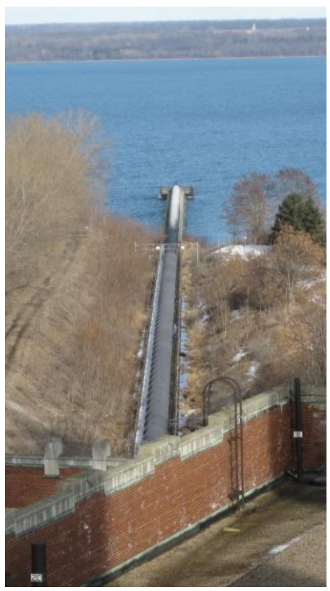
GREENIDGE GENERATING FACILITY
TECHNOLOGY INSTALLATION & OPERATION PLAN



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EXECUTIVE SUMMARY

Best Technology Available (BTA) for the Greenidge Generating Facitlity (GGF or Facility) Unit 4 was determined by New York Department of Environmental Conservation (NYSDEC) to be variable speed pumping (VSP) and cylindrical wedgewire screens (CWWS) with slot widths between 0.5 and 1.0 mm. The October 1, 2017 SPDES permit NY0001325 required the Facility to complete a wedgewire screen performance pilot study, and within three months of the pilot study approval, to submit a Technology Installation and Operation Plan (the TIOP). Finally, the permit requires the Facility to install and operate BTA by September 30, 2022.

Unit 4 (107 MW_g capacity), was initially commissioned in 1953, with an intake structure located 650 ft offshore in Seneca Lake where water depth is approximately 11 feet. The intake structure consists of I-beam piles supporting sheet pile sides with six rectangular openings covered by bar racks. Water is conveyed to Unit 4 through a 7-foot diameter steel conduit that is supported above the lake surface on a wooden pier structure. The pumphouse is 1,900 feet from the intake end of the conduit, where three horizontal, single stage, double suction centrifugal pumps provide 41,000, 60,800, or 68,000 gallon/minute, depending on whether, one, two, or three pumps are operated.

GGF has selected 0.5 mm slot width stainless steel screens to satisfy BTA requirements. In the pilot study, this slot width was demonstrated to reduce entrainment by 77% from baseline levels. The screens will be horizontally mounted on three sides (two screens per side) of the intake structure. Screen dimensions will be approximately 126 inches long and 83 inches diameter. With 22% open area for the chosen slot width, the through screen velocity will be 0.5 feet/second (feet/second) at maximum flow, and 0.45 feet/second or less under typical flows. The screens will be designed to rotate against fixed internal and external brushes to prevent fouling by zebra mussels and vegetation. The installation schedule for the new wedgewire screens will depend on when the Facility obtains any needeed permits for construcion, but the approved system must be operating by September 30, 2022, the expiration date of the Facilty's current SPDES permit.

The other BTA component, variable speed pumping (VSP) capability, was previously installed on two of the pumps in 2019. Since the third pump would only be used when full flow is required, VSP capability is not necessary on all three pumps. A testing program on the Facility's ability to operate at reduced flows has been ongoing since 2019. Further additional testing will be undertaken once the wedgewire screens are installed.

Because the VSP performance is still being evaluated, the expected combined entrainment reduction to be achieved by VSP plus CWWS cannot be precisely predicted yet. However, with 77% entrainment reduction provided by CWWS, the additional reductions to be provided by VSP, combined with operational scheduling adjustments if needed, the Facility will achieve compliance wth the 85% entrainment limit.

Determining compliance with the 85% entrainment reduction limit will be accomplished using commonly applied calculation methods incorporating baseline (maximum) and actual cooling water flows, measured entrainment densities, and demonstrated wedgewire screen efficacy values. Compliance with the 95% impingement reduction is assured by limiting the through-screen velocity to 0.5 feet/second or less.

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1. INTRODUCTION

Section 316(b) of the Clean Water Act (CWA) requires that the location, design, construction and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact.[1] These requirements are implemented by the Environmental Protection Agency (EPA) through National Pollutant Discharge Elimination System permits issued under CWA § 402, and delegated in New York to the State Department of Environmental Conservation (NYSDEC or the Department). The State of New York similarly requires that cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.[2]

The process for reaching BTA decisions, and the standards for BTA in New York, are described in Commissioner's Policy 52[3], which was adopted in 2011. For existing facilities, entrainment and impingement mortality is to be reduced in an amount equivalent (90%) of that which would be achievable with a closed-cycle cooling system.

The Greenidge Generating Facility LLC (GGF or Facility) SPDES permit NY0001325 was renewed on October 1, 2017, and included several Biological Monitoring Requirements, including the following:

1.1 BEST TECHNOLOGY AVAILABLE (REQUIREMENT 1)

NYSDEC determined that the best technology available (BTA) for the Facility cooling water intake structure is the use of cylindrical wedge-wire intake screens (slot size of 0.5 mm to 1.0 mm) and variable speed drive pumps (VSPs) at Unit 4. A pilot study will be necessary to confirm that the facility can operate reliably with wedgewire screens in this slot range

1.2 VARIABLE SPEED DRIVES ON COOLING WATER PUMPS (REQUIREMENTS 2 AND 3)

Within 6 months of the effective date of the permit, the facility was required to submit a schedule for installing and operating variable speed drives on the cooling water pumps, and to complete installation within 2 years. The drive units were installed during the summer of 2019.

1.3 CYLINDRICAL WEDGEWIRE SCREEN PILOT STUDY (REQUIREMENT 4)

A Cylindrical Wedge-Wire Screen (CWWS) Pilot Study Plan was required to be submitted within six months of the permit effective date, and a final approvable report was required at completion of the study. The NYSDEC-approved study[4] was performed during 2019, and the final report was submitted to NYSDEC on April 30, 2020. NYSDEC approved the final report on August 7, 2020.[5]

1.4 TECHNOLOGY INSTALLATION AND OPERATION PLAN (REQUIREMENT 5)

Within three months of Department approval of the CWWS Study Report, the Facility must submit an approvable Technology Installation and Operation Plan (TIOP) to meet the best technology available requirements. This plan must include:

Full description (including drawings) and schedule for testing, installing and operating wedgewire intake screens selected to meet requirements of 6 NYCRR Part 704.5 and Section 316(b) CWA;

The methodlology for assessing the efficacy of these technologies and operational measures;

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1 33 U.S.C. § 1326(b)
2 6 NYCRR §704.5
3 CP-#52 / Best Technology Available (BTA) for Cooling Water Intake Structures, July 10, 2011.
4 Letter from Colleen Kimble to Ken Scott, April 18, 2018
5 Letter from Colleen Kimble to Dale Irwin, August 7, 2020.

If the Department concurs that wedgewire screens with a slot size of 0.5 mm ≤1.0 mm are not feasible at this facility, then within five months of such notification, the TIOP shall be revised to include a Contingency Plan (see Biological Monitoring Requirement No. 13); and

Complete installation of CWWS by the Effective Date of the Permit (EDP) plus five years.

Upon approval of the TIOP, the Facility must implement the TIOP in accordance with the approved schedule. Upon approval by NYSDEC, the TIOP and approved schedule become enforceable conditions of the SPDES permit.

1.5 PERFORMANCE (REQUIREMENTS 8 AND 9)

The Facility SPDES permit contains two performance requirements which the Facility must meet:

Requirement 8. The Facility must reduce entrainment of all life stages of fish by at least 85 percent upon complete installation and implementation of the BTA and completion of the Verification Monitoring Program.

Requirement 9. The Facility must annually reduce the impingement mortality of all life stages of fish by at least 95 percent upon compleion of installation of BTA.

1.6 OBJECTIVE

This TIOP is submitted to fulfill Biological Monitoring Requirement 5 of the SPDES permit. The TIOP incorporates the entrainment data collected during the concurrent CWWS Pilot Study and first year of entrainment Verification Monitoring in 2019, as previously approved by the Department as part of the Pilot Study. In addition, because the BTA determined for the Facility consists of both wedgewire screens and variable speed pumps, both technologies, and how they will be used together to minimize entrainment, are addressed in this plan.

2. GREENIDGE GENERATING FACILITY

2.1 FACILITY DESCRIPTION

The Facility is situated outside the village of Dresden in Yates County, New York (Figure 2-1), adjacent to the shore of Seneca Lake to the east and to the Keuka Lake Outlet to the north. GGF previously had four generating units that came online between 1938 and 1953, with a combined generating capacity of 215 MW. The cooling systems for all four units withdrew water from Seneca Lake at a maximum combined rate of 131,500 gallon/minute. The facility currently consists of only one generating unit (Unit 4) with a generating capacity of 107 MW and maximum cooling water withdrawal of 68,000 gallon/minute.

The cooling water flow for Unit 4 is obtained from Seneca Lake through a 7-foot diameter intake pipe elevated on wood pilings that extends from the pumphouse to a point 650 feet offshore (Figure 2-2). At the end of the pipe, the lake is approximately 11 ft deep. The intake pipe opens facing downward and is surrounded by a 27-foot by 27-foot steel structure composed sheet piles supported by I-beam pilings. The structure has openings on the north, east, and south sides which are covered by bar racks of 3/16- inch bars, 6 inches on center (Figure 2-3Figure 2-3). The Unit 4 intake relies on suction to convey water from the lake, through the elevated intake pipe, and on to the circulating water pumps.

Unit 4 has three cooling water pumps with a combined capacity of 68,000 gallon/minute (Figure 2-4). Two pumps are used throughout most of the year and the third pump is operated only as needed during peak summer lake temperatures or used as back-up for the rest of the year. As required by the 2017 SPDES permit, variable-speed drive (VSD) units were installed on two of the three pumps in the summer of 2019.

The Unit 4 condenser, manufactured by the Westinghouse Electric Corporation, has 50,000 square feet of cooling surface made up of 9098 ¾ inch O.D. No. 18 BWG Admiralty metal tubes. The tubes have an effective length of 28 feet. The condenser has parallel upper and lower chambers that can be operated independently. Each tube bank is approximately circular in cross section, with the tubes arranged in radial lines, and is entirely surrounded by a zone of exhaust steam. The air off-take is located at the center of the condenser so that steam will flow radially inward from the exhaust steam zone to the central core which is connected to the air ejector. The circulating water inlet manifold is fitted with two motor operated backwash valves.

After passing through the Unit 4 condenser, cooling water passes into the discharge canal, which is approximately 900 feet long and empties into the Keuka Lake Outlet (KLO), a class C(T) designated water, about 700 ft upstream from Seneca Lake (Figure 2-1). Within a radius of one mile of the mouth of KLO, Seneca Lake is designated class B(T), and most of the lake more distant from the outlet is class AA(TS) (Figure 2-5).

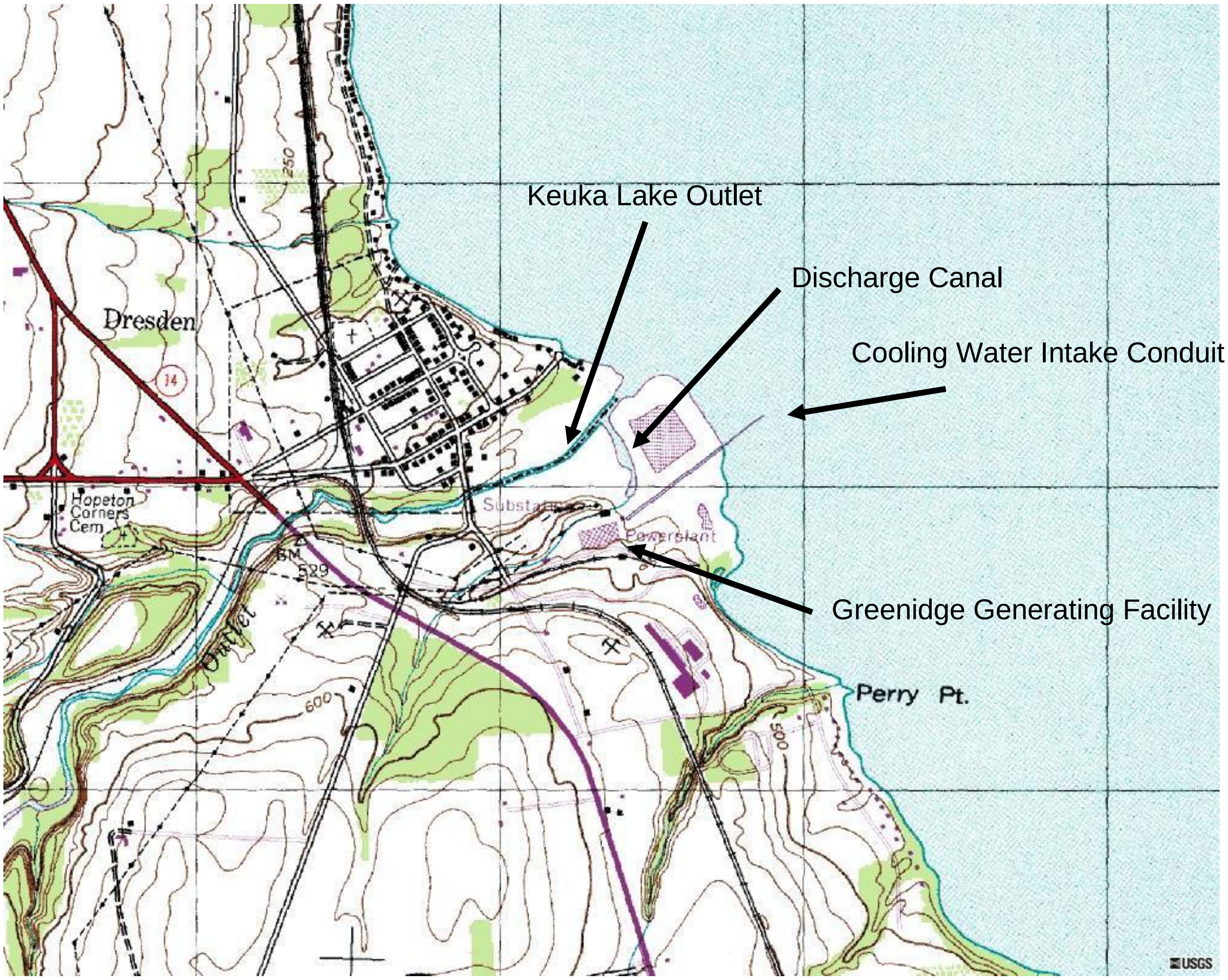

Figure 2-1 Topographic map of area surrounding Greenidge Generating Facility (USGS Dresden 7.5-minute quadrangle, 1978)

Figure 2-2 Unit 4 withdraws water from an elevated 7-ft diameter conduit that extends 650 ft from the west shore of Seneca Lake, and 1900 ft from the pumphouse.

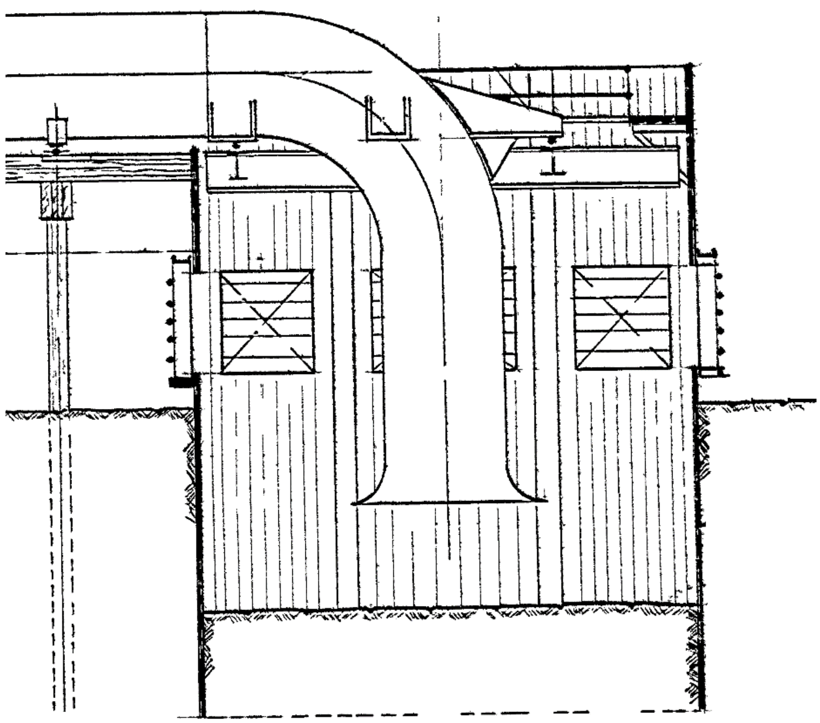

Figure 2-3 Invert of the end of the intake conduit in Seneca Lake. Sides of the structure are sheet piling, with trash-rack covered openings. Bottom of the invert is lower than the lake bottom.

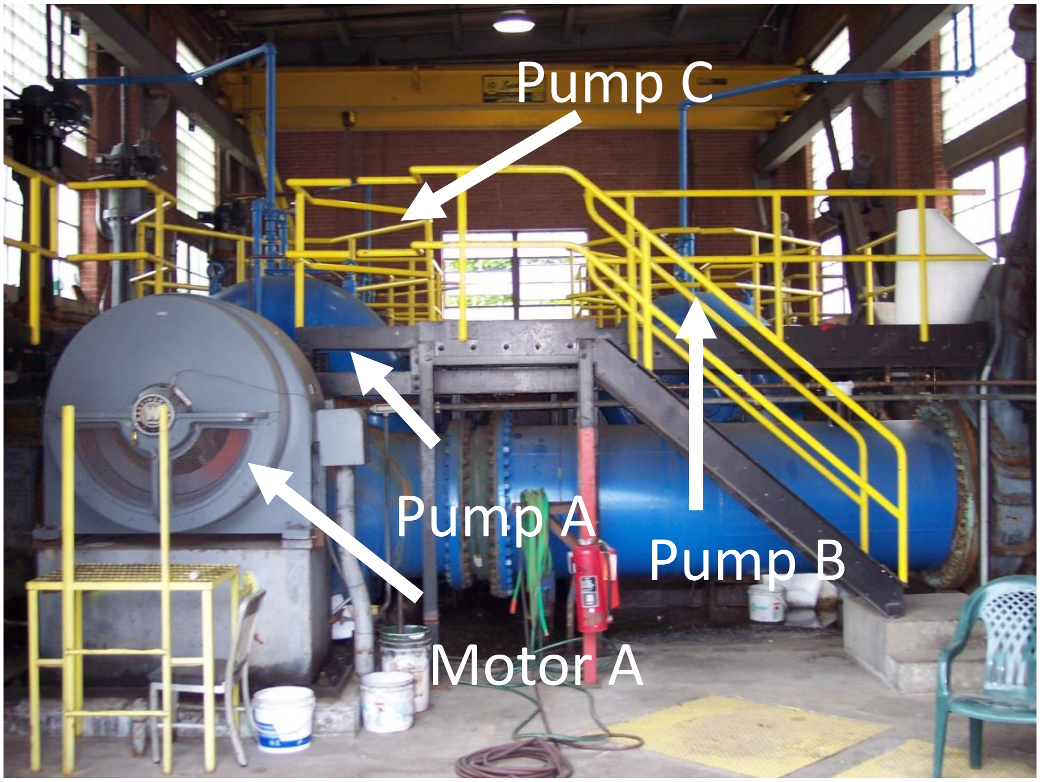

Figure 2-4 Greenidge Unit 4 circulating water pumps A, B, and C, and motor for pump A. Pumps B and C, and associated motors are located behind pump A.

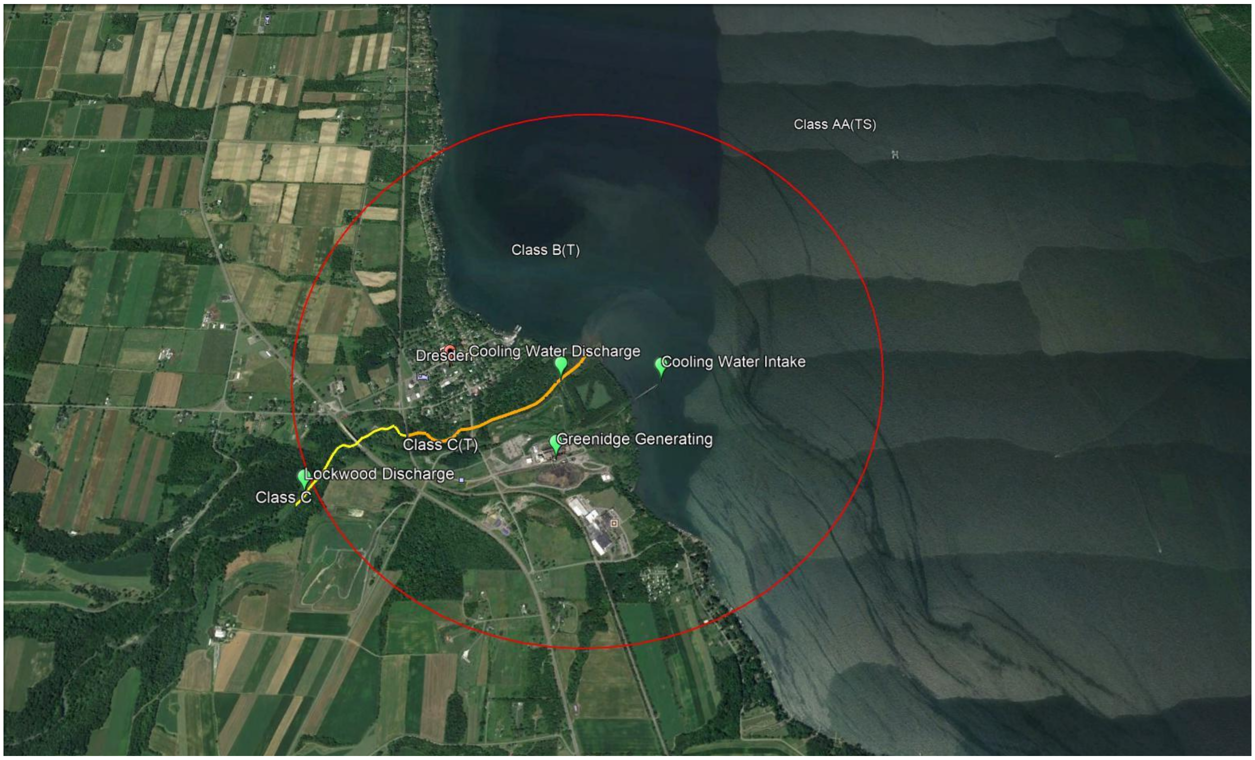

Figure 2-5 Location of Greenidge Generating Facility, its cooling water intake and discharge, and water quality classification of surrounding waters.

3. WEDGEWIRE SCREEN SYSTEM

Wedgewire screens are one component of the designated Best Technology Available (BTA) for the GGF cooling water intake. Wedgewire screens have been demonstrated to reduce impingement to negligible levels (USEPA 2014) and to reduce entrainment through the mechanisms of physical exclusion, avoidance, and depending on the ambient sweeping flow, through hydraulic bypass (NAI and ASA 2011).

3.1 DESIGN BASIS

Wedgewire screens were evaluated in the Greenidge Design and Construction Technology Review (ASA et al. 2010). The conceptual design that appeared most applicable for GGF was to fit two rotating drum screens on movable tracks on the north, east, and south sides of the intake structure at the end of the intake conduit. The screens evaluated at that time had 9-mm slot widths, and would be rotated in place for normal cleaning with fixed brushes, but could be raised above the water surface for more extensive maintenance activities. Each screen would have been five feet in diameter and six feet in length.

GGF's current plan calls for installing wedgwire screens with 0.5-mm slot width. As before, six drum screens would be mounted horizontally on three sides of the intake structure (Figure 3-1). The screens would rotate against fixed internal and external brushes for cleaning (

Figure 3-2), and a water jet would be directed along the outer screen surface to remove large debris from the hydraulic zone of withdrawal. The conceptual design calls for the screens to be removable for periodic maintenance.

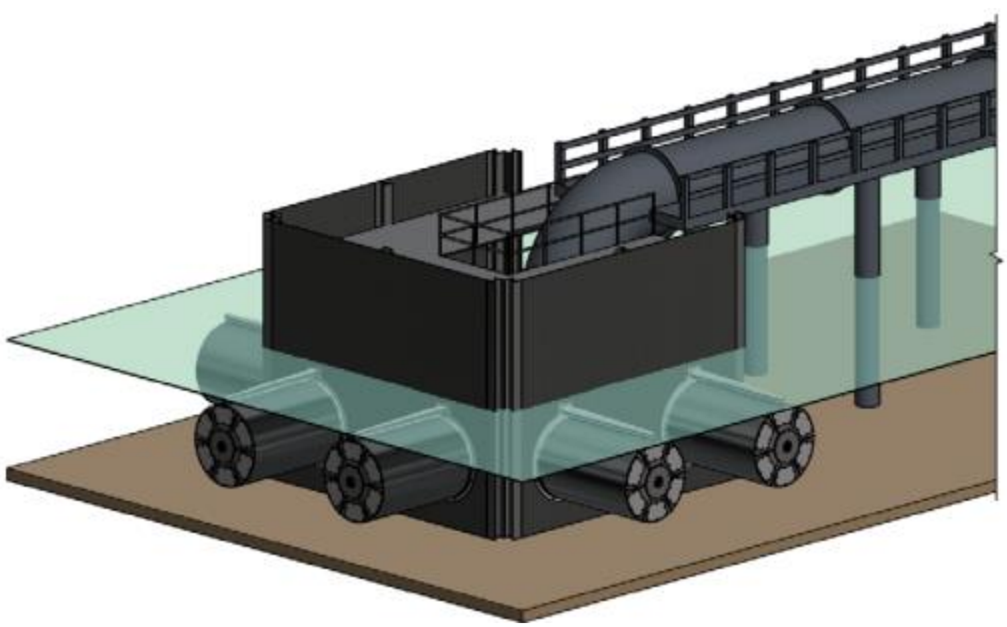

Figure 3-1 Conceptual design of wedgewire screen system at the Greenidge Generating Facility cooling water intake in Seneca Lake.

3.1.1 Water Delivery

The design basis with respect to water delivery for the wedgewire screen system is that it must provide 68,000 gallon/minute to theUnit 4 intake with a through-screen velocity of 0.5 feet/second or less.

Although many combinations of screen specifications (slot width, screen diameter and length, number of screens) could meet the flow and velocity criteria, the chosen screen design (Table 3-1),the design must also take into account potential variation in through-slot velocities over the length of the screen. This potential variation is addressed through a computational fluid dynamics (CFD) analysis of flows inside the screens. Based on this analysis, the openings in the internal flow guides will be sized to equalize the flow across the screen surface (See

Figure 3-3 for an example of CFD model output).

Figure 3-2 Example of horizontally mounted cylindrical wedgewire screen with external cleaning brushes.

Table 3-1 Design parameters for CWWS option that meets maximum through-screen velocity criterion of 0.5 feet/second or less

Design Parameter	Units	Value
Screen Length	in	126
Screen Diameter	in	83
Screen Surface	ft^2	228
% open @ 0.5 mm slot	%	22%

Open Area per Screen	ft^2	50.2
Number of Screens	#	6
Total Open Area	ft^2	301.2
Maximum Flow	gallon/minute ft^3/sec	68,000 151.5
Maximum Through-slot Velocity	feet/second	0.50

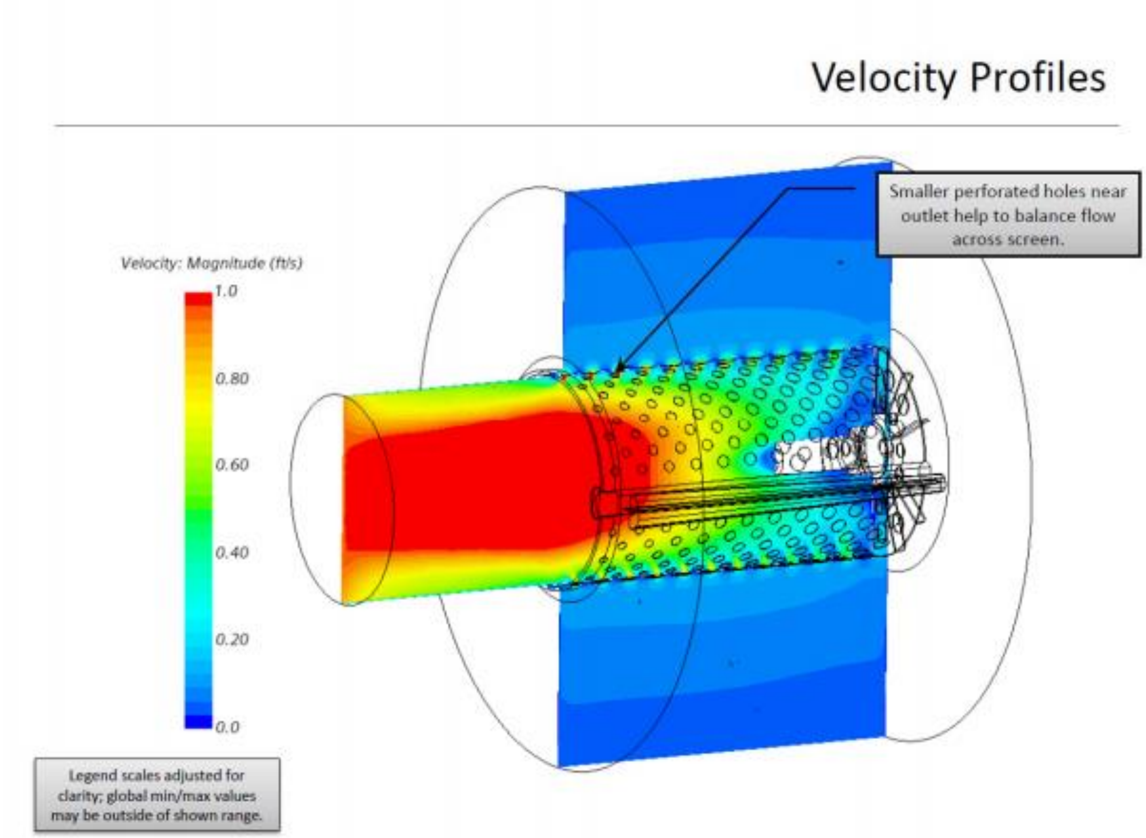

Figure 3-3 Computation fluid dynamic (CFD) analysis of internal flow patterns of wedgewire screens to equalize flow across the screen surface. Source: preliminary screen analysis from ISI.

3.1.2 Air infiltration

It is critical to operational performance that air does not enter the water delivery system between the pipe invert in Seneca Lake and the cooling water pumps. Because the system is under partial vacuum, air may (and sometimes does) leak into the system at the pump seals (See section 4.2). Other sources of air include gas effervescence during flow through the conduit, and potentially through vortices at the invert if water level within the intake structure were to drop below the lake level due to the CWWS impeding flow into the intake structure. An emergency bypass option will be designed into the new intake structure to avoid loss of suction which, if that occurred, would cause immediate Facility shutdown.

3.1.3 Impingement and Entrainment

In conjuction with other design factors, the system must meet entrainment reductions of 85% from the calculation baseline (shoreline intake, surface withdrawal, full flow, no reduction by screening, and 100% mortality) level, and impingment mortality reduction of 95% from baseline. The 2019 CWWS Pilot Study (ASA, 2020) provided estimates of entrainment reduction of CWWS at the water intake location. The 1.0 mm slot width screen reduced entrainment densities by 30%, and the 0.5 mm slot width screens achieved 77% entrainment reduction (Table 3-2).

Table 3-2 Mean empirical density and screen efficacy (% reduction of entrainment) for CWWS Pilot Study conducted at GGF in 2019.

Screen	Density	Estimated Efficacy (%)
No Screen	28.10	0
1.00 mm	19.63	30
0.50 mm	6.56	77

To meet the entrainment reduction requirement of 85%, the CWWS will need to operate in combination with the variable speed pumps, and possibly other operational measures.

The CWWS with design through-screen velocity no more than 0.5 feet/second meets the federal BTA requirements for impingement.[6] At this low through-screen velocity, impingement of live fish will be essentially eliminated and therefore the Facility will meet the SPDES permit requirement for 95% reduction from baseline.[7]

3.2 USE OF EXISTING STRUCTURE

The existing intake structure is a 27 x 27-foot crib of steel I-beams and sheet pile driven into the lake bottom. This structure has been used for Unit 4 since it began operation in 1953. During the CWWS system design, the intake structure will be evaluated to identify any upgrades to be included in the new CWWS system design. Once this evaluation is completed, the detailed design work on the screen modules will proceed.

3.3 LAKE GEOTECHNICAL AND WATER QUALITY

Geotechnical aspects of the installation will be considered once the TIOP has been approved and detailed design work is initiated. Geotechnical issues to be considered include bathymetry in the immediate vicinity of the intake end of the conduit, type and depths of sediments, depth and type of bedrock, and strength and variability of water currents.

3.4 LAKE BOTTOM EXCAVATION

Minor excavation of the lake bottom may be required for the new CWWS system. The impacted area will likely overlap the intake structure's existing 730-square foot footprint. The exact area required for the CWWS system during installation and operation will be determined during the site review and engineering design phase of the project.

[6] 40 CFR § 125.94 (c)(2)

[7] SPDES Permit Biological Requirement 9

3.5 PERMITTING FOR CONSTRUCTION

Depending upon the current state of the intake structure, and upon the final design of the CWWS system, it may be necessary to obtain federal, state, and local permits prior to working on the structure or installing the new screens. If permits are required, applications will be completed once all the required information has been generated.

3.6 SCHEDULE FOR CONSTRUCTION AND INSTALLATION

The Facility's SPDES permit requires that BTA be installed by the end of the permit term, September 30, 2022. The project schedule (Figure 3-4) will have installation completed by the end of the expiration date of the current permit.. The intermediate project milestone dates set forth in Figure 3-4 below should be considered preliminary, subject to revision as part of the project design.

GGF plans to complete the project in three phases. Phase 1, includes preparation and approval of this document, and inspection of the intake structure. Phase 2 is preparation, and if necessary repair or modification, of the existing intake structure to ensure that it can support the wedgewire screens. The construction activity required in this phase will depend on the condition of the I-beams and sheet pile walls supporting the existing structure. Evaluation of the structure integrity is currently underway. If the Facility determines that the structure will need significant repair or upgrades to support the CWWS screen system, those changes will be incorporated into the overall design. Phase 3 is the design, construction, installation, and testing of the wedgewire screens.

3.7 TESTING AND OPERATION OF SCREENS

Once screen installation is completed, testing of the screens at different flow rates will occur. Once Unit 4 is back on line, additional testing under actual operation will occur. The objective of the testing program will be to confirm that the screen system delivers adequate cooling water flow to the condensers without unacceptable head loss, and that debris removal systems are working properly. The operational flow rates with the system in place will be subject to the same operational constraints described in Section 4.

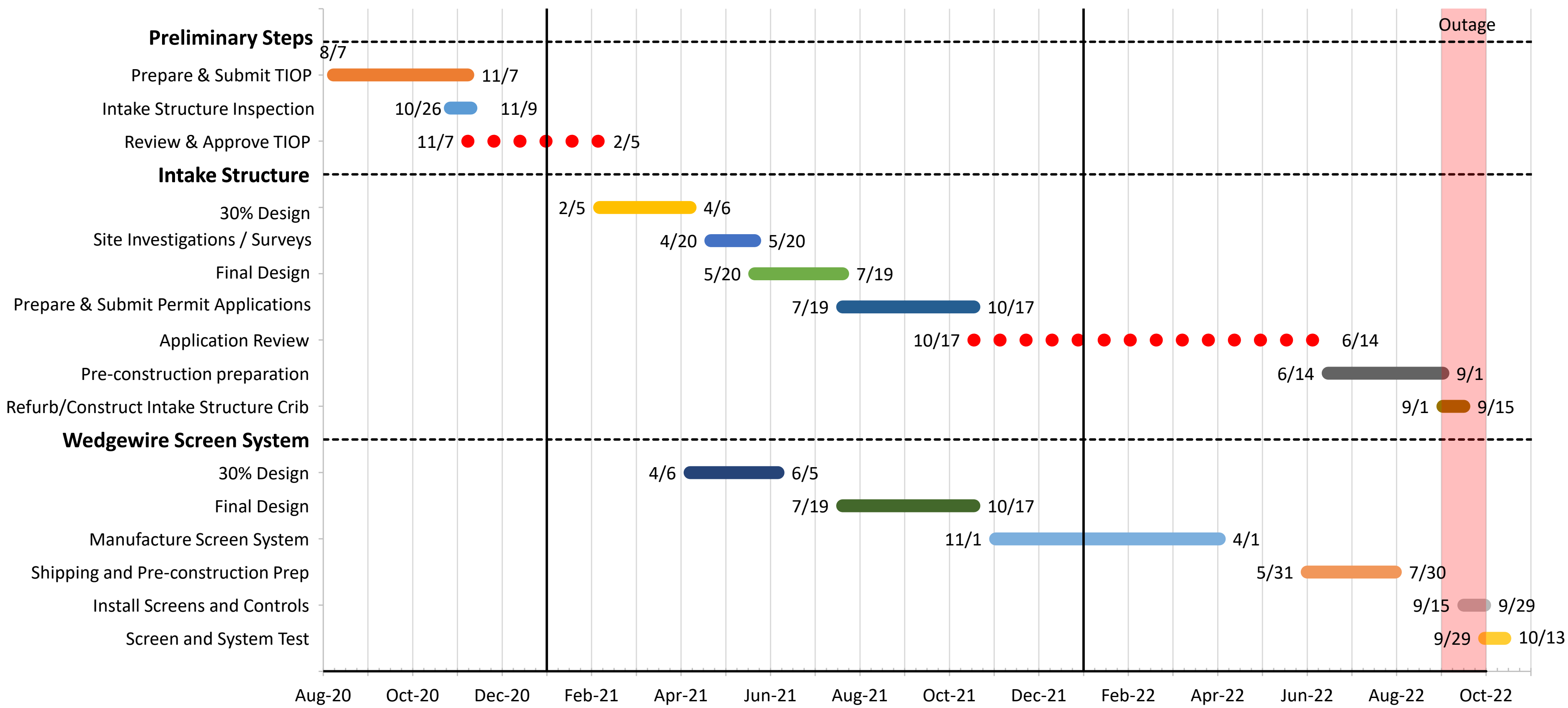

Figure 3-4 CWWS project installation schedule.

4. VARIABLE SPEED PUMPING

Unit 4 has a unique cooling water delivery system. Three horizontal-shaft pumps draw water from an intake structure situated 650 feet offshore of the west side of Seneca Lake. The intake structure is on a shallow shoal area (water depth approximately 12 ft). Water is withdrawn under negative pressure through a 7-foot diameter, 1,900-foot long, pipe held above the surface of Seneca Lake on a wooden support structure (Figure 2-2).

4.1 INTAKE CONDUIT

The GGF intake conduit extends 1,900 feet from the pumphouse to the intake structure in Seneca Lake. The 7-foot diameter of the conduit provides a cross section of 38.5 square feet, and at maximum flow of 68,000 gallon/minute, the average velocity through the conduit would be 3.9 feet/second.

Due to the original system design, the pressure in the conduit is less than atmospheric pressure, i.e. partial vacuum. Any leakages along the conduit, such as at joints, result in air entering the conduit. In addition to potential air leakage, gases dissolved in the water, primarily oxygen and nitrogen, may effervesce within the conduit as a result of the reduced pressure. The gases that accumulate in the conduit must be removed by the vacuum priming system located in the pumphouse.

4.2 COOLING WATER PUMPS

The three Unit 4 circulating water pumps (See Figure 2-4) are horizontal, single stage, double suction centrifugal pumps manufactured by Westinghouse Electric Corporation. The pumps are provided with 42-inch diameter suction connections and 36-inch diameter discharge connections. Each pump was designed to deliver 41,000 gallon/minute at low lake levels. Reported flows are calculated as 41,000 gallon/minute for one pump operation, 60,800 gallon/minute for two pump operation, and 68,000 gallon/minute for three pump operation. Only two of the three pumps are operated simultaneously, except during high Seneca Lake temperatures in the summer months.

The pumps are fitted with stuffing box-type seals and are reported to have always been a point of air entering the cooling system. As a result of the negative pressure in the intake conduit, leakage at the shaft seals results in air entering the system instead of water leaking out as would be the case in a typical pump installation. The plant has installed a water supply line to flood each seal in an effort to reduce the amount of air drawn into the leaking seals. Air infiltration presents the most problem during priming and startup of the pumps. Historically, once the pumps are running at capacity, the system can function despite air entering through the shaft seals.

At typical operational flows, the continuous air influx is flushed out by the water flow; however, there is a limit to the amount of air that can be tolerated before the pumps becomes air-bound. The air that is flushed to the condensers can also be a problem when it accumulates at the top of the water box and prevents water from entering the upper condenser tubes.

4.3 VARIABLE FREQUENCY DRIVES

In 2018 the Facility engaged KJ Electric of Syracuse, NY, to design a system to provide variable pumping capability. The plan developed with KJ Electric was to replace the electric motors on two of the three pumps with variable speed motors that operate on 460-volt AC current (Figure 4-1). Replacement of two of the motors, rather than all three, is sufficient to provide flow reduction capability because typically only two pumps are operated at a time. When the additional flow provided by a third pump is required, all pumps would be operating at full speed. The variable frequency drive units (Figure 4-2) were installed and motor replacements were completed during the summer of 2019.

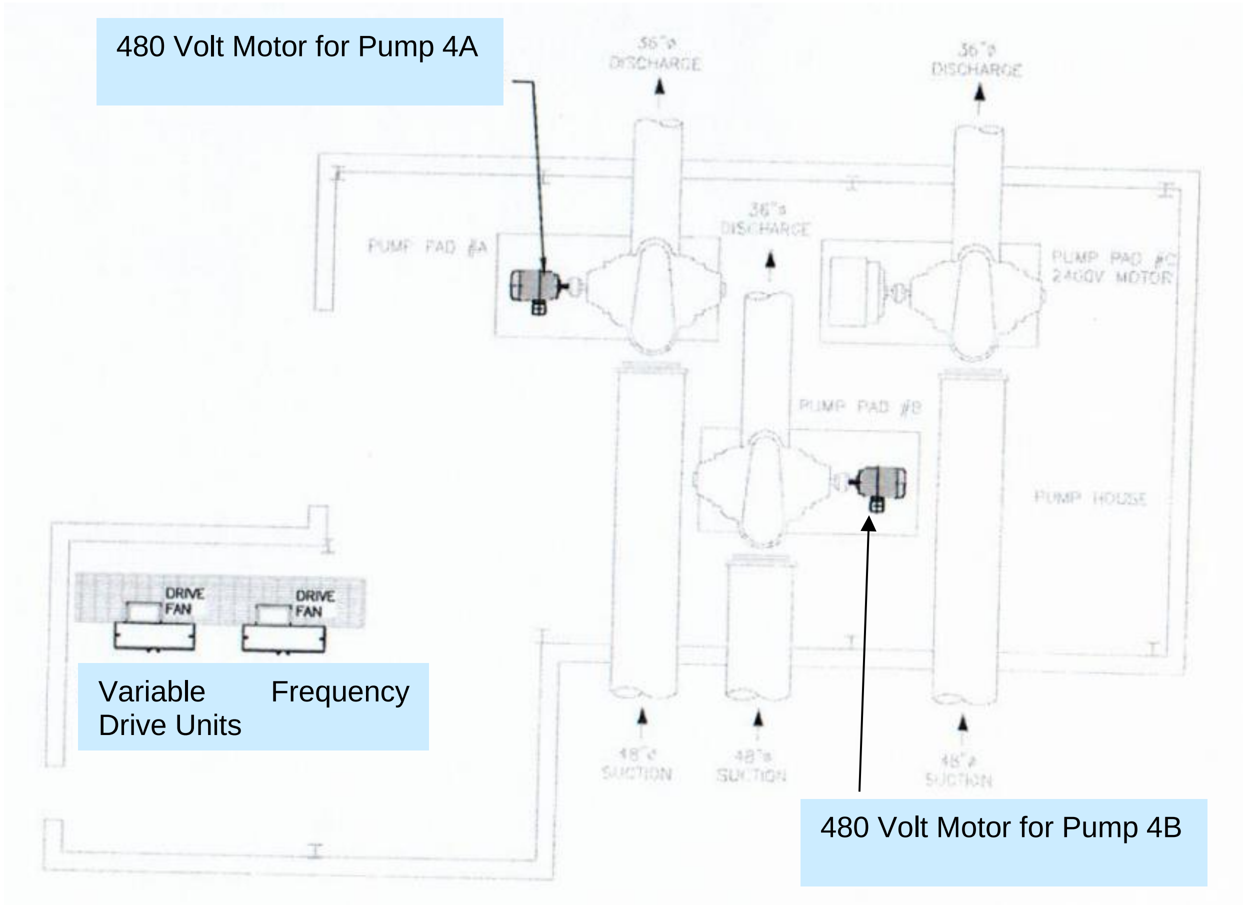

Figure 4-1 Plan view of GGF pumphouse with location of pumps, motors, and VFD units.

Figure 4-2 Variable frequency drive units installed in the GGF pumphouse.

4.4 SYSTEM OPERATION

Historical operation of the cooling system was to use two pumps (60,800 gallon/minute) whenever Unit 4 was generating, three pumps (68,000 gallon/minute) only at peak summer water temperatures, and one pump (41,000 gallon/minute) when the unit was off but available for immediate start-up. All pumps were off only during prolonged offline periods.

In February 2018, a change in operating procedure allowed the pumps to be turned off when generation is not expected to be required for several days. The Facility uses the vacuum priming system to keep the elevated conduit full and available for start up.

4.4.1 Flow Constraints

4.4.1.1 Discharge Permit Thermal Limits

Many factors collectively determine the minimum required flow through the cooling system at any point in time. Primary among these are the generation load, inlet water temperature, and the thermal discharge limitations in the Facility's SPDES permit. The permit thermal limits are the maximum discharge temperatures of 108°F (summer) and 86°F (winter), and the maximum temperature rise of the cooling water of 26°F (summer) and 31°F (winter). Facility operating data demonstrates that temperature rise (ΔT) is related to generation load and cooling water flow based on the following relationship:

$$\Delta T\ (°\mathrm{F}) \approx 10{,}000\left(\frac{gal°\mathrm{F}}{MWmin}\right)\frac{Generation(MW)}{Flow\left(\frac{gal}{min}\right)}$$

Based on this formula, the cooling water flow that would produce the limiting ΔT can be calculated for any level of generation and lake water temperatures (Table 4-1). Even at 100 MW, under summer thermal limits, the minimum flow that would be required for thermal compliance is 38,500 gallon/minute, when lake temperature is 80 °F or less.

Table 4-1 Calculated flow at limiting ΔT for GGF during winter and summer conditions at 50 and 100 MW generation load.

Lake Temperature (°F)	Winter			Summer		
	Limiting ΔT (°F)	Flow Limit (gallon/minute) @ 50 MW	Flow Limit (gallon/minute) @ 100 MW	Limiting ΔT (°F)	Flow Limit (gallon/minute) @ 50 MW	Flow Limit (gallon/minute) @ 100 MW
40	31	16,100	32,300			
45	31	16,100	32,300			
50	31	16,100	32,300			
55				26	19,200	38,500
60				26	19,200	38,500
65				26	19,200	38,500
70				26	19,200	38,500
75				26	19,200	38,500
80				26	19,200	38,500
85				23	21,700	43,500

4.4.1.2 Water Velocity through Condenser Tubes

According to the findings of a 2010 Design Construction and Technology Review (ASA et al. 2010), the minimum recommended condenser tube velocity is 3.5 feet/second. Flow velocities below 3.5 feet/second result in:

- unreliable heat transfer performance;
- possibility of siltation settlement inside the tubes; and
- biofouling of the tubes

At the limiting velocity an increase in tube maintenence and cleaning is to be expected. It is also possible that operating below the recommended velocities may negatively affect the distribution of heat through all of the cooling tubes.

Calculated average velocity through the condenser tubes at full flow of 68,000 gallon/minute would be 7.2 feet/second, and at the limiting velocity of 3.5 feet/secondthe flow would be 33,000 gallon/minute (Table 4-2).

Table 4-2 Calculation of condenser tube velocity at 68,000 and 33,000 gallon/minute.

Condenser Tube Velocity Calculation		
Number of tubes	9098	
Inside Diameter (in)	0.652	
Tube Cross Section (in^2)	0.334	
Total Area (ft^2)	21.094	
Flow (gallon/minute)	68,000	33,000
Velocity (feet/second)	7.2	3.5

4.4.1.3 Condenser Back Pressure

Back presure on the process side of the condenser also limits the minimum flow rate of the cooling water. Process back pressure increases as a result of reduced heat extraction within the condenser. This usually indicates that the condenser tubes are fouled (reduced flow). The operating system has an alarm that will sound when the condenser pressure reaches 2.6 inches Hg[8]. Current plant procedures require that when the pressure reaches 2 inches Hg, the cooling water flow through the condenser is to be reversed in an effort to clear the tubes of debris. The steam back pressure is a function of operating load, inlet water temperature and cooling water flow. Due to the nature of the current condenser's operation, the actual minimum allowable flow can only be determined by experimentation using the new VSP capabilities. To date, sufficient testing has not been completed to determine how operation at reduced flow rates will affect back pressure.

4.4.1.4 Pump Efficiency and Hydraulic Issues

The Facility cooling water pumps were designed to run at a constant speed of 320 rpm. At this speed, the pumps would be maximally efficient, and would minimize vibration and adverse hydraulic conditions. As flow is reduced, at some point efficiency drops significantly, and hydraulic anomalies may develop. The flow which will cause the onset of these anomalies has not been determined.

4.4.1.5 System Minimum Flow

Any of the factors above, or others, could be the factor which determines the minimum usable flow rate under some conditions. However, it appears that permit thermal limits and condenser tube velocity are unlikely to be the limiting factors in practice. GGF needs more experience with operating in it's current load-following mode with the VSP capability in order to determine what minimum flows are for the system.

4.4.2 Operation Plan

The combination of BTA measures (VSP capability and wedgewire screens) will provide GGF with flexibility in meeting the required 85% entrainment reduction from baseline. Because the Facility does not yet have experience in operating with both VSP capability and wedgewire screens, it isn't possible to identify every potential operating mode (that is, how cooling water flow would vary with generating load and lake water temperature under all conditons). However, given the fact that the 0.5 mm wedgewire screens alone will provide at least 77% reduction in

[8] Condenser pressure is typically measured in inches of mercury (inHg). One (1) inch of mercury is the equivalent of 0.49 lb_f/in^2. Atmospheric pressure is 29.9 inHg, or 14.7 lb_f/in^2.

entrainment, the remaining reduction attributable to VSP capability and operational planning is achievable.

While no operational limitations are expected to be necessary, to demonstrate the point that due to the use of the 0.5 mm screens the reduction attributable to VSP and/or operational planning would be minimal, two scenarios which would meet the 85% reduction are summarized below. In both scenarios, the daily generation pattern was chosen from randomly selected (with replacement) actual generation days between February 1 and June 16, 2020. Entrainment reduction calculations followed the methodology set forth in Section 5, and used the entrainment densities observed during 2019 monitoring program.

Example 1. In this scenario, it is assumed that GGF could operate with 45,000 gallon/minute of cooling water flow as long as generating load is 70 MW or less. Above 70 MW, flow would be 60,800 gallon/minute (Figure 4-3 top). There would be no restrictions on generating load, except during the period of July 5 through July11, load would be restricted to a maximum of 70 MW (Figure 4-3 middle) so that full flow would not be necessary. Due to the combined effects of the CWWS and the variable pumping rates, entrainment would be reduced to 0.22 million eggs and larvae, which is an 85% reduction from baseline entrainment of 1.43 million (Figure 4-3 bottom).

Example 2. In this scenario, it is assumed that GGF would operate with a constant cooling water flow of 60,800, except during periods of outages (Figure 4-4 top). There would be no restrictions on generating load, except for a scheduled outage from July 5 through July10 (Figure 4-4 middle). Due to the combined effects of the CWWS and scheduling the outage period, entrainment would be reduced to 0.21 million eggs and larvae, which is again an 85% reduction from baseline entrainment of 1.43 million (Figure 4-4 bottom).

These two examples are solely meant to illustrate the point that, using 0.5 mm wedgewire screens, only modest contributions from the VSP capability would be needed to achieve compliance with the entrainment requirement. We note that, even if the VSPs provided no flow reduction at all, the required entrainment reduction percentage could be achieved through appropriate outage scheduling.

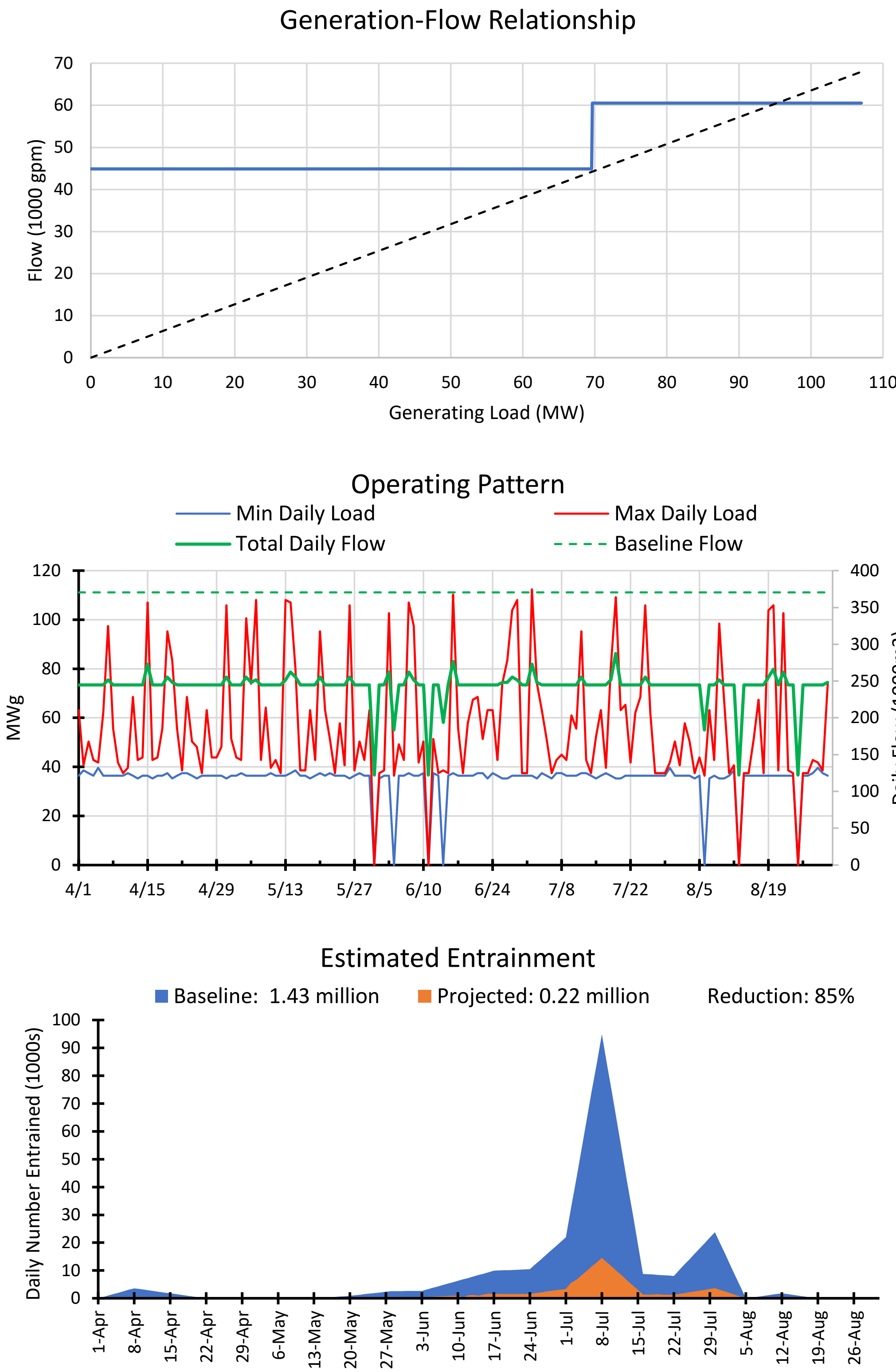

Figure 4-3 Example combination of use of VSP capability, 0.5 mm slot width wedgewire screens, and operational constraints to achieve 85% reduction of entrainment at GGF.

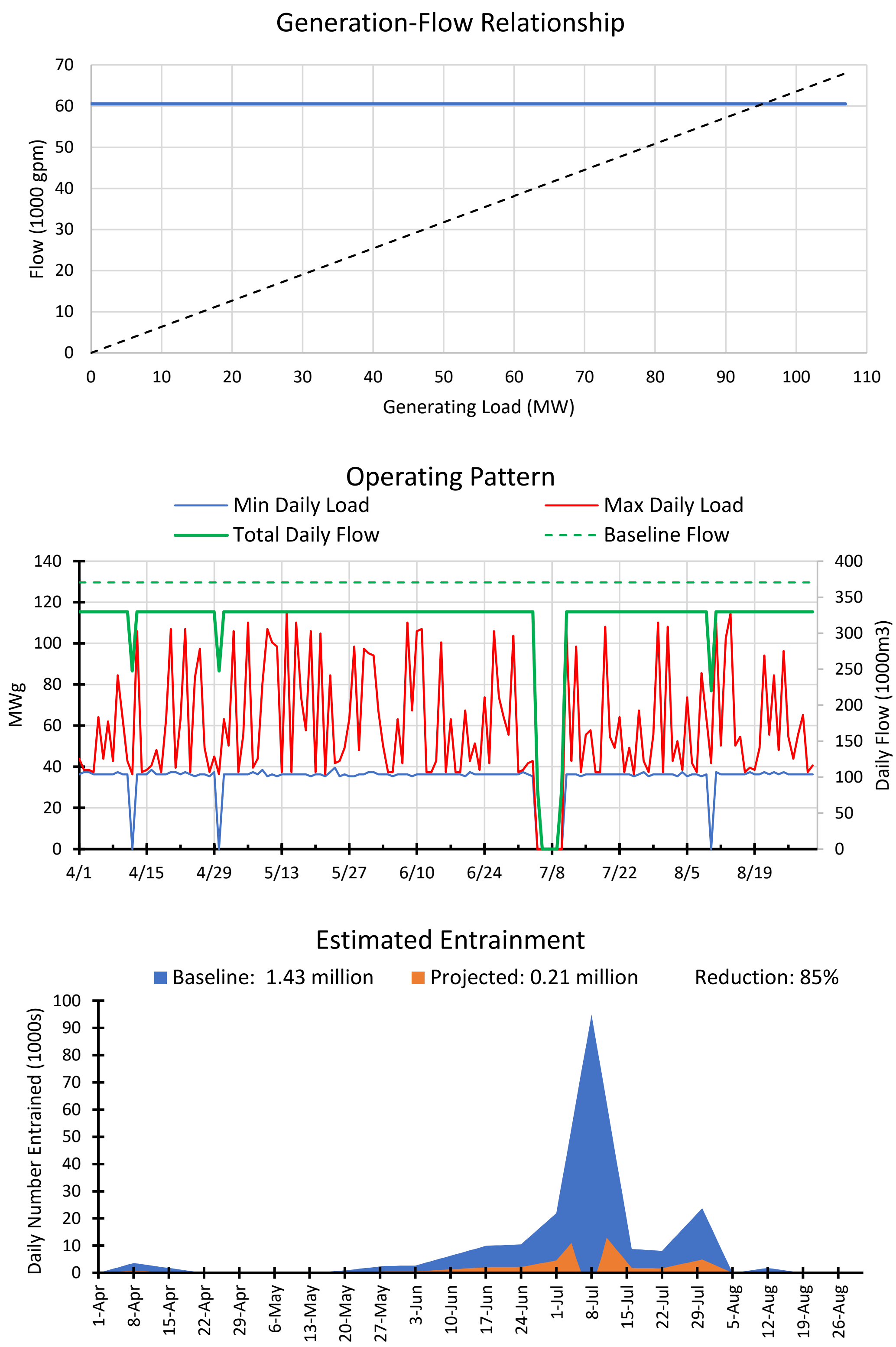

Figure 4-4 Example combination of use of VSP capability, 0.5 mm slot width wedgewire screens, and operational constraints to achieve 85% reduction of entrainment at GGF.

5. METHOD FOR ASSESSING COMPLIANCE

5.1 ENTRAINMENT

Compliance of the installed BTA with entrainment reduction requirements will be assessed by incorporating the actual cooling water flows, the efficacy of the CWWS, and the temporal pattern in density of entrained fish eggs and larvae.

The cooling water flows will be determined by the facility operating records. The CWWS efficacy is 0.77, as determined from the 2019 CWWS Pilot Study using 0.5 mm slot width screens. The density pattern is that which was determined by the first year of verification monitoring (2019).

$$Ent_{Baseline} = \sum_{d=April\ 1}^{August\ 31} \sum_{p=1}^{4} Dens_{dp}\, Vol_{Baseline}$$

$$Ent_{Actual} = (1 - Eff_w) \sum_{d=April\ 1}^{August\ 31} \sum_{p=1}^{4} Dens_{dp}\, Vol_{dp}$$

$$\%Reduction = \left(1 - \frac{Ent_{Actual}}{Ent_{Baseline}}\right) \times 100\%$$

Where:

$Ent_{Baseline}$ = Total annual entrainment under baseline conditions

$Dens_{dp}$ = density of entrainable organisms in period p on day d

$Vol_{Baseline}$ = Volume of water pumped in period p on day d under full flow (68,000 gallon/minute x 360 minutes)

Ent_{Actual} = Total actual annual entrainment

Eff_w = Efficacy of wedgewire screens with slot width w

Vol_{dp} = Volume of water pumped in period p on day d

$\%Reduction$ = percent reduction from baseline entrainment

5.2 IMPINGEMENT

One way intake technology can be used to meet BTA for impingment is by reducing through-screen velocity to 0.5 feet/second, or less.[9] The system has been designed for 0.5 feet/second velocity at the maximum flow rate, and typically operates at 89% or less of maximum flow. At this low through-screen velocity, impingement of live fish will be essentially eliminated and therefore the Facility will meet the SPDES permit requirement for 95% reduction from baseline.

[9] 40 CFR §125.94 (c)(3)

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