under this permit/authorization, it is difficult to determine the exact number of individuals that could be taken as a result of the project; however take will be minimized by following specific minimization measures. The Department has concluded that the take allowed for under this permit/authorization is not likely to jeopardize the continued existence and recovery of the state population of these bats or the whole plant-animal community of which they are a part.

Alternative Actions

The following alternatives were considered for this permit/authorization:

Alternative 1: Do not allow for any take of cave bats.

> This alternative was determined to not be feasible, due to the large number of affected activities, and is not an appropriate public health decision.

Alternative 2: Do not allow for any take of cave bats during the summer roosting period but allow for some take throughout the remainder of the year.

> This alternative was determined to not be feasible, due to the large number of affected activities that occur during the summer roosting period, and is not an appropriate public health decision.

Alternative 3: Allow for some take of cave bats, with minimization measures in place, during the summer roosting period and throughout the remainder of the year.

> This option was the preferred alternative because it addresses public health concerns; protects a large number of bats; and allows for most affected activities to continue as planned, or with minimal modifications.

Minimization Measures

This permit/authorization covers the activities listed below only if the associated minimization measures are followed and take is reported (where required). These measures must be followed when a bat is present or suspected to be present (e.g., evidence of bat presence, Endangered Resources Review). Please note that the northern long-eared bat is currently listed as threatened in Wisconsin and threatened with 4(d) rule at the federal level by the United States Fish and Wildlife Service (USFWS, http://www.fws.gov/Midwest/endangered/mammals/nleb/index.html). For the activities listed below, this Conservation Plan includes both state and federal requirements. The state cannot permit or authorize take of a federally listed species, however this Conservation Plan was written to incorporate both state and federal requirements.

For activities not listed below, contact the Wisconsin Department of Natural Resources' Endangered Resources Review Program (DNRERReview@wi.gov) for more information on state and federal requirements. Please note that building demolition, tree cutting, bridge projects, miscellaneous building projects and wind energy development typically require a full Endangered Resources Review http://dnr.wi.gov/topic/ERReview/Review.html to determine impacts to other wildlife species as well.

Note: Take covered under this permit/authorization must be reported within 5 working days (where required below). Take not reported within 5 working days is not legally covered and is in violation of the Wisconsin Endangered Species Law (s. 29.604, Wis. Stats.). Reports can be submitted via email (DNRBats@wi.gov), or by submitting a sick/dead bat report using the form: http://wiatri.net/Inventory/Bats/Report/BatForm.cfm. When using the form, state that you are reporting take in the "Additional Comments" section.

A. Health Exceptions

The landowner, rather than the DNR, is allowed to determine if they believe there is a health risk under this section (Section A).

Centers for Disease Control and Prevention (CDC) protocols should be followed for all situations where rabies or histoplasmosis is a possibility or may become a possibility if action is not taken (see Appendix 1).

Additionally, exclusions completed from June 1 through August 15 must be reported to the Department by submitting a Health Exemption Form in order to be covered under this permit or authorization. The landowner is responsible for completing and submitting the form, which is available online (http://dnr.wi.gov/topic/erreview/itbats.html). This form must be completed and submitted to the Department within **5 working days of start of work**.

If an activity qualifies as a health exception, it is exempt from timing minimization measures, and maximum take limits, but exclusions done during the non-exclusion period for human health reasons must still minimize take by following the approved exclusion protocols listed in Appendix 5. Exclusion practices used that are not described in Appendix 5 are in violation of this permit/authorization.

B. Bat Removals and Exclusions

Exclusion is defined as the process of allowing a colony of bats to leave the structure but not re-enter (i.e., use of one-way doors, see Appendices 2 and 5). Physically removing the colony of bats is not included in the definition of exclusion and is not covered under this section of the permit/authorization. Bats may be removed from the living space of a building at any time (see B.1. below).

Approved exclusion practices may be reviewed in Appendix 5. Exclusion practices used that are not described in Appendix 5 are in violation of this permit/authorization

If bats must be handled or transported for any reason during the exclusion process, the person conducting the exclusion must possess a valid Endangered/Threatened (E/T) Species Permit (http://dnr.wi.gov/topic/endangeredresources/permits.html). By obtaining the E/T Permit, the pest control operator can assure the landowner that practices used by the pest control company are in accordance with state law and no fines should incur while exclusion is completed. If bats must be handled during the exclusion, an E/T Permit holder (i.e. a rehabilitator or licensed pest control operator) may be contacted to handle the bats.

Practices that cause intentional take of the bats (i.e., sticky traps, sealing the entry/exit points to the roost with bats inside, large-hole netting that traps bats) are not considered exclusion methods, are not covered under this permit/authorization and are in violation of Wisconsin's Endangered Species Law (s. 29.604, Wis. Stats.).

1. Living Space or Place of Work

   A living space is defined as a place of residence that is routinely and consistently inhabited. A living space does not include attics that are empty or used as storage.

   If individual bats (5 or fewer) enter a living space or place of work, reasonable attempts must first be made to remove or exclude the bats alive and unharmed (see Appendix 2). If individual bats cannot realistically be removed unharmed, up to 5 bats may be killed for the purpose of removing them from a living space or place of work. No more than 5 bats may be killed within any 24 hour period and a maximum of 10 bats may be killed from June 1 – August 15 (**take report recommended – see "Note" above**).

Removals and exclusions from June 1 – August 15 are allowed in hospitals, medical clinics, day cares centers, nursing homes, assisted living facilities and restaurants.

2. Storage Areas, Attics, Barns, etc.

   Bats found in storage areas, attics, barns, etc., may be excluded from the area August 16 – May 31 (see Appendix 2). Exclusion may not occur from June 1 – August 15 unless a health exemption report form is filed (see Section A).

3. In an effort to help curb the spread of white-nose syndrome (WNS), bat exclusion professionals and pest control operators must follow these guidelines concerning cleaning equipment (NR 40, Wis. Admin. Code.):

   - Equipment used outside of Wisconsin should be thoroughly cleaned and disinfected before use in Wisconsin following the protocols in Appendix 4.
   - Equipment used at multiple sites within Wisconsin should be cleaned thoroughly and disinfected between uses following the protocols in Appendix 4. Materials that come in direct contact with bats such as bat cones or exclusion devices should not be used at multiple sites and should be discarded after use.

C. Building Demolition

Please note that timing restrictions in this section vary slightly from those listed for other activities. Bats typically leave summer roosts (in buildings or other locations) in late fall and begin to return in early spring. However, one bat species in Wisconsin is known to hibernate in buildings in winter. Bats are not actively flying during winter hibernation and can appear dead. As a result, traditional exclusion methods do not work.

1. For projects occurring where there is no evidence of bat presence (see Appendix 3), there are no restrictions.
2. For building demolition occurring from June 1 – August 15, where there is evidence of bat presence (see Appendix 3):
   - Building demolition and bat exclusions are generally not permitted during this time period in order to protect flightless pups in the roost. Exclusion and subsequent demolition may occur only if the bats are considered by the landowner to be a health risk. In these situations, a health exemption form must be completed within 5 days of starting work (see section A).
3. For building demolition occurring from August 16 – October 31 or March 16 – May 31, where there is evidence of bat presence (see Appendix 3):
   - Bats must be excluded from the building for at least 7 consecutive days immediately prior to demolition. Full exclusion is not required if the building is unsafe to enter, however reasonable attempts should still be made to exclude as many bats as possible while keeping all people safe. (Report required for unsafe buildings – see "Note" on Page 3.)
4. For building demolition occurring from November 1 – March 15, where there is evidence of bat presence (see Appendix 3):

- For any bats found prior to demolition work or encountered during the demolition phase, attempts must be made to transfer the bats to a wildlife rehabilitator for the remainder of the hibernation period OR the DNR's bat biologists must be consulted for additional options (Paul White, 608-267-0813 and john.white@wi.gov, or Heather Kaarakka, 608-266-2576 and heather.kaarakka@wi.gov).

D. Tree Cutting

Northern long-eared bats are federally protected in trees that are known maternity roosts (from June 1 – July 31) and in areas where known hibernacula could be impacted (including tree removal within 0.25 miles of a hibernacula entrance). If you will be cutting trees, please have an Endangered Resources Review http://dnr.wi.gov/topic/ERReview/Review.html conducted to determine if known northern long-eared bat maternity roosts or hibernacula exist near your project. If the Endangered Resources Review states that these areas do not exist near your project, there are no restrictions for tree cutting; however special consideration should be given to protecting snags or dying trees, particularly from June 1 – August 15.

E. Bridge Projects

The process for assessing transportation project impacts to listed species and the associated minimization measures will follow existing protocols.

1. Bridge repairs or demolition occurring from August 16 – May 31 do not have any restrictions. If bats are present, reasonable attempts should be made to prevent take by excluding the bats from the structure prior to demolition.
2. Emergency bridge repairs or demolition occurring from June 1 – August 15 are covered under this permit/authorization but must be reported within 5 working days (**report required – see "Note" above**).
3. Non-emergency bridge repairs or demolition may not occur from June 1 - August 15 unless bats are excluded prior to April 1 to prevent bats from using the bridge during the maternity period.

F. Miscellaneous Building Projects (e.g., roofing, painting, siding)

1. For projects occurring where there is no evidence of bat presence (see Appendix 3):
    - Full bat exclusions are not required.
    - If roofing, painting or siding and bats are found incidentally under shingles or roof vents, or behind shutters or siding, set the shutters or siding down and leave the area. Once the bats have left, continue with repairs. If bats do not leave, attempts should be made to transfer the bats to a wildlife rehabilitator OR the DNR's bat biologists should be consulted for additional options (Paul White, 608-267-0813 and john.white@wi.gov, or Heather Kaarakka, 608-266-2576 and heather.kaarakka@wi.gov).
2. For projects occurring from June 1 – August 15, where there is known bat presence (see Appendix 3):
    - Building projects with the potential to impact bats and bat exclusions are generally not permitted during this time period in order to protect flightless pups in the roost. Exclusion and subsequent building repairs may occur only if the bats are considered

by the landowner to be a health risk. In these situations, a health exemption form must be completed within 5 days of starting work (see section A).

- If roofing, painting or siding and bats are found incidentally under shingles or roof vents, or behind shutters or siding, set the shutters or siding down and leave the area. Once the bats have left, continue with repairs. If bats do not leave, attempts should be made to transfer the bats to a wildlife rehabilitator OR the DNR's bat biologists should be consulted for additional options (Paul White, 608-267-0813 and john.white@wi.gov, or Heather Kaarakka, 608-266-2576 and heather.kaarakka@wi.gov). Note that full bat exclusions are not required when bats are only incidentally found during miscellaneous building projects.

3. Projects occurring from August 16 – May 31 where there is known bat presence (see Appendix 3):

    - Take should be minimized during the course of the project by following applicable exclusion protocols listed in Appendix 5. Exclusion practices used that are not described in Appendix 5 are in violation of this permit/authorization.
    - If roofing, painting or siding and bats are found incidentally under shingles or roof vents, or behind shutters or siding, set the shutters or siding down and leave the area. Once the bats have left, continue with repairs. If bats do not leave, attempts should be made to transfer the bats to a wildlife rehabilitator OR the DNR's bat biologists should be consulted for additional options (Paul White, 608-267-0813 and john.white@wi.gov, or Heather Kaarakka, 608-266-2576 and heather.kaarakka@wi.gov). Note that full bat exclusions are not required when bats are only incidentally found during miscellaneous building projects.

G. Wind Energy Development

Wind energy projects typically affect tree bat species (not currently listed) and only impact cave bat species in certain situations (e.g., projects located near cave bat hibernacula may increase the occurrence of impacts to cave bats especially during fall migration in August and September). Further, there is not enough data at this time to determine the impact of potential mortality to local bat populations. Because of this uncertainty and the scope of impacts, no additional actions, above those currently requested by the Department, will be required of this industry at this time.

Mitigation

For every take of a cave bat that occurs, reasonable attempts must be made to prevent future take in the same area (e.g., exclusion of bats from the area, sealing of siding or eaves after bats are gone).

Responsible Parties

Landowners are responsible for all actions and costs incurred as a result of following this Broad Incidental Take Permit/Authorization.

Funding

Landowners are responsible for all costs incurred as a result of following this Broad Incidental Take Permit/Authorization.

Appendix 1: Health Information

Appendix 2: Removing and Excluding Bats

Appendix 3: Determining Bat Presence

Appendix 4. Cleaning and Disinfection Protocols for Bat Exclusion Professionals

Appendix 5. WDNR Exclusion Protocol

Appendix 1: Health Information

The following information was created by the Center for Disease Control and Prevention (CDC): http://www.cdc.gov/rabies/bats/contact/index.html. This information should be followed when handling or testing bats for rabies or histoplasmosis.

Recent data suggest that transmission of rabies virus can occur from minor, seemingly unimportant, or unrecognized bites from bats. Human and domestic animal contact with bats should be minimized, and bats should never be handled by untrained and unvaccinated persons or be kept as pets.

In all instances of potential human exposures involving bats, the bat in question should be safely collected, if possible, and submitted for rabies diagnosis. Rabies postexposure prophylaxis is recommended for all persons with bite, scratch, or mucous membrane exposure to a bat, unless the bat is available for testing and is negative for evidence of rabies.

Postexposure prophylaxis should be considered when direct contact between a human and a bat has occurred, unless the exposed person can be certain a bite, scratch, or mucous membrane exposure did not occur.

In instances in which a bat is found indoors and there is no history of bat-human contact, the likely effectiveness of postexposure prophylaxis must be balanced against the low risk such exposures appear to present. Postexposure prophylaxis can be considered for persons who were in the same room as a bat and who might be unaware that a bite or direct contact had occurred (e.g., a sleeping person awakens to find a bat in the room or an adult witnesses a bat in the room with a previously unattended child, mentally disabled person, or intoxicated person) and rabies cannot be ruled out by testing the bat. Postexposure prophylaxis would not be warranted for other household members.

If you woke up because a bat landed on you while you were sleeping or if you awakened and found a bat in your room, you should try to safely capture the bat and have it tested. The same precautions should be used if you see a bat in a room with an unattended child, or see a bat near a mentally impaired or intoxicated person.

The small teeth of the bat can make a bite difficult to find. Be safe and in these situations, try to safely capture the bat, have the bat tested, and seek medical advice.

Appendix 2: Removing and Excluding Bats

Bat Exclusion

Method used by The Wisconsin Bat Program

A PROVEN SOLUTION

Do you have bats that you would like to remove from your living space? The following description is the widely accepted, non-lethal approach for excluding bats from your home. Killing the bats you will find does not solve the root problem which involves locating and sealing the actual access point that the bats are using. The remaining bats and future bats will still find their way into your attic or similar roosting space until you locate and seal all access points. Bats are NOT rodents and therefore will NOT chew their way into your house if you close off the opening. They use only existing openings.

As you may already know, bats are extremely beneficial to have in your neighborhood and many property owners spend a lot of effort trying to attract bats to their area by providing artificial roosts for them. If you have bats in your home you are half-way to experiencing the benefits of these insect-eating mammals without having to share your living space. The first step is already done; you have the bats interested in your location. The second step involves providing these bats with alternative roosting options that allows them to remain on the property without having access to your home. Finally, after a successful exclusion, the bats you saved will have a good chance of staying nearby. Why should you care if they stay? A single bat can eat 1,000 or more mosquito-sized insects in one hour and the equivalent of the bat's own body weight per night. As that is just a single bat, you can imagine what a colony of 20 to 100 bats can eat in one night.

Bats will NOT attack you while you are enjoying an evening on your porch. Instead, they are enjoyable to view as they capture 100's and 1,000's of insect pests that would normally be interrupting your relaxing night outside. They conduct this service to you for free. You simply need to provide these bats with an alternative place to live that is not in your home. Like bird houses, a bat house is relatively easy to build yourself, inexpensive to purchase, and readily available from a variety of organizations.

Let's get started with the process.

First of all, timing is important when excluding bats from the home. Do not attempt to exclude bats during the summer months when the colony is established and the young are unable to fly. Bat exclusions should not be conducted from May 1st through August 31. Exclusions occurring during this time period will separate mothers from their pups, leaving the pups to die of starvation. Frantic mothers, searching for an opening to reach their pups, may enter your living space and be more difficult to deal with than what you started with. By trapping the flightless young inside, you may also have created another unexpected problem involving the smell of dead animals.

Step 1: OBSERVE
Where are the bats entering?

At sunset or just before sunrise, have one or more persons located around the house observe where the bats are exiting the building. Observers should be able to see the entire structure without turning their heads; bats can exit and take flight in a matter of seconds. Make observations

Bat Guano

for several nights. This will ensure that all or most exit-points are identified. Pay special attention to areas in which bats commonly find access to your home: corners, eaves, louvers, loose siding, window air conditioners, and loose or damaged screens. Search the building for other various structural defects needing maintenance as the bats may search for alternative openings to their former roosting site after exclusion. It may take a second year of observation to ensure you have located all possible entry points.

Visible signs such as staining and guano (bat droppings) will also help identify openings. The body oils of bats can cause

Bat guano in front of garage

staining on the main access areas of the building, though you will need to look carefully because it is not always obvious. One of the best ways to find an opening is somewhat counter-intuitive: looking down instead of up. Guano found on the ground indicates bat activity from their opening above. When you find a concentration of these small droppings on the ground next to the foundation, you will often have a better chance of finding the access point.

Step 2: INSTALL
Can we still keep the bats here in my yard by putting up a bat house?

YES. Want to provide bats with a home, just not your own? We recommend installing an alternative roost, commonly referred to as a “bat house”, in the general vicinity of the entry-points. If you exclude in the fall, installing the bat house a year before the exclusion or during the start of summer, provides the best chance for

Two types of bat houses

success. As bats come and go, they will become familiar with the structure. Upon exclusion, this familiarity will provide the best possible chance for the successful inhabitation of the bat house by the recently excluded bats. If you are interested in purchasing or building bat houses, contact the Wisconsin Bat Monitoring program. The program staff can help you decide on where to purchase the best bat house design with proven success. The Wisconsin Bat Monitoring program can also give you instructions for building your own bat house. Read our information pamphlet titled: “Building a Bat House“ to learn how to build and locate your bat house. Location and design are critical pieces as bats are more difficult to attract to a bat house than birds are to a bird house.

Step 3: EXCLUDE

1. One-way doors 2. One-week wait, 3. Seal all of the holes.

After all openings have been discovered, install one-way exits. These exits will allow bats to leave, but will not allow them to re-enter. Keep in mind the time of year as you do not want to trap the flightless young inside. Avoid excluding bats between May 1^{st} and August 31^{st}.

One-way exclusion devices can be created using plastic netting with one-sixth inch (0.4 centimeter) or smaller mesh. Shape the plastic netting so that it covers the opening entirely and extends at least two feet below it. Using staples or duct tape, attach the top and side edges of the

Applying screen for one-way door

plastic netting to the building, leaving the bottom edge open. Be conscious of the netting’s tautness; you should be able to slide your hand into the bottom opening though not so loose that the bats may easily crawl back up the opening. At sunset the following night, some of the bats will escape through the open, bottom portion. Leave the netting up for five to seven days; this will ensure that all bats have exited the building. After all bats have been excluded, you may then seal the openings permanently with appropriate construction materials.

Space on bottom for bats to escape

Remember that bats will not chew their way back inside your house. So, after you've found and sealed all of the access points you will have successfully excluded the bats from your living space.

Other materials can be used to create one-way exits, such as plastic sheeting or PVC pipe. Install the plastic sheeting in the exact manner as the plastic netting. A portion of PVC pipe, which should be similar in size to a tube of caulk, can be inserted into the opening. Seal the remaining portion of the opening that surrounds the outer rim of the pipe.

Clean-up

After the bats have been successfully excluded, most people will want to clean the guano out of the building. When cleaning enclosed spaces, there is one simple precaution you should take in protecting yourself from being exposed to a disease known as histoplasmosis. Histoplasmosis is a respiratory disease caused by a fungus that can grow on accumulations of bird and bat guano and may become airborne if disturbed during the cleaning process. The fungus is not necessarily present at your site; however it is best to approach any clean-up with some safety measures. Symptoms of histoplasmosis usually appear within 3 to 17 days after exposure, and may resemble a cold or chronic cough. The risk of histoplasmosis can be reduced and even prevented by wearing a face mask and gloves while working. Wash all clothes and equipment after cleaning out the previously occupied space. If you want nothing to do with a possible risk to your health there are professional cleaning services that can do this for you. Search online or in your phone directory for a local business. There are also a number of exclusion professionals that deal specifically with bat removal in the State of Wisconsin if you are not comfortable with the do-it-yourself method.

PVC one-way door

Summary

This is how you conduct widely accepted, non-lethal approach to excluding bats from your living space.

1. Observe your building around sunset or sunrise to detect all locations bats are using for access.
2. Install a bat house prior to conducting exclusion in order to maintain the beneficial insect-eating service of the bats in your back yard.
3. Install a one-way door over the opening(s) and wait a week until all of the bats have left.
4. Permanently seal the access points with appropriate materials.
5. Enjoy a night on your deck or patio and watch your relocated colony of bats eat 100's to 1,000's of mosquito-sized insects.
6. Let us know how it worked out as we would like to hear your success story about relocating bats from your attic to their own bat house.
7. For additional information on bats of Wisconsin check out our bat website.

Wisconsin Bat Monitoring Program
http://wiatri.net/inventory/bats

Bat Access points to your living space

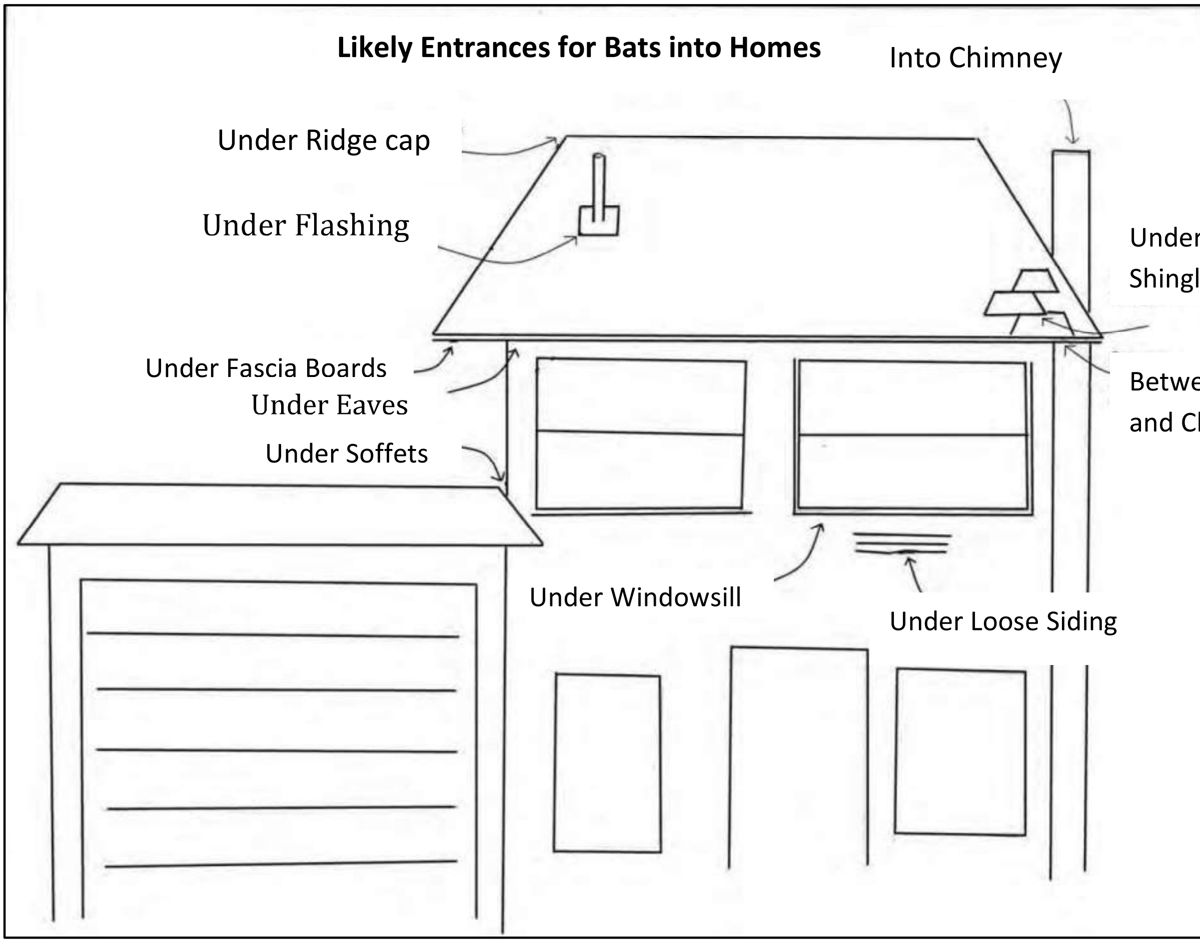


Figure 1: There are several common entry points for bats to find their way into your home. Check for guano piles and stains around these points first in locating the entry points.

Exit Only

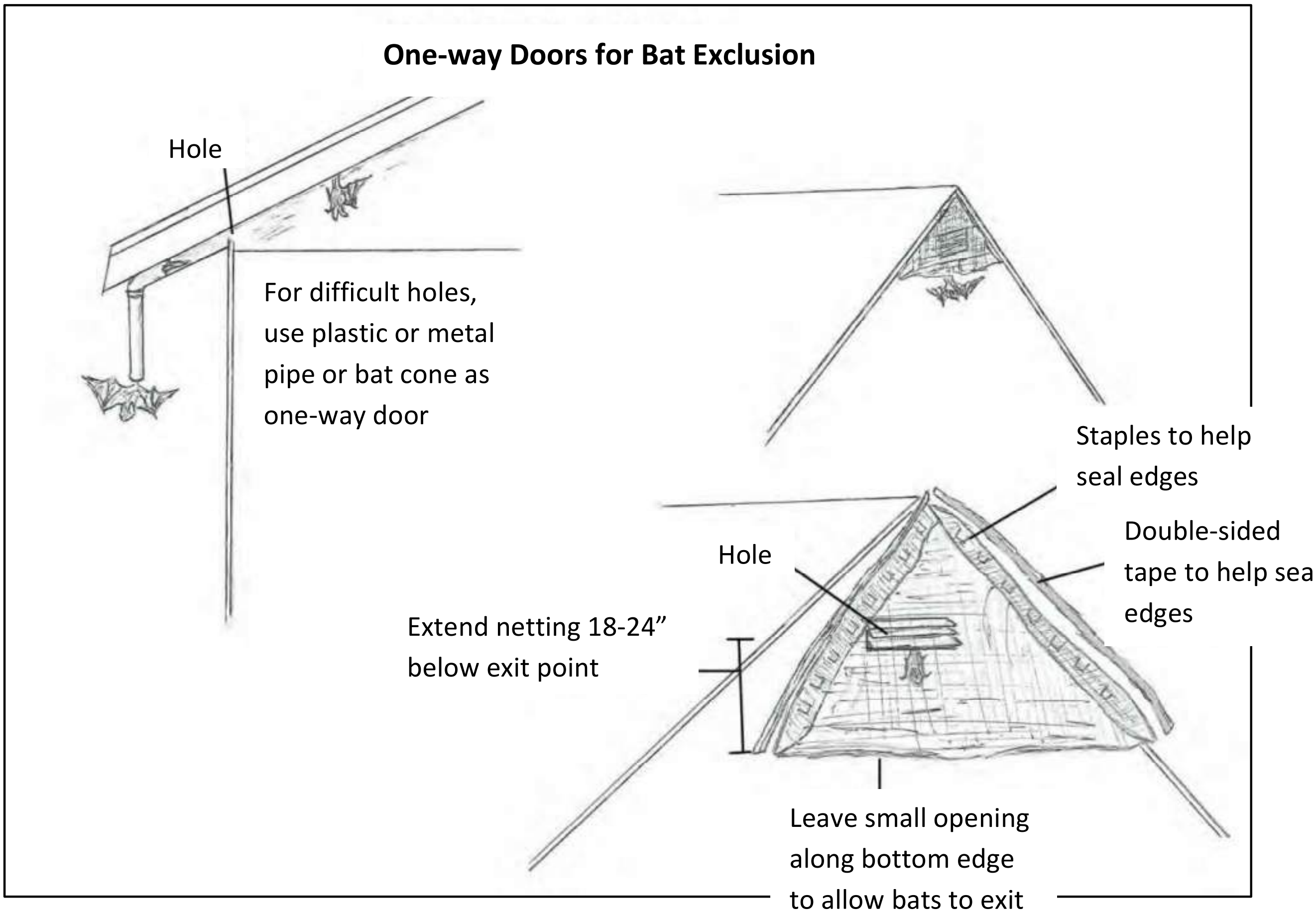


Figure 2: Two common one-way door designs: PVC tube for a small oddly-shaped hole, and netting or mesh for larger holes.

Appendix 3: Determining Bat Presence

1. Take note of places where bats are likely to enter your home. Bats can enter through holes smaller than a quarter in size. Places like fascia boards, where two buildings meet, between the building and a chimney, under loose shingles, under ridgecaps, under windows, through vents into attics, under flashing, under eaves and under loose siding are all common places for bats to enter.

2. Look for evidence on the ground. Bats will defecate while they roost, and piles of guano usually indicate where bats are roosting.

3. Look for evidence on the building itself. Places where bats enter and exit often have stains from urine and skin oils on the siding and holes. These can be good indications of where bats are entering.

4. Monitor in the evening. Even if no visible signs occur, bats may still be roosting in a building. Observe the building at dusk to see if any bats fly out of openings. Listening at this time can also alert the observer to the presence of bats. Bats will often become very vocal 5-10 minutes before they take flight to forage. Bats make an audible buzzing and clicking while they are roosting.

Appendix 4.

The WDNR is requiring cleaning of all equipment and clothing that comes in contact with cave bats and their habitat at any point during the year in an effort to control human transmission of white-nose syndrome. The fungus that causes white-nose syndrome, *Pseudogymnoascus destructans* was listed as prohibited invasive species in 2011 under NR. 40, and allow for the following control measures.

All equipment and clothing that is used outside of the state of Wisconsin and at multiple sites within the state during exclusion must be cleaned according to the protocols listed in appendix 4. Protocols are in accordance with U.S. Fish and Wildlife Service white-nose syndrome decontamination procedures: http://whitenosesyndrome.org.

Additionally, to minimize risk of possible transfer of the SARS-CoV-19 to North American bats, follow these guidelines for proper Personal Protective Equipment during work.

1. Per CDC guidelines for COVID-19, to block or minimize exchange of respiratory droplets wear a mask when doing work involving bats, including installation of one-way doors and cleaning of attics.
2. Use of disposable equipment and coverings (gloves, coveralls and booties) is highly recommended.
3. All equipment used during the exclusion process should be thoroughly scrubbed or brushed to remove all organic material.
4. Once scrubbed of organic material, clothing and equipment must be sealed in a plastic container or bag to be transported to a suitable site for cleaning. Anything that can be disposed of must be sealed in a plastic trash bag and discarded.
    a. All equipment and clothing that can be **completely submersed** must be washed with Woolite in wash cycle, rinsed, then
        i. submersed in hot water (>131 degrees F) for a minimum 20 minutes
        ii. soaked in 1:10 bleach solution for a minimum of 10 minutes,
        iii. soaked in 1:128 Lysol for a minimum of 10 minutes.
    b. All equipment that **cannot be completely submerged** in a solution or hot water or must be used immediately between sites must be scrubbed to remove all organic material and wiped with Lysol disinfecting wipes so that the entire surface is disinfected.
5. All equipment and clothing must air dry.
6. Prior to entering the vehicle, clean or remove clothing and footwear to avoid contaminating vehicles.

Appendix 5: WDNR Exclusion Protocol

Exclusion activities outside of the following protocol are not covered under the Broad Incidental Take Permit/Authorization and mortality may incur fines. The landowner and/or the pest control operator completing the work may be liable for fines.

Exclusion is the act of allowing bats to leave but not return to a building through the use of one-way doors. One-way doors may be comprised of the following materials and design:

1. **Tubing**- Tubes for exclusion may be plastic or metal and should hang down at least 10-15 inches from the opening. Netting may be installed at the end of the tube to prevent re-entry but the mesh must be plastic with holes smaller than 1/6th inch.
2. **Mesh or netting**- Netting may be installed over entry/exit points, but the netting must have holes 1/6th inch or smaller so as to not trap bats, and must extend at least two feet below the entry point. The mesh/netting must be open at the bottom to allow bats to exit under the screen.
    a. If it is found the netting used is tangling and trapping bats, the pest control operator must remove the bats and release them, and the netting must be replaced with smaller mesh or with a different type of one-way door.
3. **Plastic sheeting**- Plastic sheeting may be installed in a similar fashion to the mesh. There should be enough space behind the plastic to allow the bats to crawl out from behind the sheeting. It must be open at the bottom to allow the bats to exit.
4. **Changes to roosting environment**- changes can be made to the roosting habitat to discourage use by bats. These may include, but are not limited to, installation of windows to increase light in the roost, or installation of sheet metal on roosting surface to limit ability of bats to hang. Any changes to the roost environment must not cause take.

Exclusion devices must remain up for at least 5 days prior to sealing the openings, and there must not be bats in the roost when building is sealed.

APPENDIX E-32 PUBLIC-Historic Properties Management Plan

Historic Properties Management Plan

Cornell Hydroelectric Project

FERC Project No. 2639

Chippewa River
Chippewa County, Wisconsin

Report prepared for

Xcel Energy

Eau Claire, Wisconsin

Plan prepared by

Mead & Hunt

www.meadhunt.com

April 2021

Table of Contents

Figures

Appendices

List of Abbreviations

CFR	Code of Federal Regulations
FERC or Commission	Federal Energy Regulatory Commission
HPMP	Historic Properties Management Plan
National Register	National Register of Historic Places
NGVD	National Geodetic Vertical Datum
NPS	National Park Service
NRHP	National Register of Historic Places
NSPW or Licensee	Northern States Power Company-Wisconsin d/b/a Xcel Energy
Project	Cornell Hydroelectric Project
Settlement Agreement	Lower Chippewa River Settlement Agreement
SHPO	Wisconsin State Historic Preservation Officer
UWMR-CRM	University of Wisconsin-Milwaukee Cultural Resources Management Group
WDNR	Wisconsin Department of Natural Resources

1. Introduction

Northern States Power Company – Wisconsin (NSPW or Licensee), d/b/a Xcel Energy, currently holds a license issued by the Federal Energy Regulatory Commission (Commission or FERC) to operate and maintain the 30.75-Megawatt Cornell Hydroelectric Project (Project). The Project is designated as FERC Project No. 2639.

The Project is located on the Chippewa River in the city of Cornell, Wisconsin in northwest Chippewa County (see Figure 1-1). The Project was constructed in 1913 and the powerhouse and a portion of the dam were re-constructed during a period spanning from 1974-1977. It operates under terms of a 50-year operating license that was issued by the FERC on December 26, 1973. This Historic Properties Management Plan (HPMP) is anticipated to be incorporated into the new license issued by the Commission.

Under the new license, it is anticipated the Licensee will be directed to implement the provisions of the statewide Programmatic Agreement[1] for managing historic properties that may be affected by new and amended licenses issuing for the continued operation of existing hydroelectric projects in the state of Wisconsin, dated December 30, 1993 (hereinafter Programmatic Agreement). The Programmatic Agreement (see Appendix A) stipulates, among other provisions, that "each Licensee, within one year of license issuance, will develop an HPMP and file the plan with the FERC and the Wisconsin State Historic Preservation Officer (SHPO) for review and approval." This HPMP was developed in consultation with the SHPO to comply with the terms of the Programmatic Agreement and Project license.

[1] Programmatic Agreement Among The FERC, The Advisory Council On Historic Preservation, The State Of Wisconsin, State Historic Preservation Officer, And The State Of Michigan State Historic Preservation Officer, For Managing Historic Properties That May Be Affected By New And Amended Licenses Issuing For The Continued Operation Of Existing Hydroelectric Projects In The State Of Wisconsin And Adjacent Portions Of The State Of Michigan.

Figure 1-1: Cornell Hydroelectric Project Location

2. Project Background Information

2.1 Operational Practices That Could Affect Historic Properties

Project operation as described in the current license was modified as part of the 2001 Lower Chippewa River Settlement Agreement (Settlement Agreement) and formalized via FERC's February 12, 2003 Order Amending License and Modifying Minimum Flows and Reservoir Elevations. Settlement Agreement members included the National Park Service (NPS), Wisconsin Department of Natural Resources (WDNR), U.S. Fish and Wildlife Service, and several non-governmental organizations. Under the terms of the Settlement Agreement, the Project is operated in a limited peaking mode providing that a minimum flow of 400 cfs is released at all times for the protection of aquatic habitat and fish spawning areas of the Chippewa River downstream of the Cornell Dam. The Settlement Agreement also established requirements for reservoir fluctuations. From April 1 to June 7 of each year the reservoir elevation is required to be maintained and operated between elevations 1001.5 and 1002.0 feet NGVD to enhance fish spawning. From June 8 through Labor Day of each year during the hours of 12:00 pm and 8:00 pm, the reservoir is required to be maintained and operated between elevations 1001.0 and 1002.0 feet NGVD to minimize fluctuations during peak recreational use. At all other times, the reservoir elevation is maintained between 1000.0 and 1002.0 feet NGVD.

The current minimum flow and reservoir elevation requirements were agreed upon as part of the Settlement Agreement, therefore, NSPW is required to operate the Project according to said terms until 2033. The Licensee is proposing to evaluate the operational impacts of the Cornell Project, including minimum flows and reservoir fluctuations, concurrent with the relicensing of its remaining lower Chippewa River hydroelectric projects beginning no later than 2028. The resulting information from such a study would then be used to assess the need to modify the operation of the Cornell Project, if necessary, concurrent with any operational changes required in the new licenses for the upstream and downstream hydroelectric projects.

There are no regularly scheduled (i.e. annual) drawdowns of the flowage, however, water level fluctuations of 0.5 to 2 feet do occur as allowed under the current license. Given the fact that all Project structures are in good repair, it is unlikely that any drawdowns of the flowage will be required in the near-term. Despite only modest fluctuations in the reservoir elevation, there is a history of shoreline erosion in one area of the east shoreline on the upper part of the reservoir. This area has a particularly steep bank and the erosion has stabilized in recent years.

2.2 Previous Survey and Evaluation Activities

Several recent archaeological surveys have been conducted within the project boundary. Beginning in 1992 (WHS Project # 93-0448), the WDNR conducted a Phase I survey for the addition of a toilet/shower building at Brunet Island State Park. The survey did not identify any historic properties.

In 2001 (WHS Project # 01-1517), the WDNR conducted a Phase I survey for the addition of a parking area in Brunet Island State Park. A Native American cemetery (CH-001) had been reported in the vicinity of the proposed improvements. Shovel testing of the Area of Potential Effect for the proposed parking area did not find any evidence of burials or other historic properties.

In 2004 (WHS Project # 04-0064), the WDNR conducted a Phase I survey for the addition of a garage south of the existing ranger station. The survey was conducted northeast of the intersection of State Highway 64 (South Riverside Drive) and Pine Point Road. The survey did not identify any historic properties.

In 2006 (WHS Project # 06-0825), the Mississippi Valley Archaeological Center conducted a Phase I survey for a proposed Ice Age National Scenic Trail extension 1.5 to 2 miles long and 6-8 feet wide. The survey did not identify any historic properties.

In 2009 (WHS Project # 09-0801), the Great Lakes Archaeological Center conducted a Phase I survey of a 1.36-mile segment of County Highway CC. The survey did not identify any historic properties.

In 2019 (WHS Project # 18-1010), TRC Companies conducted a Phase I survey of a portion of the Project shoreline. Two archaeological sites (CH-0137 and CH-0150) were found to overlap the Project area. Shovel testing did not identify any historic properties. Additionally, the reservoir shoreline was inspected by boat for erosion exposed evidence of artifacts, however, none were found. All previously reported archaeological sites were well vegetated and stable. A copy of the report is included in Appendix B. The SHPO reviewed the report and agreed with the recommendations to proceed with a five-year monitoring plan for the shoreline.

In 2019 (WHS Project # 18-1010), the University of Wisconsin-Milwaukee Cultural Resources Management Group (UWM-CRM) evaluated the Cornell dam and powerhouse for eligibility for the National Register of Historic Places (NRHP). The Project was determined eligible for the NRHP under Criterion A: History and UWM-CRM's report recommended the dam and powerhouse be included as part of the Cornell Wood Product Co. Historic District (see Appendix C for the review documentation). The SHPO concurred with their recommendation via their March 12, 2020 letter and further recommended the log pond remnants and conveyor trough be listed as contributing elements to the Cornell Wood Product Co. Historic District. The SHPO did not suggest these two features be listed as contributing elements under Criterion D, but rather as other contributing elements that help one to better understand the larger history of the complex (see Appendix C).

NSPW does not contest the inclusion of the log pond remnants or conveyor trough in the Historic District. However, these two elements are not part of the Project nor are they expected to be impacted by Project operations. Therefore, specific management procedures for these elements will not be included in this HPMP.

3. Management Plan

3.1 Procedures for Identifying Archaeological Properties

3.1.1 Previously Surveyed Lands

Except for the previously disturbed access road to the tailrace fishing area and powerhouse, all NSPW-owned Project uplands have been surveyed for archaeological evidence. The access road to the tailrace fishing area and powerhouse has been heavily disturbed by previous activity and is not proposed to be surveyed prior to any future ground-disturbing activities. Therefore, future archeological surveys of upland areas owned by NSPW will be limited to the periodic shoreline monitoring described in Section 3.1.1.1.

3.1.1.1 Periodic Shoreline Monitoring

The most recent shoreline monitoring, conducted by a qualified archaeologist in 2019, found that archeological sites 47CH1, 47CH2, 47CH30, and 47CH150 were "well vegetated and stable." No cultural resources or human remains were encountered during the more comprehensive Phase I archaeological field survey.

As a result, NSPW recommends proceeding with regular monitoring of the shoreline. Through the term of the new license, NSPW will systematically and periodically monitor the shoreline of the Cornell Flowage for erosion-exposed archaeological properties. The shoreline will be initially monitored during the fifth year after license issuance and every fifth year thereafter. In all cases, a qualified archaeologist will conduct the surveys by inspecting the shoreline, either on-foot or from a boat, and performing surface reconnaissance of any eroded banks that have the potential to yield archaeological finds. Particular attention will be devoted to the known archaeological sites within the project boundaries to determine if erosion is occurring at these locations over time. At each such site, photographs will be taken during the initial monitoring survey from documented fixed locations (readily identifiable landmarks, coordinates, etc.) to serve as a reference for gauging potential erosional changes over time.

Results of the periodic monitoring will be forwarded to the SHPO (two copies) with the subsequent year's annual report (see Section 4.1). If archaeological properties are identified as eroding during shoreline monitoring, the Criteria of Evaluation, 36 CFR Part 60, at Section 60.4, and as appropriate, the principles set forth in Hydroelectric Development in the United States, 1880-1940 by Dr. Duncan Hay (1991) will be applied by NSPW's archaeological consultant and the results forwarded to the SHPO for review.

Based upon the results from the first two shoreline surveys and the pre-licensing shoreline surveys, NSPW, in consultation with the SHPO, will determine the need and frequency for additional shoreline monitoring or mitigation activities to be carried out during the remainder of the new license. If it is determined that additional shoreline monitoring is unnecessary or that the monitoring frequency can be extended, FERC will be advised of the decision along with supporting rationale.

3.1.2 Previously Unsurveyed Lands

Previously unsurveyed lands within the project boundary are limited to currently submerged lands and lands on private property.

3.1.2.1 Submerged Lands

For unsurveyed lands that are normally inundated by the Cornell Flowage, NSPW will conduct an archaeological survey during any planned reservoir drawdown after this plan is approved by the SHPO and the FERC, providing that all the following criteria are met:

1) The drawdown is a full drawdown that exposes the entire original riverbed.
2) The drawdown does not occur during the winter when survey is impossible due to frozen ground, snow, and/or ice cover.
3) The survey will not cause, occasion, or prolong the duration or extent of drawdown.
4) The lands exposed by the drawdown have not been previously surveyed.

The survey shall be scheduled during the drawdown planning process and conducted after the reservoir has reached the maximum depth of drawdown and the previously inundated areas are safe for access. Survey methods to be applied shall be in accordance with the Wisconsin Archaeological Survey Guidelines For Conservation Archaeology In Wisconsin.

3.1.2.2 Reporting

Results from the periodic shoreline monitoring discussed in Section 3.1.1.1 and submerged lands discussed in Section 3.1.2.1 will be forwarded to the SHPO with the subsequent year's annual report (see Section 4.1). If archaeological properties are identified as impacted by Project operations during the monitoring, the Criteria of Evaluation, 36 CFR Part 60, at Section 60.4, and as appropriate, the principles set forth in Hydroelectric Development in the United States, 1880-1940 by Dr. Duncan Hay (1991), will be applied by NSPW's archaeological consultant and the results forwarded to the SHPO for review.

3.1.2.3 Lands Not Owned by the Licensee (Private Lands)

If archaeological properties are identified as eroding during shoreline monitoring, the Criteria of Evaluation, 36 CFR Part 60, at Section 60.4, and as appropriate, the principles set forth in Hydroelectric Development in the United States, 1880-1940 by Dr. Duncan Hay (1991), will be applied by NSPW's archaeological consultant and the results forwarded to the SHPO for review.

If NSPW is unable to gain access to private property to conduct research that is required as part of this HPMP, the following actions will be taken:

1) The Wisconsin SHPO will be notified of the inability to gain access to the property with the property owner's name and address specified.
2) Copies of correspondence with the landowner(s) will be forwarded to the SHPO demonstrating all reasonable attempts to gain access to the inaccessible property.
3) A copy of an appropriate topographic map depicting the location of the inaccessible property will be forwarded to the SHPO.

3.2 Procedures for Protecting Archaeological Properties

3.2.1 Inadvertent Discoveries

Although extensive surveys have occurred on Licensee-owned lands within the project boundary, future ground-disturbing activities have the potential to reveal historic properties that have not been previously identified.

3.2.1.1 Archaeological Properties (Not Including Burials)

In the event an inadvertent discovery of archaeological artifacts occurs during ground disturbing activities, all activity within the immediate area will cease and the following steps shall be followed before the activity can proceed:

1) NSPW will contact the SHPO as soon as possible and notify them of the potential site.
2) NSPW will retain a qualified archaeologist to determine if the artifacts discovered are part of an archaeological property.
3) NSPW will consult with the SHPO, based upon the information obtained from the archaeologist's findings from step 2, to determine a path forward which would allow the ground-disturbing activities to proceed. The Procedures for Protection of Archaeological Properties outlined in Section 3.2.2 shall be followed.

3.2.1.2 Burials

In the event an inadvertent discovery of archaeological artifacts occurs during ground disturbing activities, all activity within the immediate area will cease and the following steps shall be followed before the activity can proceed:

1) NSPW will contact the SHPO and the Tribal Historic Preservation Officer (THPO) for the Forest County Potawatomi Community as soon as possible notifying them of the potential burial site.
2) NSPW will retain a qualified archaeologist to determine if the discovery is a burial site.
3) NSPW will consult with the SHPO and the THPO, based upon the information obtained from the archaeologist's findings from step 2, to determine a path forward which would allow the ground-disturbing activities to proceed. In all situations, the appropriate Native American Community shall be allowed to complete an expeditious repatriation ceremony prior to re-internment of remains. The Procedures for Protection of Archaeological Properties outlined in Section 3.2.2 shall be followed.

3.2.2 Procedures for Handling Inadvertent Discoveries

Avoidance shall be the primary guiding principle for the treatment of all inadvertent discoveries. In the event avoidance is not an option or avoidance will not mitigate adverse impacts to the inadvertent discoveries, the following activities shall be conducted in the following order:

1) Phase II Determination of Eligibility (non-burial sites only).
2) In-Place Preservation or Shoreline Stabilization.
3) Data Recovery.

3.2.2.1 Determination of Eligibility

Any amount of human remains which are discovered is protected under 157.70 of the Wisconsin State Statutes as a burial and all require protection. Therefore, the determination of eligibility (Phase II Investigation) only applies to non-burial inadvertent discoveries. If inadvertently discovered artifacts cannot be avoided, NSPW may elect to retain a qualified archaeologist to complete a Phase II investigation to determine if the artifacts are eligible for the NRHP and whether they should be protected as an archaeological property. If the Phase II study concludes the site is not eligible for the NRHP, and the SHPO concurs, the ground disturbing activity can continue as planned or In-Place Preservation/Shoreline Stabilization does not need to occur.

3.2.2.2 In-Place Preservation or Shoreline Stabilization

Should future activities identify archaeological properties or burials, as described above, In-Place Preservation through avoidance shall be the primary mitigating activity. If avoidance is not feasible, data recovery as outlined in Section 3.2.2.3 shall be implemented prior to resuming or initiating ground-disturbing activities in the immediate vicinity of the site.

Should future shoreline monitoring reveal that an archaeological property needs to be protected from erosion, NSPW will give priority to in-place preservation through shoreline stabilization rather than data recovery. Before proceeding with stabilization, NSPW will develop an erosion control plan in consultation with the SHPO. Based on comments from the consultation, NSPW shall develop a formal written plan that will be submitted to the SHPO for review and approval. In the case of stabilization of a burial, the THPO will also be included in all consultation and the appropriate Native American Community shall be allowed to complete an expeditious repatriation ceremony prior to re-internment of remains. If stabilization is not possible, data recovery as outlined in Section 3.2.2.3 shall be implemented.

3.2.2.3 Data Recovery

Where preservation in-place is deemed unfeasible by NSPW and data recovery is necessary, a data recovery plan will be developed that is consistent with the Secretary's Standards and generally consistent with Treatment of Archaeological Properties (Advisory Council on Historic Preservation, 1980). The data recovery plan will, at a minimum, include the following information:

1) Identity of the property where data recovery is to be performed, as well as any property that will be destroyed or already has been affected without the benefit of data recovery.
2) The research questions that are to be addressed through data recovery and explanations of their relevance and importance.
3) The means to recover, analyze, manage, and disseminate data to the professional archaeological community and the general public, and, explanations of the relevance of these means to the research questions; means to involve the interested public in the data recovery project; and, as appropriate, keep Indian tribes informed of the data recovery project while affording them the opportunity to participate.
4) A schedule for implementing the data recovery plan.
5) Provisions for the disposition of recovered materials and records, in accordance with Section 5.3 herein.
6) A schedule for submitting progress reports to the SHPO, where such reports are appropriate.

The data recovery plan shall be submitted to the SHPO and THPO (for burials only). If the SHPO and THPO do not object to the plan within 30 days, NSPW will implement the plan at the earliest opportunity. Implementation will be followed by submittal of a final report (two copies) to the SHPO and THPO (for burials only) for review and approval that will detail the results of the data recovery efforts.

3.3 Procedures for Protection of Historic Facilities

NSPW will preserve historic hydroelectric generating facilities and associated facilities under NSPW ownership that are within the historic district boundary and eligible for the NRHP. These facilities will be preserved in-place by maintaining and operating them according to 36 CFR Part 67, Guidelines for Rehabilitating Historic Buildings (revised 1990), and applicable NPS Briefs.

NSPW will undertake in-place preservation according to the following:

1) NSPW, for the term of its license, will take reasonable precautions to preserve facilities and structures under NSPW ownership, determined potentially eligible for the National Register of Historic Places, to guarantee their integrity of design, materials, workmanship, location, setting, feeling, and association to the extent relevant to the National Register eligibility and public safety.

   Specifically, NSPW will avoid destroying, demolishing, or altering its facilities or their environments which are deemed eligible for the NRHP or are located within the historic district. Distinguishing qualities, characteristics, stylistic features, or examples of skilled craftsmanship characteristic of the facility will be retained. NSPW will avoid damaging facilities when conducting routine maintenance and will attempt to repair instead of replacing deteriorated features.

2) If NSPW proposes to alter a historic facility in a manner contrary to the clear aim and intent of the Programmatic Agreement, it will develop a proposal outlining the alterations, file the proposal with the SHPO, and allow them thirty days to provide comment.

   NSPW will not act upon the proposal until the thirty-day comment period has expired and will cooperate with the SHPO to further clarify plans and specifications at their request. Further clarifications and plans will include relevant photographs and other needed documentation, a description of the planned and proposed alternatives and mitigative measures, and a project plan and schedule. At the expiration of the forty five-day comment period, NSPW will proceed with the proposal after incorporation of appropriate suggestions only if the SHPO does not object to the plan. If NSPW feels some of the suggestions or objections are inappropriate, it will attempt to resolve the conflicts through direct consultation with the SHPO. If the issues cannot be resolved, NSPW will follow the steps outlined in Section 5.0.

3) In case of emergency, NSPW will respond in a manner to ensure public safety and will notify the SHPO as soon as circumstances permit, but not more than seven days following the emergency. Notification will include an explanation of any major modifications to historic properties/resources that were required to ensure public safety.

4) NSPW will not solicit the SHPO for comments when completing routine maintenance and replacement in kind at its facilities, which are eligible for the NRHP. Routine repair and replacement in kind includes the following: concrete repair work, maintenance of existing generating and hydraulic equipment (except for equipment identified in the eligibility form as a contributing element to its eligibility), maintenance of existing buildings and structures, dike repair and maintenance, maintenance and improvement of electrical systems, replacement of substation and transmission components, compliance with Commission-mandated safety improvements not requiring structural modifications, and placement of maintenance of public safety devices and signs.

5) NSPW will abide by the Programmatic Agreement for all its facilities that have been determined eligible for the National Register of Historic Places.

3.4 Proposed Accommodations for Public Interpretation

NSPW has developed an interpretive kiosk for its Chippewa and Flambeau River hydroelectric projects that generally describes the prehistoric and historic attributes of the project sites, including the Cornell Project. The kiosk is a table-top, four-panel display that was developed in cooperation with the Wisconsin SHPO many years ago for loan to the public and for display at public events. The kiosk is a very good public interpretation tool that serves its purpose well. Therefore, no other interpretive accommodations that pertain to historical attributes are proposed or contemplated for the Cornell Project.

4. Reports and Curation

4.1 Annual Reports

Upon issuance of the License, NSPW will submit an annual report to the SHPO and the Commission outlining all activities associated with implementing this HPMP by January 31 of each year for the term of the Project license. The report will describe activities undertaken during the previous year as well as activities planned for the ensuing year.

4.2 Curation of Artifacts

NSPW shall ensure that, except as otherwise required above, all artifacts, notes, records, reports, maps, and any other type of documentation that are recovered or generated in accordance with this HPMP, are curated in the State of Wisconsin. Curation shall be in a facility that meets the requirements of 36 CFR Part 79, insofar as this purpose can be achieved consistent with the rights of private property owners.

5. Dispute Resolution

Should the SHPO, NSPW or any other party object to any action or any failure to act pursuant to a provision of this HPMP, the matter shall be referred to the FERC for dispute resolution. The procedures to be followed shall be in accordance with sections V.B. and V.C. of the Programmatic Agreement.

APPENDIX A. Programmatic Agreement

PROGRAMMATIC AGREEMENT
AMONG
THE FEDERAL ENERGY REGULATORY COMMISSION,
THE ADVISORY COUNCIL ON HISTORIC PRESERVATION,
THE STATE OF WISCONSIN, STATE HISTORIC PRESERVATION OFFICER,
AND
THE STATE OF MICHIGAN, STATE HISTORIC PRESERVATION OFFICER,
FOR MANAGING HISTORIC PROPERTIES
THAT MAY BE AFFECTED BY NEW AND AMENDED LICENSES ISSUING
FOR THE CONTINUED OPERATION OF
EXISTING HYDROELECTRIC PROJECTS IN
THE STATE OF WISCONSIN
AND ADJACENT PORTIONS OF
THE STATE OF MICHIGAN

WHEREAS, the Federal Energy Regulatory Commission (hereinafter, "Commission") proposes to issue new and amended licenses, pursuant to Part I of the Federal Power Act, 16 U.S.C. Sections 791(a) through 825(r), for the continued operation of existing hydroelectric projects (hereinafter, "Projects") in the State of Wisconsin and in adjacent portions of the State of Michigan's Upper Peninsula; and,

WHEREAS, the Commission has determined that issuing new and amended licenses for Projects may affect properties included in, or eligible for inclusion in, the National Register of Historic Places (hereinafter, "Historic Properties"); and,

WHEREAS, the Commission has consulted with the Advisory Council on Historic Preservation (hereinafter, "Council"), the State of Wisconsin, State Historic Preservation Officer (hereinafter, "Wisconsin SHPO"), and the State of Michigan, State Historic Preservation Officer (hereinafter, "Michigan SHPO"), pursuant to Section 106, National Historic Preservation Act, <u>as amended</u> (16 U.S.C. Section 470f; hereinafter, "the Act") and the Council's regulations implementing this Section, 36 C.F.R. Part 800, concerning such Projects and their potential effects; and,

WHEREAS, the Commission, the Council, the Wisconsin SHPO, and the Michigan SHPO are the executing parties to this Programmatic Agreement (hereinafter, "Parties"); and,

WHEREAS, for the purposes of this Programmatic Agreement, the Michigan SHPO agrees to coordinate its responsibilities for review and comment through the Wisconsin SHPO, and the Wisconsin SHPO agrees to coordinate and cooperate on all decisions regarding cultural resources in the State of Michigan with the Michigan SHPO; and, WHEREAS, the contents of the documents appended to this Programmatic Agreement are herewith incorporated entirely by reference and held to be integral to it; and,

WHEREAS, this Programmatic Agreement does not supersede Programmatic Agreements executed prior to the date of its execution;

NOW, THEREFORE, the Commission, the Council, the Wisconsin and Michigan SHPOs agree that Projects will be administered according to the following stipulations, thus satisfying the Commission's responsibilities under the Act for the individual Projects to which they apply.

S t i p u l a t i o n s

The Commission will ensure that the following measures are carried out by applicants for new or amended licenses (hereinafter, "Licensees") for Projects located entirely in the State of Wisconsin or in the States of Wisconsin and Michigan.

Licensees whose applications are tendered the Commission after the date this Programmatic Agreement is executed will comply with all parts of this Programmatic Agreement.

Licensees whose applications, as of the date this Programmatic Agreement is executed, are already tendered, may omit Part I, herein.

I. PRE-LICENSING PROCEDURE

The following steps will be completed by Licensees before tendering the Commission an application, in consultation with the Wisconsin SHPO, and in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (published in the Federal Register, Vol. 48, No. 190, pages 44716 through 44742; hereinafter, "Secretary's Standards"). [1] Moreover, these steps will be completed by or under the direct supervision of a person or persons whose qualifications at least meet the Secretary's Standards, as applicable to the relevant preservation discipline.

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[1] See Appendix One of this Programmatic Agreement.

A. Identification of Historic Buildings, Structures, and Objects: Licensees will identify historic buildings, structures, and objects associated historically, structurally, spatially, or functionally with their Projects and within their Projects' Areas of Potential Effects [2] (hereinafter, "APE"). Upon completing this identification, Licensees will submit two copies of the resulting reports, prepared in accordance with the guidelines, Architecture/History Survey Report Specifications For Compliance-Driven Surveys, [3] to the Wisconsin SHPO pursuant to 36 C.F.R. Part 800, at Section 800.4.

B. Identification of Archaeological Properties: Licensees will survey Project shoreline areas within their APEs, except that no Licensee will be required by the stipulations of this Programmatic Agreement to survey shoreline areas within another Licensee's Project boundary, to identify archaeological sites currently subject to erosion, in accordance with the Wisconsin Archaeological Survey Guidelines For Conservation Archaeology in Wisconsin; [4] prepare reports based on the results of surveys; and submit these reports, in duplicate copies, along with all appropriate documentation to the Wisconsin SHPO for review and comment. All supporting photographic documentation will be submitted as original prints.

C. Evaluation of Identified Properties: Licensees will apply the Criteria of Evaluation, 36 C.F.R. Part 60, at Section 60.4, and, as appropriate, the principles set forth in

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2 For purposes of this Programmatic Agreement, the APE for Projects for which a new or amended license issues, as APE is defined in 36 C.F.R. Part 800, at § 800.2(c), includes all the following: (a) lands enclosed by the project boundary as delineated in the existing License, (b) attached or associated buildings and structures extending beyond the project boundary, which contribute to the National Register for Historic Places eligibility of the hydroelectric generating facility, (c) lands or properties outside the project boundary, where the project may cause changes in the character or use of Historic Properties, if any Historic Properties exist.

3 See Appendix Two of this Programmatic Agreement.

4 See Appendix Three of this Programmatic Agreement.

Hydroelectric Development in the United States, 1880-1940, [5] to every historic building, structure, object, and archaeological property identified in fulfillment of this Part of this Programmatic Agreement, in accordance with 36 C.F.R. Part 800, at Section 800.4.

1. For each individual property to which the Criteria of Evaluation is applied the Licensee will report its results in written form. For each individual property that the Licensee finds to be eligible for listing on the National Register of Historic Places, the Licensee will report these results on a National Park Service Form 10-900; (hereinafter, "Form").

2. Licensees will complete the Forms according to National Register Bulletin Nos. 15 and 16, and the Wisconsin Supplementary Manual, [6] and submit to the Wisconsin SHPO an original and two copies of each Form completed, with other supporting materials. Other supporting materials will include the following.

a. For archaeological properties, Licensees will include a professionally-written report detailing the results of the Phase 1 Survey, stipulated at Part I.B, herein, describing any analysis and interpretation of the data undertaken subsequent to the Phase 1 Survey.

b. Licensees will include all supporting photographic documentation, as original prints, for each of the three copies submitted to the Wisconsin SHPO, submitted as physically separate documents.

c. Licensees will include a cover letter summarizing the Licensee's determination of eligibility for each of the properties documented on the Forms.

3. Licensees may avoid this requirement for eroding archaeological properties by consulting with the Wisconsin SHPO and employing means acceptable to the Wisconsin SHPO for stabilizing such properties and preserving them in place.

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[5] This reference is to a 1991 nationwide historic context on the development of hydroelectric power generation by Dr. Duncan Hay, for the Edison Electric Institute. See Appendix Four of this Programmatic Agreement for the relevant portions of this document.

[6] See Appendix Five of this Programmatic Agreement.

4. Licensees may seek additional assistance in the evaluation of archaeological properties from National Register Bulletin Nos. 12, 36, and 38.

5. If the Wisconsin SHPO deems the documentation to be incomplete, the Wisconsin SHPO may return it to the Licensee to be revised. If the Wisconsin SHPO deems the documentation complete, the Wisconsin SHPO will apply the Criteria for Evaluation, 36 C.F.R. Part 60, at Section 60.4, in accordance with 36 C.F.R. Part 800, at Section 800.4; sign the completed Form formalizing the determination of eligibility; retain the original Form; and return two signed copies to the Licensee.

6. The Licensee will file a copy of the completed Form bearing the Wisconsin SHPO's signature with the Commission, for information, with all supporting materials.

II. POST LICENSING PROCEDURE

In fulfilling the requirements of this Part of this Programmatic Agreement, Licensees, in consultation with the Wisconsin SHPO, will address all issues regarding Historic Properties that were not resolved prior to a license's issue, and will ensure that Historic Properties are considered in the continued operation and maintenance of hydroelectric facilities during the term of their licenses in accordance with the following stipulations. To further this purpose, Licensees will develop Historic Resources Management Plans (hereinafter, "HRMP").

A. Interim Procedures: Until a Licensee's HRMP has been approved, the Licensee will comply with 36 C.F.R. Part 800, at Sections 800.4 through 800.6, with respect to any proposed ground-disturbing activities.

B. Historic Resources Management Plan: Each Licensee, within one year of a license issuing, will develop an HRMP that addresses each of the following subjects, or that provides documentation sufficient to justify any omissions, based on the irrelevance of the omitted subject. The Licensee will file one copy of the HRMP with the Commission and one with the Wisconsin SHPO for review. If the Wisconsin SHPO agrees with the HRMP, the Licensee will implement it.

✓1. Shoreline Monitoring: The HRMP will include a procedure for monitoring the Project shoreline on a periodic basis and reporting the results of monitoring by submitting an archaeological report in two copies to the Wisconsin SHPO. If archaeological properties are identified during monitoring, the

Licensee will implement Part I.C, herein.

2. Unsurveyed Lands Within the Project Boundary: At Projects where no prior archaeological survey has been conducted, including lands normally inundated by the Project reservoir and property owned by someone other than the Licensee (hereinafter, "Private Property"), the HRMP will include the following procedures:

a. For unsurveyed lands that are not normally inundated by the project reservoir, the Licensee will include one of the following procedures in the HRMP.

(1) The Licensee may include a procedure for ensuring that an archaeological survey is conducted in the planning stage of any significant ground-disturbing activity (including, but not limited to, land management, timber management, recreational development, and lease or sale) proposed to be carried out by the Licensee on these lands that may disturb Historic Properties.

(2) Alternatively, the Licensee may include a procedure for completing archaeological surveys for these lands within ten years of the date the license issues.

b. For unsurveyed lands that are normally inundated by the project reservoir, the HRMP will include a procedure for developing appropriate methods and techniques to identify Historic Properties which become accessible during periods of Project reservoir drawdown or dewatering, and a tentative schedule for conducting the surveys. Fulfilling this requirement will not cause, occasion, or prolong a period of drawdown or dewatering.

c. The Licensee, in the HRMP, will include the following procedure for taking into account effects to archaeological properties on Private Property to which the Licensee may be unable to gain access to conduct archaeological research.

(1) The Licensee, if unable to gain access to Private Property to conduct archaeological research, will notify the Wisconsin SHPO of the inability to gain access, identifying the property owners by name and address.

(2) The Licensee will provide the Wisconsin SHPO with a copy of all relevant correspondence demonstrating the Licensee's reasonable attempts to gain access for the purpose of conducting archaeological research.

(3) The Licensee will furnish the Wisconsin SHPO with a copy of the appropriate USGS topographic map showing the exact location of the Private Property.

(4) The Licensee, in the event shoreline monitoring, conducted pursuant to Part II.A.1, herein, discloses a change in an archaeological site located on Private Property to which the Licensee has been unable to gain access for conducting archaeological research, or if the Licensee learns that the ownership or control of such Private Property is transferred, will make further attempts to gain access and inform the Wisconsin SHPO of these further attempts and of their results.

3. Archaeological Properties on Non-Managed Lands Within the Project Boundary: Previously-recorded archaeological properties on lands for which no ground-disturbing activities are contemplated (hereinafter, "Non-managed Lands") will be listed as such in the HRMP.

C. In-Place Preservation At Shorelines: In general, Licensees will give priority to preserving Historic Properties in place through shoreline stabilization, in developing HRMPs, and may use shoreline stabilization for other purposes.

1. Shoreline Stabilization: Where stabilization efforts may disturb Historic Properties, the Licensee will describe or specify the type of stabilization proposed, such as placement of rip-rap or revegetation, the provisions for archaeological data recovery, if any are warranted, and a budget and a schedule for implementing the plan. If the Wisconsin SHPO does not respond within forty-five days of receiving the submission, or responds with no objections to the Licensee's plan, the Licensee will implement the plan.

2. Data Recovery Plans: Where preservation in place is deemed not to be feasible and data recovery is found to be necessary, Licensees will develop all plans for recovering archaeological data in consultation with the Wisconsin SHPO, ensure that such plans are consistent with the Secretary's Standards and generally consistent with, Treatment of Archaeological Properties (Advisory Council on Historic Preservation, 1980). Archaeological data recovery plans will, at a minimum, include the following information.

a. The Licensee will identify the property, properties, or portions of properties where data recovery is to be carried out, as well as any property, properties, or portions of properties that will be destroyed or already have been affected without the benefit of data recovery.

b. The Licensee will specify the research questions that are to be addressed through data recovery and explain their relevance and importance.

c. The Licensee will specify the means to recover, analyze, manage, and disseminate data to the professional archaeological community and the general public, and, explain the relevance of these means to the research questions; involve the interested public in the data recovery project; and, as appropriate, keep Indian tribes informed of the data recovery project and afford them the opportunity to participate.

d. The Licensee will include a schedule for implementing the data recovery plan.

e. The Licensee will include a plan for the disposition of recovered materials and records, according to Part IV.D. herein.

f. The Licensee will propose a schedule for submitting progress reports to the Wisconsin SHPO, where such reports are appropriate.

3. Implementing a Data Recovery Plan: The Licensee will submit the data recovery plan to the Wisconsin SHPO and, if the Wisconsin SHPO does not object within 30 days, implement the data recovery plan at the earliest opportunity.

4. Final Reports of Data Recovery: After a data recovery plan has been implemented, the Licensee will submit two copies of a final report detailing the results of the data recovery efforts to the Wisconsin SHPO for review and approval.

D. In-Place Preservation of Historic Hydroelectric Generating Facilities and Other Structures: Licensees will operate and maintain National Register eligible hydroelectric generating facilities (hereinafter, "Facilities") according to 36 C.F.R. Part 67, Guidelines for Rehabilitating Historic Buildings (revised 1990), and applicable National Park Service Preservation Briefs.

1. During the term of a license, the Licensee will take every reasonable precaution to preserve Facilities as Historic Properties; guarantee their integrity of design, materials, workmanship, location, setting, feeling, and association, to the extent that each of these qualities is relevant to National Register eligibility; and ensure public safety. To further these purposes, Licensees will adhere closely

to the following guidelines.

2. Specifically, Licensees will avoid destroying, demolishing, or otherwise altering their Facilities, any distinguishing qualities or characters of their Facilities, or any stylistic features or examples of skilled craftsmanship which may characterize their Facilities. Licensees will similarly avoid such effects upon their Facilities' environments within the Projects' boundaries. Licensees will avoid damage to their Facilities resulting from cleaning surfaces, and will repair rather than replace deteriorated features of their Facilities.

3. The Licensee proposing to alter its Facilities or its Facilities' environment contrary to the clear aim and intent of this Programmatic Agreement to preserve intact such Facilities and their environments, may do so only upon notice of any such proposal given to the Wisconsin SHPO and the Secretary of the Commission.

a. The Licensee will afford the Wisconsin SHPO and the Commission forty-five days, commencing on the date on which they all receive the notice of such proposal, to review the notice of such proposal, during which time the Licensee will take no actions that would foreclose the Wisconsin SHPO's and the Commission's full opportunity to object.

b. The Licensee will attach to the notice of such proposal such plans and specifications for such proposals as the Wisconsin SHPO and the Commission may require, and will respond with such further or clarified plans and specifications as the Wisconsin SHPO or the Commission may request. Required plans and specifications will include a description of the proposed undertaking, including relevant photographs and other needed documentation; a description of alternatives and mitigation measures, both considered and proposed; and a project plan and schedule.

c. If, after this forty-five days, there is no objection, the Licensee may implement the plans and specifications. Any party desiring to object within forty-five days will do so according to Part V.B, herein.

4. In cases of emergency, Licensees will respond in a manner ensuring public safety, and will notify the Wisconsin SHPO as soon as circumstances permit, but not more than seven days following the emergency, to explain any major modifications to Historic Properties required to cope with the emergency.

5. Licensees will not be required to seek the

Wisconsin SHPO's comments for completing routine repair and replacement in kind at their Facilities. Such routine repair and replacement in kind includes concrete repair work, maintenance and overhaul of existing generating and hydraulic equipment (except for equipment identified in the Form as a contributing element to its Facilities' National Register eligibility), maintenance of existing buildings and structures, dike repair and maintenance, maintenance and improvement of electrical systems, replacement of substation and transmission components, compliance with Commission mandated safety improvements not requiring structural modifications, development and maintenance of exterior public recreation components not requiring structure modifications, and placement and maintenance of public safety devices and signs.

6. Facilities that, at the time of licensing, are not National Register eligible, but become eligible, will become subject to the stipulations of this Programmatic Agreement as of the time they become eligible.

E. Public Interpretation: In their HRMPs, Licensees will propose, in detail, ways to interpret Historic Properties for the benefit of the public.

III. COMPLIANCE MONITORING, REPORTS, AND PUBLIC INVOLVEMENT

The purpose of this Part is to ensure compliance with the stipulations of this Programmatic Agreement through reporting.

A. Compliance Monitoring: The Commission and the Wisconsin SHPO have the right to monitor activities carried out pursuant to this Programmatic Agreement, and the Council will review such activities if requested. Licensees will cooperate with the Commission and the SHPO in carrying out this responsibility.

/ B. Annual Reports: Licensees, on January 31 of every year, will submit annual reports to the Wisconsin SHPO and the Commission outlining all activities associated with implementing the HRMP and this Programmatic Agreement, and undertaken in the preceding year and planned during the ensuing year.

C. Archaeological Report Dissemination: Licensees will submit all archaeological reports prepared according to the terms of this Programmatic Agreement to the Commission and the Wisconsin SHPO within six months of completing the report. Upon receiving written request, the Licensee may furnish copies of reports to other interested parties. The Licensee will ensure that precise locational data is withheld if it appears that its release might jeopardize Historic Properties (See National

Register Bulletin No. 29).

D. Public Involvement: Licensees will consult with the Wisconsin SHPO and the Commission to determine whether interested persons, as defined at 36 C.F.R. Part 800, at Section 800.1(c)(2), should be informed of effects to Historic Properties.

IV. TREATMENT OF HUMAN REMAINS AND GRAVE-ASSOCIATED ARTIFACTS; CURATION OF ARCHAEOLOGICAL COLLECTIONS, NOTES, MAPS, AND OTHER DOCUMENTATION; AND COMPLIANCE WITH THE NATIVE AMERICAN GRAVES PROTECTION AND REPATRIATION ACT

Licensees will ensure that the following stipulations are implemented.

A. Tribal Reservations and Lands of the United States: Licensees will ensure that all human remains and other cultural items [7] encountered on lands embraced within the exterior boundaries of Indian reservations or in dependent Indian communities (hereinafter, "Tribal Lands), or lands controlled or owned by the United States (hereinafter, "U.S. Lands") are treated in accordance with the Native American Graves Protection and Repatriation Act (hereinafter, "NAGPRA"), 25 U.S.C. Section 3001, et seq.

1. NAGPRA creates rights for certain parties that go beyond the right merely to be consulted, set forth in the Act, that are pertinent to the inadvertent discovery, intentional removal, ownership, and repatriation of human remains and other cultural items recovered from Tribal and U.S. Lands. Thus archaeological data recovery and similar mitigative actions developed pursuant to the Act must also meet NAGPRA requirements when they occur on Tribal or U.S. Lands.

2. Licensees using Tribal or U.S. Lands for purposes

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[7] NAGPRA defines "cultural items" as (a) human remains, (b) funerary objects "reasonably believed" to have been associated with human remains or, "by a preponderance of the evidence," a specific burial site, (c) sacred religious objects, and (d) cultural patrimony, defined as material remains of "historical, traditional, or cultural importance to the Native American group or culture itself ...." "Unassociated" funerary objects were, according to the Senate Select Committee report accompanying NAGPRA, specifically excluded from its protections.

requiring the issue of a license, will, within one (1) year of such a license issuing, prior to and apart from the discovery of any human remains or other cultural items, identify the following items in consultation with the Wisconsin SHPO.

a. the specific Native American organizations with a proprietary interest in any human remains and other cultural items that may be encountered and recovered,

b. the kinds of artifacts that will be considered to be cultural items as defined in NAGPRA, including associated and unassociated funerary objects, sacred objects, or objects of cultural patrimony,

c. the kinds of analysis and curation to which the material will be subjected, along with a schedule for any disposition of the material, and

d. a specific course of action to be taken if human remains and other cultural items are encountered unexpectedly during project operation or project development, including recreational development.

3. Before excavating or removing discovered human remains or other cultural items from U.S. Lands, the Licensee will make every reasonable effort to protect the property and consult with the appropriate Native American groups. The Licensee will secure the consent of the appropriate Native American groups before removing any human remains or other cultural items from Tribal Lands.

B. Consistency With NAGPRA's Purpose: Licensees will ensure that any action taken is consistent with NAGPRA's purpose of protecting Native American's interred human remains and other cultural items.

C. Other Than Tribal and U.S. Lands: Licensees will ensure that all human remains and grave-associated artifacts encountered on lands that are neither Tribal nor U.S. Lands are treated according to Section 157.70, Wisconsin Statutes, with consideration given to the Council's policy on the treatment of human remains.

D. Curation of Archaeological Collections, Notes, Maps, and Other Documentation: Licensees will ensure that, except as otherwise required above, all artifacts, notes, records, reports, maps, and any other type of documentation that are, respectively, recovered, written, made, drawn, or otherwise generated according to this Programmatic Agreement, are curated in the State of

Wisconsin, unless the Michigan SHPO specifically requests that items pertaining to Michigan be delivered to the Michigan SHPO for curation, in a facility that meets the requirements of 36 C.F.R. Part 79, insofar as this purpose can be achieved consistent with the rights of Private Property owners.

V. DISPUTE RESOLUTION

A. Foundational Considerations: The Commission alone is statutorily mandated to ensure compliance with the National Historic Preservation Act and the Federal Power Act, notwithstanding this or any other Programmatic Agreement.

1. In all matters arising under this Programmatic Agreement, the Commission reserves to itself the sole right and authority to determine, consistent with the Council's regulations, the means of taking into account the effects of undertakings on Historic Properties, and, consistent with its own regulations, the best adapted use of a waterway.

2. Neither this Programmatic Agreement, nor any part of it will be interpreted to give any other party this right or authority.

3. While a Licensee may implement measures and adopt findings, where a consensus with the SHPO for such measures or findings is found to exist, a Licensee's right to seek the Commission's resolution of any matter disputed between it and any other Party to this Programmatic Agreement will not be abridged.

B. Procedures: If the SHPO, a Licensee, Licensees or the Council objects to any action or any failure to act on the part of any Party to this Programmatic Agreement, any Licensee, or Licensees within 45 days of such action or failure to act, the objecting Party, Licensee, or Licensees will file written objections with the Commission.

1. The Commission will consult with the Parties any interested parties, Licensee, or Licensees to resolve the objection.

2. The Commission may initiate sua sponte such consultation to resolve any of its objections to actions or to failure to act on the part of any Party, Licensee, or Licensees.

C. Council Comments: If the Commission determines that the matter cannot be resolved by consultation, the Commission will request the Council's further comments pursuant to 36 C.F.R. Part 800, at Section 800.6(b).

1. Any Council comment provided in response to such a request will be taken into account by the Commission in accordance with 36 C.F.R. Part 800, at Section 800.6(c)(2), with reference to the subject of dispute.

2. After consultation and review of written responses the Commission will issue a decision on the matter.

D. Status of Actions Not In Dispute: The Commission's responsibility to carry out all actions under this Programmatic Agreement that are not the subject of dispute will remain unchanged.

VI. EXECUTING, AMENDING, AND TERMINATING THIS PROGRAMMATIC AGREEMENT

This Programmatic Agreement will continue in full force and effect in its present form until it is amended or terminated.

A. Execution: Execution and implementation of this Programmatic Agreement evidences conclusively that the Commission has satisfied its Section 106 responsibilities for all individual Projects in the State of Wisconsin or the States of Wisconsin and Michigan issued new or amended licenses after the date whereon this Programmatic Agreement is executed.

B. Amending This Programmatic Agreement

1. The Commission, the Wisconsin SHPO, the Michigan SHPO, the Council, or any interested party may request an amendment to this Programmatic Agreement, whereupon the Parties will consult in accordance with 36 C.F.R. Part 800, at Section 800.13.

2. This Programmatic Agreement will be amended only upon the agreement of the Commission, the Wisconsin SHPO, the Michigan SHPO, and the Council.

3. Historic Properties affected by a new license issuing to Wisconsin Power & Light for its continued operation of the Shawano Project, Project No. 710, in Shawano and Menominee Counties, are protected under a Programmatic Agreement for that project. Some of those Historic Properties are on lands belonging to the Menominee Indian Tribe of Wisconsin. If the Programmatic Agreement for the Shawano Project is terminated or amended with the result that the Shawano Project is administered under this Programmatic Agreement, the Parties will consult together and with the Menominee, both directly and through counsel, to amend this Programmatic Agreement sufficient to

afford their interests in Historic Properties located on their lands protection equal or superior to that stipulated in the Programmatic Agreement for the Shawano Project alone.

C. Terminating This Programmatic Agreement: The Commission, the Wisconsin SHPO, the Michigan SHPO, or the Council may terminate this Programmatic Agreement by giving notice to the Parties at least thirty days before the desired termination date, provided that the Parties will have consulted in good faith before notice is given to avoid termination by amendment or by other actions.

FEDERAL ENERGY REGULATORY COMMISSION

By Fred E. Springer Date 12/1/93
Fred E. Springer, Director
Office of Hydropower Licensing

ADVISORY COUNCIL ON HISTORIC PRESERVATION

By Robert D. Bush Date 12/30/93
Robert D. Bush, Ph.D., Executive Director

STATE HISTORICAL SOCIETY OF WISCONSIN

By ______ Date ______
Jeff Dean, State Historic Preservation Officer

MICHIGAN DEPARTMENT OF STATE, BUREAU OF HISTORY

By ______ Date ______
Dr. Kathryn Eckert, State Historic Preservation Officer

APPENDIX B. 2019 Archaeological Report (Privileged)

The 2019 Report has been eFiled as Privileged in a separate file.

APPENDIX C. Determination of Eligibility

Xcel Energy®

February 6, 2020

1414 West Hamilton Avenue
P.O. Box 8
Eau Claire, WI 54702-0008

Mr. Tyler B. Howe
State Historic Preservation Office
816 State Street
Madison, WI 53706

Subject: **National Register of Historic Places Evaluation**
Cornell Hydro – FERC Project No. 2639

Dear Mr. Howe:

In 2018, Northern States Power Company – Wisconsin (NSPW), d/b/a Xcel Energy, licensee for the Cornell Hydroelectric Project (Project), began the Federal Energy Regulatory Commission's relicensing process for the facility. The relicensing process, in part, requires the Project be evaluated for eligibility for the National Register of Historic Places (NRHP) pursuant to Section 106 of the National Historic Preservation Act. Accordingly, licensee retained the services of UW-Milwaukee's Cultural Resource Management (UWM-CRM) to evaluate the Project's eligibility for the NRHP.

Enclosed you will find two copies of UWM-CRM's technical memo for the architectural and history investigations of the Project, two copies of the corresponding NRHP evaluation form, and photographs of the Cornell Wood Products Co. Historic District (District). In the technical memo, our consultant concluded the District, which includes the Project, is eligible for the NRHP. The only Project structure considered to be a contributing element to the District is the Cornell Dam. The powerhouse and associated substation were determined non-contributing elements.

Xcel Energy plans on developing a draft Historical Resources Management Plan (HRMP) for the Project based upon our consultant's conclusions and your pending comments. A SHPO consultation form is included for your review. We look forward to your comments.

Should you have any questions, feel free to contact me at (715) 737-1353 or at matthew.j.miller@xcelenergy.com.

Sincerely,

Matthew J. Miller

Matthew J. Miller
Hydro License Compliance Consultant

Enclosures

c: Shawn Puzen – Mead & Hunt (via e-mail)
Jennifer Haas – UWM CRM (via e-mail)
Project Files

UNIVERSITY of WISCONSIN
UWMILWAUKEE
UWM Cultural Resource Management

UWM CRM
Helping to Insure the Future of the Past

Sabin Hall, SAB 280
3413 N. Downer Ave.
Milwaukee, WI
53211-0413
414 229-3870 phone
414 229-5848 fax

TECHNICAL MEMO

ARCHITECTURE HISTORY INVESTIGATIONS
CORNELL HYDROELECTRIC GENERATING STATION
FERC PROJECT #2639
CITY OF CORNELL, CHIPPEWA COUNTY, WI

Prepared by Kelly Blaubach, M.A., Architectural Historian

Introduction and Project Description

In October 2019, UWM-Cultural Resources Management conducted architecture/history investigations for the subject project located on the Chippewa River in the City of Cornell, Chippewa County. See attached map for project location.

Proposed activities involve the relicensing of the hydroelectric facility by owner Xcel Energy. The architecture/history investigations documented in this report were designed to comply with the *Programmatic Agreement Among the Federal Energy Regulatory Commission, the Advisory Council on Historic Preservation, the State of Wisconsin, State Historic Preservation Officer, and the State of Michigan, State Historic Preservation Officer, for Managing Historic Properties that may be Affected by New and Amended Licenses Issuing for the Continued Operation of Existing Hydroelectric Projects in the State of Wisconsin and Adjacent Portions of the State of Michigan* (hereafter referred to as the Programmatic Agreement).

Area of Potential Effect

Given the project description and its potential to impact the project area, an Area of Potential Effect (APE) was established which included just the Cornell Hydroelectric Facility, comprised of a dam and powerhouse. This property was reviewed for potential historic significance.

Literature Search and Methodology

Prior to the field survey, UWM-CRM conducted a search of the Wisconsin Historic Preservation Database (WHPD) and the State and National Registers of Historic Places (NRHP). The search did not reveal any previously-surveyed properties within the project APE. No NRHP-listed properties were identified within the APE, although the Cornell Pulpwood Stacker, located nearby, was listed in the NRHP in 1994.[1] On October 2, 2019, UWM-CRM conducted a reconnaissance field survey to view the project and assess its potential significance.

[1] National Register of Historic Places, Cornell Pulpwood Stacker, City of Cornell, Chippewa County, Wisconsin, National Register #93001425.

Results

The Cornell Dam was constructed in 1913 and consists of a gated spillway, overflow spillway, and embankment wall across the Chippewa River. The powerhouse, adjacent to and east of the gated spillway, was built between 1974-77, a reconstruction of a previous powerhouse at the site constructed in 1913. Through the course of the field survey and additional historic research, it was determined that the Cornell Hydroelectric Facility was historically and functionally associated with the adjacent manufacturing property, as well as the previously-listed Cornell Pulpwood Stacker. Originally constructed in 1913 by the Brunet Falls Manufacturing Company, the dam and original powerhouse provided hydroelectrical and hydromechanical power for the adjacent pulp and paper mill. Mill Yard Park to the north of the mill, containing the Pulpwood Stacker, served to receive and store raw pulpwood for mill operations.

In keeping with Part I, Sections A and C of the Programmatic Agreement, UWM-CRM completed a Determination of Eligibility for the entire historic mill property, using National Park Service Form 10-900 to document and evaluate the Cornell Wood Products Co. Historic District.

Summary and Recommendations

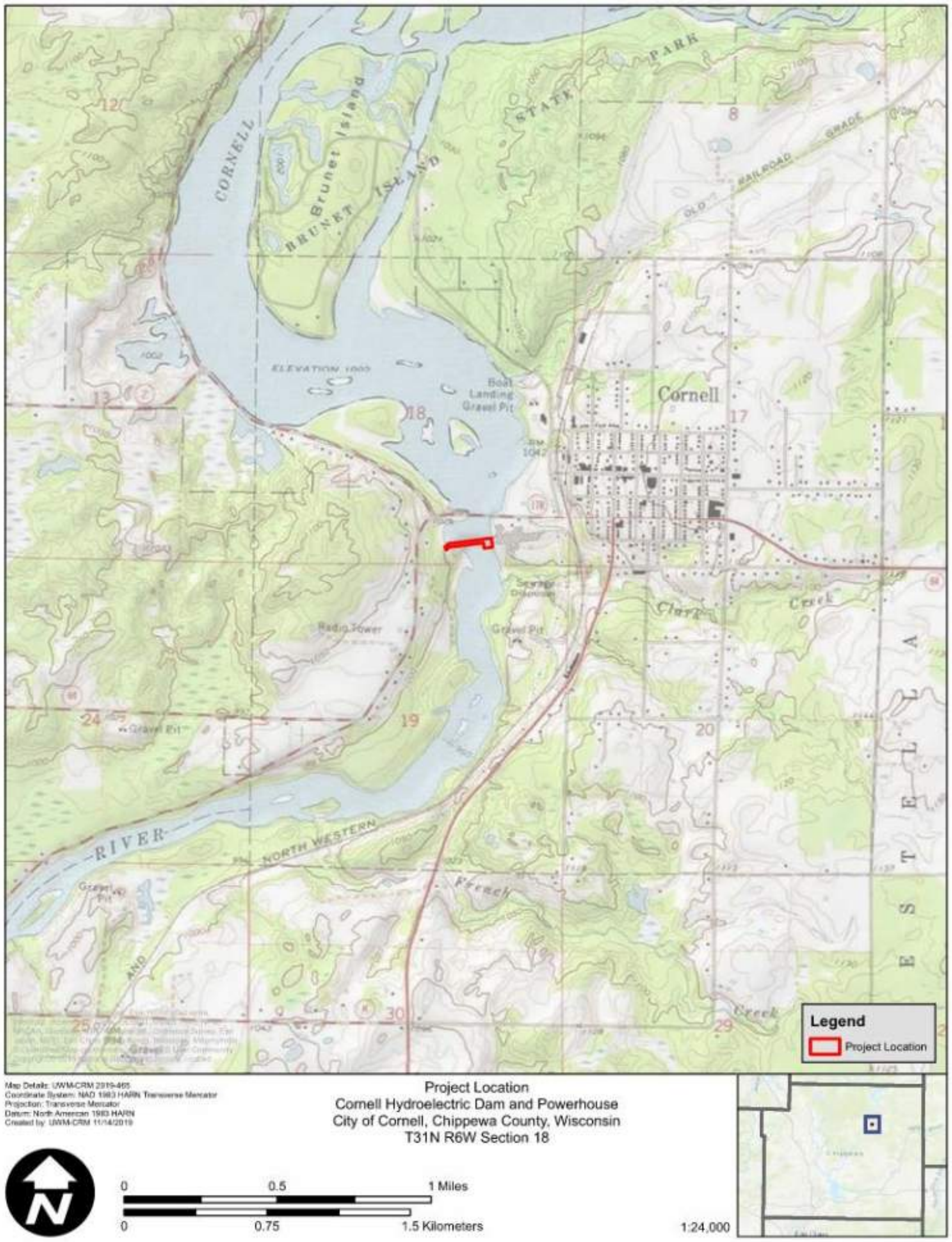
Following the completion of the Determination of Eligibility, UWM-CRM recommended the Cornell Wood Products Co. Historic District, of which the subject project is a part, as eligible for listing in the NRHP under *Criterion A: History*. Please feel free to contact me with any questions or concerns.

Sincerely,

Kelly Blaubach
Architectural Historian
UWM-CRM

Attachments:
1. Project location
2. Property photo

Attachment 1.



Attachment 2.

Cornell Wood Products Co. Historic District, Dam in foreground, with powerhouse, mill buildings and pulpwood stacker in background

United States Department of the Interior
National Park Service

National Register of Historic Places Registration Form

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in National Register Bulletin, *How to Complete the National Register of Historic Places Registration Form.* If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions.

1. Name of Property

Historic name: Cornell Wood Products Company Historic District
Other names/site number: ____
Name of related multiple property listing:
N/A
(Enter "N/A" if property is not part of a multiple property listing

2. Location

Street & number: 50 Bridge Street, 121 Park Road
City or town: City of Cornell State: WI County: Chippewa County
Not For Publication: ☐ Vicinity: ☐

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act, as amended,

I hereby certify that this __ nomination _X_ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60.

In my opinion, the property ___ meets ___ does not meet the National Register Criteria. I recommend that this property be considered significant at the following level(s) of significance:

___national ___statewide _X_local
Applicable National Register Criteria:

_X_A ___B ___C ___D

____

Signature of certifying official/Title: Date

____

State or Federal agency/bureau or Tribal Government

In my opinion, the property ___ meets ___ does not meet the National Register criteria.

Signature of commenting official: **Date**

Title : **State or Federal agency/bureau or Tribal Government**

4. National Park Service Certification

I hereby certify that this property is:

___ entered in the National Register

___ determined eligible for the National Register

___ determined not eligible for the National Register

___ removed from the National Register

___ other (explain:) ____________________

Signature of the Keeper Date of Action

5. Classification

Ownership of Property

(Check as many boxes as apply.)

Private: [X]

Public – Local [x]

Public – State [ ]

Public – Federal [ ]

Category of Property

(Check only **one** box.)

Building(s) [ ]

District [X]

Site [ ]

Structure [ ]

Object [ ]

Number of Resources within Property

(Do not include previously listed resources in the count)

Contributing	Noncontributing	
4	3	buildings
0	0	sites
2	2	structures
0	0	objects
6	**5**	**Total**

Number of contributing resources previously listed in the National Register 1

6. Function or Use

Historic Functions
(Enter categories from instructions.)
INDUSTRY/*Manufacturing facility* = Pulp and Paper Mill

Current Functions
(Enter categories from instructions.)
INDUSTRY/*Manufacturing Facility* = Factory
INDUSTRY/*Energy Facility* = Hydroelectric Dam
RECREATION AND CULTURE/*Outdoor recreation* = Park

7. Description

Architectural Classification
(Enter categories from instructions.)
_Other: Astylistic Utilitarian _
_Other: Gravity Dam__
Other: Pulpwood Stacker

Materials: (enter categories from instructions.)

Principal exterior materials of the property:		
	Foundation	concrete
	Walls	brick, concrete
	Roof	metal, asphalt

Narrative Description

(Describe the historic and current physical appearance and condition of the property. Describe contributing and noncontributing resources if applicable. Begin with **a summary paragraph** that briefly describes the general characteristics of the property, such as its location, type, style, method of construction, setting, size, and significant features. Indicate whether the property has historic integrity.)

Summary Paragraph

The Cornell Wood Products Company Historic District is located in the City of Cornell, Chippewa County, and is situated across and on the east bank of the Chippewa River. The district is comprised of resources located both north and south of Bridge Street and a hydroelectric dam spanning the Chippewa River. The hydroelectric facility supplied electrical and mechanical power to the paper mill throughout the historic period.

One of the most modern plants when originally constructed in 1911-13 by the Brunet Falls Manufacturing Company, the Cornell Wood Products Company Historic District contains a dam, powerhouse, mill yard, pulp wood stacker, and mill buildings associated with paper and pulp milling and production. The O'Keefe-Orbison Engineering & Construction Company conducted the initial engineering work, with H.M. Byllesby and Company acting as consulting engineers, and L.I. Fletcher overseeing construction work on the project. V.D. Simons, the secretary and general manager on the board of directors for the Brunet Falls Manufacturing Company, provided input and specific design details for the project, some of which were reportedly unique in paper mill construction at the time.[1]

The Cornell Wood Products Company Historic District is comprised of 6 contributing resources and 5 non-contributing resources, including the Cornell Pulpwood Stacker, which has been listed in the National Register.[2] Resources include a multi-section concrete gravity dam and powerhouse, a paper mill complex with associated receiving and office buildings, and a mill yard containing the pulpwood stacker, modern park pavilions, and visible remnants of the log storage pond and conveyor troughs. While this still-functioning paper mill complex has been altered over time, several important resources that convey its historic significance remain.

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[1] "The New Plant of the Brunet Falls Mfg. Co.," *Paper*, February 26, 1913, 130.

[2] National Register of Historic Places, Cornell Pulpwood Stacker, City of Cornell, Chippewa County, Wisconsin, National Register #93001425.

Narrative Description

Hydroelectric Facility

1. Dam (Contributing)

The Cornell Hydroelectric Dam spans east to west across the Chippewa River, which flows from north to south. It was constructed between 1911 and 1913 by the Brunet Falls Manufacturing Company. This 500-foot, multi-section structure was constructed of reinforced concrete atop a foundation of micaceous, grey, granite rock. The dam is comprised of several sections which are distinguished by their function, and includes a gated spillway, an overflow flashboard spillway, and a western embankment wall.

Gated Spillway

The original gated spillway was 260 feet long, containing twelve steel tainter gates in twenty-foot bays, separated by reinforced concrete piers. The concrete portions of the spillway have been repaired periodically throughout its history, including repairs to the piers and aprons in 1930-31, 1952, 1962, and 1981. Between 1974 and 1976, the adjacent powerhouse was reconstructed, shrinking in width across the Chippewa River from approximately 200 feet to 128 feet wide. Two new 37-foot wide radial gates were added immediately west of the new, smaller powerhouse. As recently as 2008, six of the gated spillway's tainter gates were removed and replaced in kind, four of the gates were repaired, and all were painted. Gate hoists were replaced and a new hoist bridge was constructed atop the dam platform.

Overflow Spillway

The overflow spillway section is 210 feet long, consisting of four ogee-curved bays separated by stepped concrete piers on the downstream side. Coated-plywood flashboards span the top of each bay, supported by metal rods. These flashboards are effective in holding back the water on the upstream side of the dam; however, in the case of a high water event, the flashboards are intended to fail, allowing water to over-top in just this section of the dam in order to limit impact form upstream flooding and avoid damage to the gated spillway and powerhouse. The flashboards were originally timbers, and were replaced with coated plywood, probably in 1984.

Embankment Wall

The concrete-core embankment wall is located at the western end of the dam structure. The reservoir side of the embankment is covered in rip rap, while the downstream side is ballasted by concrete pilasters. The upstream embankment was raised three feet in 1942, and raised again between 1974 and 1976, when additional head was added to the reconstructed hydroelectric facility.

2. Powerhouse (Non-contributing)

Demolition of the old powerhouse and construction of the new took place between 1974-77, involving the almost-complete replacement of the original 1913 powerhouse with the exception of a portion of the original substructure. This new, single-story powerhouse measured 128 feet wide and 151.5 feet long, and was described as a "semi-outdoor" type of facility. The large generator room houses three generator and turbine units above the S-shaped draft tubes and a minimum flow generator/turbine unit. The outdoor "deck" over the generating room is designed to carry a construction crane across the roof of the generator room, with hatches providing access to equipment below if needed. When finished, the 1977 Powerhouse did not extend as far across the Chippewa River as the previous powerhouse; the extra space adjacent to the extant gated spillway was converted into an additional gated spillway section, containing two, 37-foot wide radial gate bays, separated by heavy concrete piers downstream. Power generated at this facility is no longer used exclusively by the adjacent mill; rather, power is generated for and distributed through Xcel's larger power system. Dam and powerhouse operations are controlled locally or remotely from the company's Wissota Hydroelectric Facility, located 20 miles downstream.

Generating Equipment

The 1977 powerhouse contains three Allis-Chalmers 10,000 KW, 7.2 KV, 3 phase, 60 Hz horizontal-type generators with horizontal turbines, operating at a rate of 13,900 HP under a head of 36 feet and a 750 KW minimum flow unit. The powerhouse currently generates 33.2 MW of power.

3. Substation (Non-contributing)

A modern substation is located at the eastern edge of the historic district, just south of Bridge Street. It was reconstructed by Xcel Energy at the site of an earlier substation between 2011 and 2014.

Mill complex (b. 1913, addn. c1920, c1925, c. 1960, c. 1980)

Plans from 1913 for the original mill buildings depicted an L-shaped mill complex consisting of a series of interconnected structures housing different steps of the milling process. Buildings were constructed of reinforced concrete columns and lintels, with large windows in each bay.[3] Most window openings have been partially or fully filled with brick. A slight Greek Revival influence is found in the gable ends of these early buildings, which often feature enclosed pediments pierced by the reinforced concrete columns. Additions made to the mill complex within the first 20-30 years after original construction were built using similar style and materials. Current facilities include additional spaces for receiving and storage, both as additions to the larger mill complex and stand-alone buildings. Most newer buildings have been constructed or re-clad with vinyl siding with metal or asphalt-shingled, gabled roofs. Some of the older portions of the complex have also been re-sided with metal or vinyl siding, some as recently as 2008. Portions of the complex no longer extant include a club house that was located

[3] "The New Plant of the Brunet Falls Mfg. Co.," 136.

just south of Bridge Street near the river, and a later office and receiving building north of the boiler house that was removed between 2008 and 2010.

4. Mill Building (Contributing)

Originally constructed in 1913, the mill building began as an L-shaped structure with a separate boiler house, club house, and office building to the north. Rail lines for shipping and receiving bisected the property. Original components of the L-shaped mill building included a cook room, where logs from the mill yard were initially received, which measured 44x52 feet and 100 feet high. At the time of construction, the powerhouse was an integral part of the milling complex, as the hydromechanical pulp grinders further processed the wood after cooking.[4] East of the cook room was a machine room measuring 43x315 feet, followed by two finishing buildings measuring 44x80 feet and 51x68 feet. The last finishing building formed the eastern-most "L" portion of the building. A boiler house separated from the main mill and located north of the cook room measured 44x56 feet.

By 1920, additions to the mill proper and larger mill complex included a separate warehouse and storehouse to the north, as well as a flat-roof, rectangular addition in the "L" portion of the original mill. By 1938, a long rectangular, gable-roofed addition, possibly another machine room, was added to the south directly abutting the existing machine room. Another gable-roofed building, approximately the width of the combined machine rooms, was added to the eastern end of the complex south of the original finishing room. This addition extended the length of the mill complex another approximately 330 feet. Both the eastern addition and the new machine room were constructed in a similar style to the original buildings, with reinforced concrete beams and lintels infilled with brick and multi-paned windows. The easternmost elevation of the eastern addition may have at one time served as the "formal" entrance to the mill complex, as the center of the eastern façade features a shed-roofed portico supported by columns, with a shallow pediment above a central staircase. A long, shed-roofed shipping bay, constructed between 1938 and 1951, surrounds the northern facades of this eastern addition, the original finishing building, and the flat-roof rectangular addition.

By 1951, a series of rectangular, two-story additions and circular cooking vats had been added south of the machine rooms. In 1980, a metal-framed, gable-roofed warehouse was added to the northern façade of the mill building, replacing a similar stand-alone structure with a monitor roof. Portions of the western mill buildings were re-clad with metal siding in 2008.

With regards to integrity, the mill building has experienced multiple additions expanding its production capacity and adapting to changing methods of shipping and transportation. However, the original buildings and those additions that were constructed in similar style and

[4] The powerhouse and dam were separated from the milling complex and its operations in 1974, when the powerhouse was reconstructed to generate only hydroelectrical – no hydromechanical - power for Northern States Power Company.

with similar materials during the next 20 to 30 years are largely still extant and visible amid the additions constructed outside the period of significance (See Figures 1-3).

5. Front Office (Contributing)

This rectangular building was constructed in 1913 at the time of the original mill complex construction. This building features a hipped, asphalt-shingle roof, and vinyl siding. Windows throughout are single-paned, vinyl replacements arranged in an asymmetrical fashion. The primary façade faces north, and features a central, hipped roof porch that has been enclosed. The entryway opens off the eastern end of this porch and is sheltered by a flat-roofed awning. This building has historically served as a free-standing office for the mill property.

6. Receiving (Contributing)

This rectangular receiving building was constructed circa 1920, appearing on 1920 mapping as a "Storehouse." This front-gabled building features a concrete block foundation, a metal-clad roof, and vinyl siding. Fenestration is limited to two 1-over-1 double hung windows on the eastern elevation. This is also the primary elevation of the building, containing a central metal-door entryway with the two windows to the south.

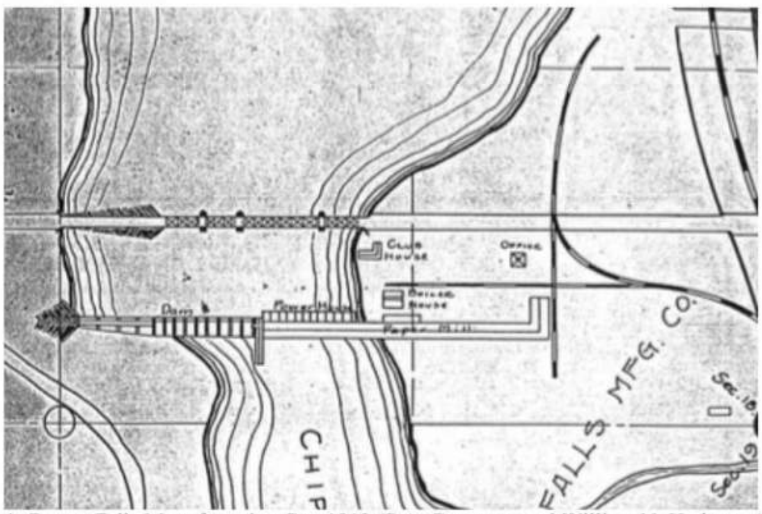

Figure 1: Brunet Falls Manufacturing Co., 1913 (S.A. Carpenter and William N. Herbert, *Atlas of Chippewa County*, Gailloux and Harris: 1913).

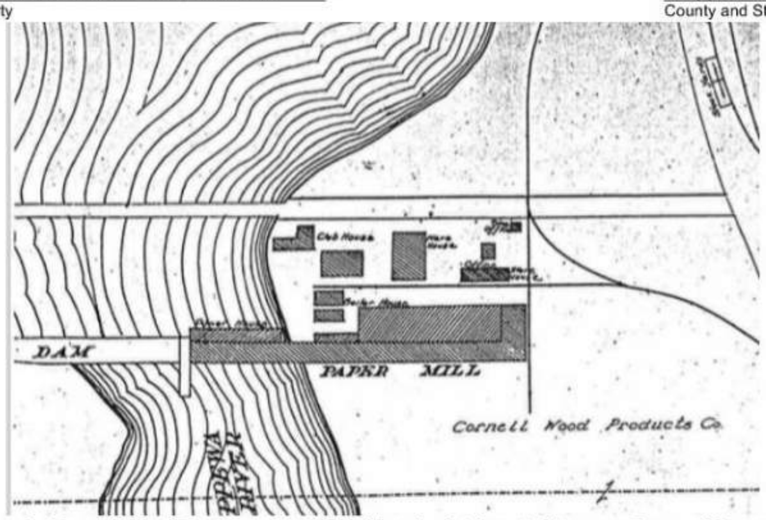

Figure 2: Cornell Wood Products Co., 1920 (*Standard Atlas of Chippewa County, Wisconsin*, Chicago: Geo. A. Ogle and Co., 1920).

Figure 3: 1938 aerial view of Cornell Wood Products Co. (USDA, *Chippewa County* [aerial photo], 1:20,000, Photo #BRR-6-63, 1938).

Mill Yard Park

The Mill Yard, where pulpwood logs were shipped and stored until processing, is located across Bridge Street to the north of the mill complex. This road has always bisected this historic mill property, with the mill yard and mill buildings connected via the log conveyor trough. The mill yard historically contained a number of inter-connected structures and buildings all intended to receive, cut, and store raw pulpwood prior to being sent to the mill for processing. At one time this included an office, tool building, pump house, slasher building, stacker pit building, and a log pond and conveyor troughs (See Figure 4). The Mill Yard operated as originally intended until 1972, when wood pulping activities at the mill ended. This approximately 14-acre portion of the historic district was donated to the City of Cornell in 1983 by then-owner Globe Industries. The Mill Yard has since been developed as a community park, with baseball fields, skate park, visitor's center and museum, and picnic pavilions.

Evidence of the water conveyance systems are still visible within the park, though they do not retain enough integrity to be included as separate resources. The tops of the curving walls of the log storage pond are partially evident in the ground near the northwestern edge of the property, and a portion of the conveyor trough leading southwest from the yard to the mill building has been maintained. The slasher building and pumphouse were destroyed by fire in 1990, prompting the structural evaluation and National Register listing of the adjacent Pulpwood Stacker.

7. Pulpwood Stacker (Contributing)
The most prominent extant structure from the original mill yard is the Pulpwood Stacker. Listed in the National Register in 1993, the stacker is a steel cantilever truss structure that stands 175 feet above the ground at an angle of approximately 45 degrees. It was designed by the Joor Engineering Company of England and produced by the Minneapolis Tool and Machinery Company. Assembled on site in 1912, it conveyed logs that had been cut to 4 foot lengths upwards inside the truss structure and deposited the logs at several points along the stacker's length into the wood yard below, creating a large "stack" of wood awaiting transport to the mill. Stockpiling raw materials in this manner allowed for the mill to be run continuously, even during the winter months. The Pulpwood Stacker is identified as the only remaining structure of its kind, and was listed in the Register under *Criterion A* for Industry and *Criterion C* for Engineering.

8. Visitor's center (Non-contributing)
This rectangular building was constructed in Mill Yard Park in 1996. Designed by Brian Larson of Ayers Associates, the City of Cornell funded this visitor's center to describe the history of the community as well as the restored pulpwood stacker nearby. This one-story building features a hipped roof with wide overhanging eaves and vinyl siding. The primary façade faces southwest, and includes an off-center entryway flanked by large aluminum display windows.[5]

9. Wood Yard office (Contributing)

[5] "Cornell to Build Visitor's Center," *Ladysmith News*, December 28, 1995.

This rectangular building was constructed circa 1913, shortly after the construction of the mill yard. It originally served as the Woodyard Office, with space for meals and break times for the woodyard workers.[6] The side-gabled building measures 12x39 feet, and features an asphalt-shingled roof, asbestos siding, and a centrally-located brick chimney. Fenestration throughout is irregular, and includes both multi-paned and single-paned windows. The eastern elevation contains a central entryway, as well as a small shed-roofed addition at the northeast corner. The building currently houses part of a Native American historical exhibit.

10. Picnic Pavilion (Non-contributing)
The Picnic Pavilion in Mill Yard Park was constructed circa 1990, following the donation of the former mill yard by then-owners Globe industries to the City of Cornell in 1983. This rectangular building rests on a concrete slab with a gabled, metal-clad roof. Fourteen bays on the eastern elevation contain metal overhead doors separated by wooden piers. The north and south elevations contain four slightly smaller overhead doors, also separated by wooden piers and surmounted by a vertical-board cornice. The western elevation contains 8 overhead door bays, with a central section of the façade clad simply with wooden siding. The interior of the pavilion contains an enclosed central core with restrooms, with the remainder of the open interior space containing picnic tables.

11. Lions Pavilion (Non-contributing)
The Lions Pavilion in Mill Yard Park was constructed circa 1990, following the donation of the former mill yard by then-owners Globe Industries to the City of Cornell in 1983. This open-air pavilion is a square structure constructed atop a concrete slab. Wooden posts support a gabled metal roof with a monitor at the ridgeline.

Figure 4: Pulpwood Stacker and mill yard, during or shortly after construction in 1913 ("The New Plant of the Brunet Falls Mfg. Co.," *Paper*, February 26, 1913, 134).

[6] "Cornell Wood Products Company," Site file, Wisconsin Historical Society, Division of Historic Preservation.

1. Statement of Significance

Applicable National Register Criteria
(Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing.)

[x] A. Property is associated with events that have made a significant contribution to the broad patterns of our history.

[ ] B. Property is associated with the lives of persons significant in our past.

[ ] C. Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.

[ ] D. Property has yielded, or is likely to yield, information important in prehistory or history.

Criteria Considerations
(Mark "x" in all the boxes that apply.)

[ ] A. Owned by a religious institution or used for religious purposes

[ ] B. Removed from its original location

[ ] C. A birthplace or grave

[ ] D. A cemetery

[ ] E. A reconstructed building, object, or structure

[ ] F. A commemorative property

[x] G. Less than 50 years old or achieving significance within the past 50 years

Areas of Significance
(Enter categories from instructions.)
Industry

Period of Significance
1913-1972

Significant Dates
1913, c. 1920,
c. 1925, c. 1960

Significant Person
(Complete only if Criterion B is marked above.)
N/A

Cultural Affiliation
N/A

Architect/Builder
O'Keefe-Orbison Engineering & Construction Co. (engineer)
H.M. Byllesby Co. (consulting engineers)
L. I. Fletcher (builder)

Statement of Significance Summary Paragraph (Provide a summary paragraph that includes level of significance, applicable criteria, justification for the period of significance, and any applicable criteria considerations.)

The Cornell Wood Products Company Historic District was constructed by the Brunet Falls Manufacturing Company in 1911-13. The construction of the pulp mill complex, which included a mill yard and hydroelectric dam, resulted in profound growth for the new City of Cornell, which was struggling like many northern Wisconsin settlements after the exhaustion of the area's timber resources. The pulp mill complex remained a major driver of economic growth throughout the twentieth century. It is recommended as eligible for listing in the National Register of Historic Places under *Criterion A: History*, on the local level for its association with the development of the city. It is also eligible under *Criterion A* on the regional level for its association with the history of pulp and paper milling in northern Wisconsin. In total, the resources of the district represent all functions of a pulp and paper mill, including wood storage, pulp milling and finishing, and power generation. The period of significance for the district is from 1913, when the construction of the paper mill complex was completed, until 1972, when the paper mill closed, the pulpwood stacker and mill yard were decommissioned, and the hydroelectric portion of the facility was redeveloped by Northern States Power Company.

No evidence was found to suggest eligibility under *Criterion B: Significant Person*.

Under *Criterion C: Architecture*, the Cornell Wood Products Company Historic District contains astylistic utilitarian buildings and structures. Original buildings have experienced several alterations and additions, as may be expected for an industrial property in continuous use for approximately 60 years. However, these alterations have had a cumulative negative effect on the integrity of the original buildings and structures, and as such is not recommended as eligible under *Criterion C*.

Under Criterion Consideration G for properties that have achieved significance within the past 50 years, the Cornell Wood Products Historic District's period of significance extends until 1972, which is just short of the 50-year requirement. However, this period of significance under *Criterion A* is justified by the continued operation of the paper mill complex and the economic importance of the business in the City of Cornell until that time. Furthermore, while a few of the resources within the district were constructed relatively recently, the majority of resources are over 50 years old and constructed within the period of significance.

Pulp and Paper Mill Industry Historic Context

Paper milling in Wisconsin began in Milwaukee around 1848, eventually becoming the state's third largest industry by 1948, one hundred years later. Wisconsin contained all of the necessary conditions for successful paper production, including abundant water resources, potential sites for conversion to water power, skilled labor, and market access for products. However, the search for raw materials for making paper was always a struggle. As the demand for paper products only increased, adequate supply of cloth rags, straw, and waste paper became harder to acquire.[7]

This problem of scarce papermaking materials coincided with the rise of another problem in the state. Near the end of the nineteenth century and early twentieth century, Wisconsin's logging and lumber milling industry was on the decline as the valuable pine forests of the Northwoods were exhausted. What was left behind in the state's depleted forests were hardwood trees such as aspen, fir, and hemlock, which were less valuable and harder to transport via waterway.[8] In the 1880s and 1890s, grinding and chemical processing were instituted on a large scale in Wisconsin's mills, in which these less valuable woods could be broken down into paper pulp, the raw material for a new papermaking process. Wisconsin companies also began importing these pulpwoods from western and Canadian territories to supplement their stock. The new pulp and paper-making process vastly increased the output of Wisconsin's mills, and also diversified the types of paper and paperboard products that could be manufactured. As responsible forest management policies were enacted throughout the remainder of the twentieth century, pulpwood harvesting has become the driver of the modern lumber industry.[9]

Wisconsin's abundant waterpower resources helped to fuel development across all areas of industry during the nineteenth century. However, the papermaking industry's reliance on adjacent waterpower was proportionally much greater; approximately 15 times more power was required in papermaking than the average manufacturing establishment in 1900.[10] Many of Wisconsin's rivers were first improved for the sole purpose of providing mechanical power to adjacent milling operations. Pulping and paper mills commonly included both hydroelectric generators for in-plant electrical power needs as well as hydromechanical generators to operate pulp wood grinders. As the industry made the complete transition from ground wood pulp to chemically processed wood pulp after 1900, on-site developed waterpower was often in excess of what mills actually needed.[11] Even as technological advancements during the twentieth century made steam the dominant power source in other industrial fields, mills were slow to make the change because the waterpower rights they already owned made their use of its hydroelectricity basically costless.[12]

Although paper industries in the state were concentrated in the Fox River Valley during the nineteenth century, paper making began moving to northwestern Wisconsin, the location of the necessary raw materials, in earnest after 1900. The earliest pulp and paper company on the

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[7] Barbara Wyatt, ed., "Pulp and Paper Production," *Cultural Resource Management in Wisconsin*, (Madison, WI: State Historical Society of Wisconsin, 1986), Vol. 2, 6—1.
[8] Barbara Wyatt, ed., "Logging and Lumber Milling," *Cultural Resource Management in Wisconsin*, (Madison, WI: State Historical Society of Wisconsin, 1986), Vol. 2, 5—14.
[9] Wyatt, "Logging and Lumber Milling," 5—15.
[10] Maurice Lloyd Branch, "The Paper Industry in the Lake States Region: 1834-1947," (PhD diss., University of Wisconsin, 1954), 24-25.
[11] Duncan Hay, *Hydroelectric Development in the United States, 1880-1940* (Washington, D.C.: Edison Electric Institute, 1991), 34.
[12] Branch, "The Paper Industry," 53.

Chippewa River was the Eau Claire Pulp and Paper Company, organized in 1882.[13] By 1910, Wisconsin ranked third in the nation in paper production. The types of paper and paperboard products manufactured in Wisconsin changed after the passage of the Underwood Tariff Act in 1913. This allowed for the import of cheaper newsprint and wrapping papers from foreign countries, namely Canada. Between 1919 and 1949, regional and state paper production shifted to feature tissue, sanitary, and other high quality specialized papers, while the production of newsprint and wrapping papers fell off considerably.[14] After the Great Depression, many regional paper making mills were acquired and consolidated by multi-national firms like St. Regis Paper Company.[15]

Cornell History

The first permanent white settler to the Cornell area was Jean Brunet, arriving from Chippewa Falls in 1840. He established the first trading post in the area on the west bank of the Chippewa River next to a series of rapids where the river dropped approximately 27 feet. The community that grew around this trading post was called Brunet Falls. In 1866, Ezra Cornell, a wealthy New York capitalist and a founder of Cornell University in Ithaca, New York, visited the area in order to inspect the lands he would later acquire on behalf of Cornell University. The harvesting of the timber and the eventual sale of these lands provided millions for the university's endowment fund over time. Much of the land comprising and surrounding the current City of Cornell was purchased from Cornell University in 1902. In 1903, the Cornell Land and Power Company were granted water rights to build a dam at this location by the Wisconsin legislature. Following the arrival of the railroad to the area that same year, settlement of the area began to accelerate. The name of the community was changed from Brunet Falls to Cornell in 1905 to honor the memory of Ezra Cornell, and his original plattings for the townsite were incorporated into the developing community.[16]

Talk of a dam and mill in Cornell began as early and 1903, but it was not until 1911 that Brunet Falls Manufacturing Company began clearing the flowage area and the site of the future dam and paper mill.[17] In 1913, the dam, powerhouse, paper mill, and pulpwood stacker were completed and placed in operation. Brunet Falls Manufacturing Company, having encountered severe financial hardship during the construction of the project, was bought out by Cornell Wood Products Company in 1914 and continued in the manufacture of paper and paperboard products in the City of Cornell for decades. By 1930, Cornell contained 1,510 inhabitants, with a large percentage of those working at the pulping mill, the city's only major manufacturer.[18] Flowage and operating rights to the hydroelectric portion of the mill complex were conveyed to Northern States Power Company of Wisconsin in 1929. Cornell Wood Products retained ownership of the

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[13] Herbert W. Meyer, Builders of Northern States Power Company, (Minneapolis, MN: Northern States Power Company, 1957), 111.
[14] Branch, "The Paper Industry," 80-81.
[15] Wyatt, "Pulp and Paper Production," Vol. 2, 6—8.
[16] "Last of Its Kind: The Cornell Pulpwood Stacker," pamphlet, Greater Cornell Area Community Development Association, Inc., undated.
[17] "Government Grants Post Office at Cornell," *Eau Claire Daily Telegram*, November 4, 1903, 4.
[18] John G. Gregory, ed., *West Central Wisconsin: A History, 1856-1947*, Vol. 1, *xiv*.

remaining portion of the mill complex, while leasing the powerhouse and dam from Northern States Power.

In 1936, Northern States Power donated 179 acres of land within the flowage area they now owned to the City of Cornell. This became Brunet Island State Park in 1940, and developed and grew as a park and wilderness refuge over time. The Park is now one of the most important elements of Cornell's recreational and tourism industry.[19] The Cornell Wood Products Company remained the major manufacturing enterprise and employer in Cornell, changing its corporate structure twice, the last time becoming a part of the multi-national St. Regis Paper Company. In 1972, St. Regis ceased its milling operations in Cornell. The mill-yard and pulpwood stacker were decommissioned, and Northern States Power implemented a major retrofit of the hydroelectric portion of the property, including an almost total reconstruction of the powerhouse.

The closing of the mill posed a potential disaster for the Cornell community. However, while the closing disrupted some families and had some immediate negative economic effects on the city, within five years Cornell had created an industrial park housing five light manufacturing firms. By 1977, Flintkote Company, a roofing material manufacturer, had taken over the mill complex and the city recovered a portion of the 300 jobs that were lost when the mill closed.[20] Since that time, Cornell's mill property has been owned by a series of manufacturing entities, which have all continued to provide jobs to the community. The city embarked on a successful campaign to save the former pulpwood stacker and list it in the National Register of Historic Places, and in the 1980s and 1990s, began to construct a park and community center around the iconic structure. Today, the pulpwood stacker serves as the symbol of the City of Cornell.

Cornell Wood Products Company History

Previously owned by Cornell University in Ithaca, New York, the land surrounding the future city of Cornell in Chippewa County was slowly acquired by the Cornell Land and Power Company of Eau Claire beginning in 1902. The Brunet Falls Manufacturing Company was organized in May of 1911, sharing several of the same board members as the Cornell Land and Power Company. Shortly after, the Cornell Land and Power Company conveyed all of their project lands and flowage rights to Brunet Falls Manufacturing, and Brunet Falls began contracting for design, engineering, and construction services for the building of a dam and paper mill. The O'Keefe-Orbison Engineering and Construction Company conducted the initial surveying and engineering work, with the H.M. Byllesby Company acting as consulting engineers. L.I. Fletcher of Chippewa Falls directed the concrete and construction work.[21]

The finished dam, paper mill, and mill yard represented the most modern and innovative pulp and paper mill in Wisconsin when it was finished in 1913. Most notably, the mill yard contained the largest pulpwood stacker in existence, which represented the industry's shifting reliance on rail versus waterway transportation, and illustrates the continuous pattern of technological

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[19] Fred Steffen, "Wood Products, Brunet Island State Park Vital to Cornell Life," *Eau Claire Leader-Telegram,* Friday, July 22, 1966, 8-10.
[20] "Cornell Rebounds from Mill Closing," *Eau Claire Leader-Telegram*, September 30, 1977, 1D.
[21] "The New Plant of the Brunet Falls Mfg. Co.," 130.

invention and innovation that characterized the paper industry.[22] Railcars loaded with pulpwood arrived near the western edge of the mill yard, unloading their logs into a curved concrete log pond, 400 ft. long, 20 feet wide, and 5.5 feet deep. At the southern end of the log pond, the logs were picked up on conveyors and carried into the slasher building, which cut the logs into 4-foot lengths. From the slasher building, the 4-foot bolts were conveyed up through the parallel trusses of the stacker. Several places along the stacker conveyor belt could be opened to deposit the wood bolts at various points along the stacker's 250-foot length. The lower openings were used first, and as the wood pile grew in height below, the higher openings were used so that the pile could continue to increase.

Underneath the wood yard were a series of rounded concrete water conveyor troughs that cut into equal areas of the ground beneath the wood pile. Covered with heavy planks, the troughs could be uncovered and the bolts fed into the troughs, which conveyed the bolts southwest to the mill buildings for processing and pulping (See Figure 5).

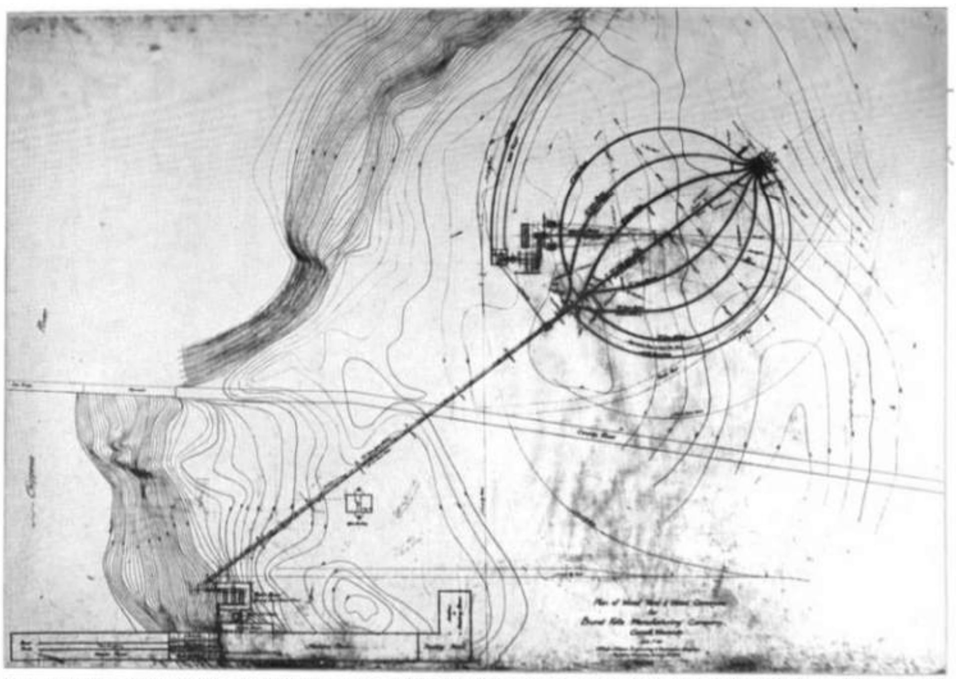

Figure 5: Plan of the Brunet Falls Manufacturing Facility, 1913, with dam and mill buildings at lower left, and mill yard and stacker at upper right ("The New Plant of the Brunet Falls Mfg. Co.," 128).

[22] National Register of Historic Places, Cornell Pulpwood Stacker, 8—2.

Following financial hardship during the construction of the mill and dam, the Brunet Falls Manufacturing Company sold the property and water rights to the newly-formed Cornell Wood Products Company in 1914. Pulp produced at the mill was used to make Cornell Wood Board, a water-resistant paneling product for building interiors.

Figure 6: Advertisement, 1916 (*The Waukesha Freeman*, August 31, 1916, 6).

In 1929, Cornell Wood Products Company conveyed ownership of the flowage lands and associated land rights, along with the dam and powerhouse, to Northern States Power Company. Cornell Wood Products retained ownership of the remainder of the mill property and operations, and continued to operate the hydro development under a lease agreement with Northern States Power. The powerhouse and dam generated 2.2 MW of electricity used exclusively by the mill. In 1953, The Cornell Wood Products Company became the Cornell Paperboard Products Company, headquartered in Milwaukee. A merger between the Cornell Paperboard Products Company and the St. Regis Paper Company of New York, a multi-national corporation that owned another Wisconsin paper mill in Rhinelander, occurred in 1960.

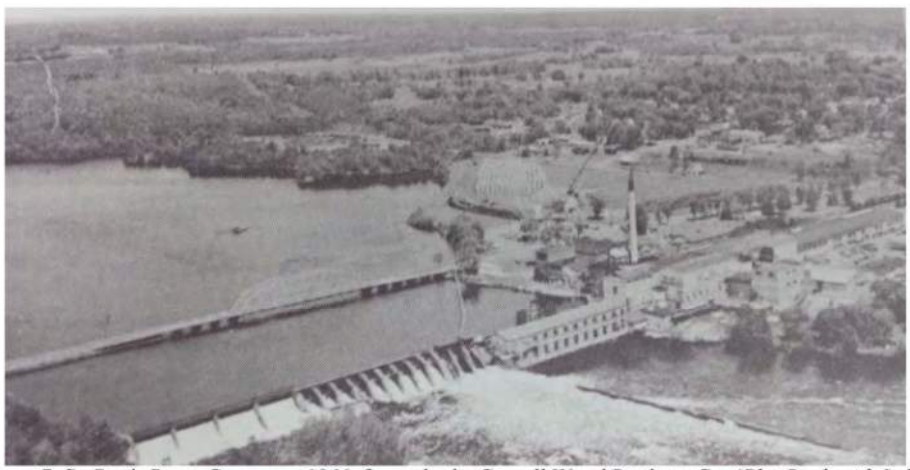

Figure 7. St. Regis Paper Company, 1966, formerly the Cornell Wood Products Co. (*Plat Book with Index to Owners, Chippewa County, Wisconsin*, Rockford IL: Rockford Map Publishers, 1966.)

In 1971, St. Regis gave notice that it would cease operations at the Cornell mill the following year. Northern States Power, now the sole operator of the dam and powerhouse which formerly had only powered the adjacent mill, began a reconstruction project to increase hydroelectric generation for distribution through their power grid. Completed in 1977, the project included the almost complete reconstruction of the powerhouse. Later owners and manufacturers of the mill property included Flintkote Company and Globe Industries. In 2002, ABC Supply Company, a wholesale distributor of roofing and siding materials, bought the mill property. Their subsidiary, Mule-Hide Dry Felt Manufacturing, currently leases and operates the mill.[23]

The wood yard and stacker were decommissioned when St. Regis ceased operations in 1972. Globe Industries Inc. donated the mill yard park to the City of Cornell in 1983, which has worked to preserve the pulpwood stacker as a symbol of the pulping and paper industry in Wisconsin.

[23] "New Life for Globe," *Madison Wisconsin State Journal*, February 26, 2002, 10.

Comparable pulp and paper mills in the Chippewa River Valley and northern Wisconsin that have been previously-surveyed in the Wisconsin Historic Preservation Database (WHPD) include: the Eau Claire Pulp and Paper Mill (AHI 41233) on the Chippewa River, and the Rhinelander Paper Company Mill and Hydroelectric Facility (AHI 21336) on the Wisconsin River. Both properties contain most of their original mill buildings and have experienced multiple additions and alterations to their original forms. Both also have adjacent hydroelectric dams, which at one time provided hydromechanical power for the pulping and grinding machines within the facilities. The integrity of the Cornell Wood Products Company Historic District is roughly equal with the Eau Claire and Rhinelander facilities; like them, the Cornell facility has retained most of its original buildings while allowing for the various alterations and additions required in a continuously-functioning industrial property.

While Eau Claire retains a portion of its historic wood yard for milling operations, the Rhinelander mill appears to have historically stored its raw wood materials in log booms on the Wisconsin River, which are no longer extant. The Cornell Wood Products Co. Historic District differs from both the Eau Claire and Rhinelander properties in that the historic mill yard—though no longer belonging to the current mill owners—has nonetheless been preserved as a city park, with the pulpwood stacker and remnants of the yard's former structures denoting the park's historic function. While the Cornell Pulpwood Stacker has already been listed in the National Register as a stand-alone structure, its inclusion in this historic district provides greater context for its own historical significance within the history of pulp and paper milling in Wisconsin, and further enhances the historical integrity and significance of the entire Cornell Wood Products Company.

Narrative Statement of Significance (Provide at least **one** paragraph for each area of significance.)

Under *Criterion A: History*, the Cornell Wood Products Company Historic District represents shifting trends in pulp and paper manufacturing, from traditional paper-making materials to a new reliance on wood pulp. Wood pulp mills also answered an economic need in the region after the decline of the log and lumber milling industry, as much of the timber left behind was suitable for pulping. The Cornell Wood Products Company functioned as the primary economic driver in the City of Cornell for most of the twentieth century, and remains one of the most highly-intact examples of a pulp and paper mill in northern Wisconsin. The collection of related resources within the district provide an excellent illustration of all elements of pulp and paper production, including transportation and storage of raw materials, milling operations, and power generation. As such, the Cornell Wood Products Company Historic District is recommended as eligible for listing in the National Register under *Criterion A: History*.

2. Major Bibliographical References

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--"Logging and Lumber Milling." Volume 2, Section 5.

--"Pulp and Paper Production." Volume 2, Section 6.

Previous documentation on file (NPS):

____ preliminary determination of individual listing (36 CFR 67) has been requested
__x_ previously listed in the National Register
____previously determined eligible by the National Register
____designated a National Historic Landmark
____ recorded by Historic American Buildings Survey #__________
____recorded by Historic American Engineering Record # __________
____ recorded by Historic American Landscape Survey # __________

Primary location of additional data:

__x_ State Historic Preservation Office
____ Other State agency
____ Federal agency
____ Local government
__x_ University
__x_ Other
Name of repository: ___Xcel Energy, Inc.______________________________

Historic Resources Survey Number (if assigned): _AHI 31496__________

3. Geographical Data

Acreage of Property approx. 48 acres

Use either the UTM system or latitude/longitude coordinates

Latitude/Longitude Coordinates (decimal degrees)
Datum if other than WGS84:__________
(enter coordinates to 6 decimal places)

1. Latitude: Longitude:
2. Latitude: Longitude:
3. Latitude: Longitude:
4. Latitude: Longitude:

Or
UTM References
Datum (indicated on USGS map):

☐ NAD 1927 or ☒ NAD 1983

1. Zone: 15N	Easting: 645109	Northing: 5003322
2. Zone: 15N	Easting: 645209	Northing: 5002874
3. Zone: 15N	Easting: 645173	Northing: 5002726
4. Zone: 15N	Easting : 644686	Northing: 5002698
5. Zone: 15N	Easting : 644568	Northing: 5002870
6. Zone: 15N	Easting : 645053	Northing: 5003320

Verbal Boundary Description (Describe the boundaries of the property.)

Beginning at the northwest corner of the intersection of Bridge Street and Park Road (the southeast corner of Mill Yard Park), the historic boundary travels across Bridge Street and south for approximately 280 feet along the eastern edge of the hydroelectric substation, before turning west to follow the southern edge of the hydroelectric substation to the eastern edge of the access road, a distance of approximately 120 feet. From there, the boundary turns south, following the eastern edge of the access road for approximately 510 feet before continuing west along the southern edge of the access road for a distance of approximately 1630 feet, crossing over the Chippewa River approximately 360 feet south of the dam. At the western edge of the Chippewa River, the boundary travels northwest to the western edge of the dam embankment wall, continuing north from there along the shoreline to the buoy line upstream from the dam, a distance of approximately 700 feet. The boundary follows the buoy line east back across the river for approximately 850 feet, then travels north and northeast along the shoreline for approximately 1670 feet. The boundary then travels approximately 180 feet east to the northwestern edge of the Thomas Road and Park Road intersection (the northeastern corner of Mill Yard Park, then turns south, traveling approximately 1150 feet along the western edge of Park Road to the point of beginning.

Boundary Justification (Explain why the boundaries were selected.)

The boundaries of the Cornell Wood Products Company Historic District include those areas historically and functionally associated with milling operations at the site. The boundary crosses over a portion of Bridge Street between the historic mill yard and the mill complex. The road has historically bisected this property; logs were transported between the mill yard and mill building via an underground conveyor trough. The bridge carrying Bridge Street across the Chippewa River was not included in the district due to its construction outside the period of significance (1977), as a replacement for an earlier bridge. Moreover, the mill property historically depended on rail transportation as its dominant method of shipping its product and not over-the-road transportation.

The eastern boundary is visually defined by the western edge of the Park Road pavement as well as the eastern edge of the gravel hydroelectric access road south of Bridge Street. The southern boundary continues along the southern edge of the hydroelectric access road and across the Chippewa River. The western boundary is drawn to encompass the edge of the dam embankment wall on the western shoreline, while the boundary line back across the river coincides with the buoy line north of the dam and powerhouse. The remainder of the western boundary is visually defined by the eastern shoreline of the Chippewa River, while the last part of the northern boundary line runs parallel Thomas Street, located on the other side of Park Road.

4. Form Prepared By

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city or town: Milwaukee state: WI zip code: 53211
e-mail kjblaub@uwm.edu
telephone: 414-229-3078
date: 11/11/19

Additional Documentation

Submit the following items with the completed form:

- **Maps:** A **USGS map** or equivalent (7.5 or 15 minute series) indicating the property's location. – *see attached*
- **Sketch map** for historic districts and properties having large acreage or numerous resources. Key all photographs to this map. – *see attached*
- **Additional items:** (Check with the SHPO, TPO, or FPO for any additional items.)

Photographs and Photo Log

Submit clear and descriptive photographs. The size of each image must be 1600x1200 pixels (minimum), 3000x2000 preferred, at 300 ppi (pixels per inch) or larger. Key all photographs to the sketch map. Each photograph must be numbered and that number must correspond to the photograph number on the photo log. For simplicity, the name of the photographer, photo date, etc. may be listed once on the photograph log and doesn't need to be labeled on every photograph. – *see attached*

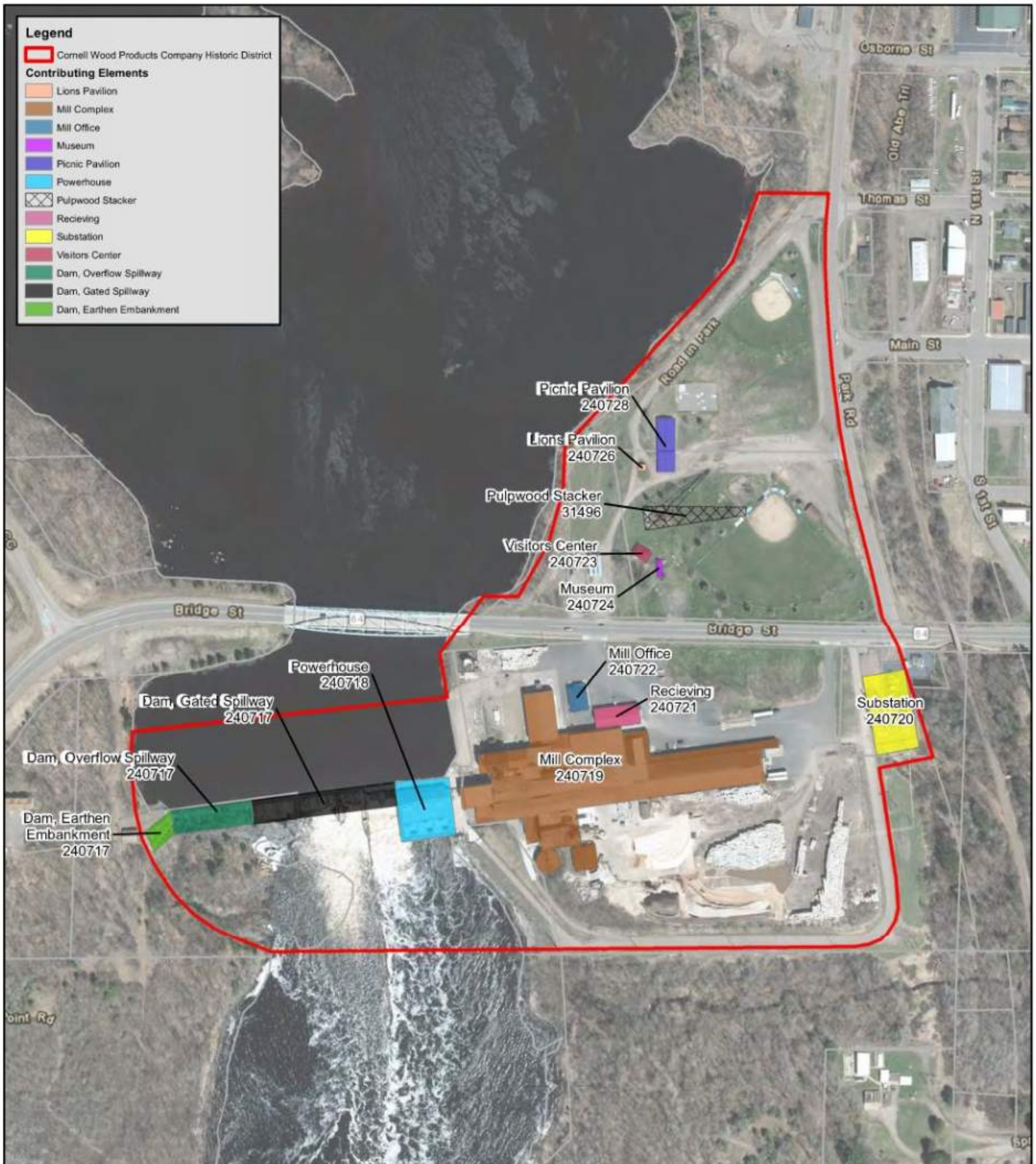
Map Details: UWM-CRM 2019-465
Coordinate System: NAD 1983 HARN Transverse Mercator
Projection: Transverse Mercator
Datum: North American 1983 HARN
Created by: UWM-CRM 11/4/2019

UTM Map
Cornell Wood Products Company
City of Cornell, Chippewa County, Wisconsin
T31N R6W Section 18

0 500 1,000 2,000 Feet

0 250 500 Meters

1:10,000



Map Details: UWM-CRM 2019-465
Coordinate System: NAD 1983 HARN Transverse Mercator
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Historic Boundary with Contributing Elements
Cornell Wood Products Company
City of Cornell, Chippewa County, Wisconsin
T31N R6W Section 18

0 250 500 1,000 Feet

0 60 120 240 Meters

1:4,000

Cornell Wood Products Co.
Sketch Map
Contributing
Non-contributing
Historic Boundary
Picture # and direction
Thomas Street
N 1st St
Park Rd
S 1st St
180'
1670'
1150'
Lions pavilion 240726
Picnic pavilion 240728
Log Pond remnants
Pulpwood Stacker 31496
Visitor's center 240723
Museum 240724
Conveyor Trough
Bridge Street
Mill office 240722
Buoy Line
850'
Receiving, 240721
160'
Mill Complex, 240719
Dam, 240717
Powerhouse 240718
Substation 240720
200'
360'
510'
280'
1630'
© 2018 Google
Access Road

Photo Log

Cornell Wood Products Co. Historic District
City of Cornell
Chippewa County, WI

Photographs by Kelly J. Blaubach, UWM-CRM
Photos taken 10/2/19
Images on file at UWM-CRM

Description of Photograph(s) and number, include description of view indicating direction of camera:

Photo 1 of 26
Cornell Wood Products Co. Historic District
Powerhouse, from access road
AHI 240718a, looking northwest

Photo 2 of 26
Cornell Wood Products Co. Historic District
Powerhouse interior, generating room
AHI 240718b, looking west

Photo 3 of 26
Cornell Wood Products Co. Historic District
Powerhouse, deck above generating room and tailrace
AHI 240718c, looking south

Photo 4 of 26
Cornell Wood Products Co. Historic District
Dam, gated spillway
AHI 240717a, looking west

Photo 5 of 26
Cornell Wood Products Co. Historic District
Top of dam
AHI 240717b, looking west

Photo 6 of 26
Cornell Wood Products Co. Historic District
Dam, overflow spillway and gated spillway, with mill buildings and pulpwood stacker in backgound
AHI 240717c, looking northeast

Photo 7 of 26
Cornell Wood Products Co. Historic District
Atop dam, towards tailrace and access road
AHI 240717d, looking south

Photo 8 of 26
Cornell Wood Products Co. Historic District
Hydroelectric Power Substation
AHI 240720, looking north

Photo 9 of 26
Cornell Wood Products Co. Historic District
Mill complex from west river bank
AHI 240719a, looking east

Photo 10 of 26
Cornell Wood Products Co. Historic District
From top of dam, looking towards mill complex
AHI 240719b, looking east

Photo 11 of 26
Cornell Wood Products Co. Historic District
Southwest elevation, mill complex
AHI 240719c, looking north

Photo 12 of 26
Cornell Wood Products Co. Historic District
Eastern elevation, mill complex
AHI 240719d, looking west

Photo 13 of 26
Cornell Wood Products Co. Historic District
Northern elevation, mill complex
AHI 240719e, looking southwest

Photo 14 of 26
Cornell Wood Products Co. Historic District
Northern elevation, mill complex
AHI 240719f, looking southwest

Photo 15 of 26
Cornell Wood Products Co. Historic District
Office building, mill complex
AHI 240722, looking southwest

Photo 16 of 26
Cornell Wood Products Co. Historic District
Receiving building, mill complex
AHI 240721, looking southwest

Photo 17 of 26
Cornell Wood Products Co. Historic District
Mill complex, from Mill Yard Park
AHI 240719g, looking southwest

Photo 18 of 26
Cornell Wood Products Co. Historic District
Pulpwood Stacker, Mill Yard Park
AHI 31496a, looking northeast

Photo 19 of 26
Cornell Wood Products Co. Historic District
Pulpwood Stacker, Mill Yard Park
AHI 31496b, looking north

Photo 20 of 26
Cornell Wood Products Co. Historic District
Wood Yard office, Mill Yard Park
AHI 240724, looking north

Photo 21 of 26
Cornell Wood Products Co. Historic District
Visitor's Center, Mill Yard Park
AHI 240723, looking northeast

Photo 22 of 26
Cornell Wood Products Co. Historic District
Picnic Pavilion, Mill Yard Park
AHI 240728, looking northwest

Photo 23 of 26
Cornell Wood Products Co. Historic District
Lion's Club Pavilion Mill Yard Park
AHI 240726, looking north

Photo 24 of 26
Cornell Wood Products Co. Historic District
Mill Yard Park, remnants of log pond, looking N

Photo 25 of 26
Cornell Wood Products Co. Historic District
Mill Yard Park, conveyor troughs, looking northeast

Photo 26 of 26
Cornell Wood Products Co. Historic District
Mill Yard Park, conveyor troughs, looking southwest towards mill complex

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11

Photo 12

Photo 13

Photo 14

Photo 15

Photo 16