

1. DISTRIBUTION LIST

The following individuals will receive a copy of the Thermal Discharge Study Work Plan and any revisions.

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2. INTRODUCTION

The Greenidge Generating Station (“Greenidge Station”) located on the western shore of Seneca Lake in Dresden, New York (Yates County) is operated by Greenidge Generation LLC. The facility is a steam electric generating station consisting of one natural gas-fired boiler and one turbine generator, designated Unit 4, with a rated maximum generating capacity of 107 MW. Unit 4 has once-through condenser cooling via three cooling water circulating pumps with a combined pump capacity of 91,200 gpm (name plate). Two pumps are used throughout the year and the third pump is operated during the summer months or used as back-up for the rest of the year.

Greenidge Generation LLC is in the process of complying with Additional Requirement #9A contained in the facility’s current SPDES Discharge Permit (SPDES No. NY-0001325) issued by the New York State Department of Environmental Conservation (NYSDEC) with an effective date of October 1, 2017. The Greenidge Station SPDES permit Additional Requirement #9A requires that an approvable Thermal Discharge Study Work Plan (“Work Plan”) be submitted by December 31, 2017 (Effective Date of Permit + 3 months) to demonstrate compliance with the criteria governing thermal discharges contained in 6 NYCRR Part 704.2. The thermal standards contained in 6 NYCRR §704.1 and criteria contained in 6NYCRR §704.2 include the following items:

- Thermal discharges shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife;

- The natural seasonal temperature cycle shall be retained;
- Annual spring and fall temperature changes shall be gradual;
- Large day-to-day temperature fluctuations shall be avoided;
- Development or growth of nuisance organisms shall not occur;
- For lakes, water temperature at the surface shall not be raised more than 3°F (ΔT) over the temperature that existed before the addition of heat of artificial origin;
- NYSDEC shall specify definable, numerical limits for all mixing zones;
- Conditions in the mixing zone shall not be lethal in contravention of water quality standards to aquatic biota; and
- The location of mixing zones for thermal discharges shall not interfere with spawning areas, nursery areas and fish migration routes.

A summary of thermal discharge limits for the Greenidge Station as defined in the current SPDES permit are:

- Daily maximum discharge flow of 134 MGD;
- Daily maximum excess water temperature (i.e., temperature difference between the discharge and intake) of the Greenidge Station: summer 26°F and winter 31°F; and
- Daily maximum discharge temperature: summer 108°F and winter 86°F.
- For the purposes of the permit, summer is defined May 1st through October 31st; and winter is defined as all other dates.

As per the permit language, this Workplan includes a brief description of the facility; a summary of past thermal studies; a proposed study protocol; and a schedule for conducting field studies, thermal modeling and submission of an approvable Thermal Discharge Study Report (“Report”). The thermal discharge study report is required to also include all information obtained from implementing the Workplan; provide a comparison of the applicable criteria to the varying operating conditions of the facility under critical ambient temperature when all units are operating during summer, winter or other critical climatological conditions under maximum thermal discharge loading condition; and provide all assumptions, calculations, and models used in deriving the Daily Maximum Discharge Temperature and sizing of the mixing zone. Three additional model projections are also required that start with the “baseline worst conditions scenario” with increases in the critical air temperature in increments of 2°F. Based on completing this type of analysis at other facilities discharging to lake environments in New York State, the background equilibrium lake temperature needs to be modified to reflect the increased air temperature.

3. PLANT INTAKE AND DISCHARGE

The Greenidge Station has a once-through cooling water system and is permitted to discharge a daily maximum cooling water discharge flow of 190 MGD to the discharge canal via a 7 foot by 10 foot concrete tunnel (Outfall 001). Figure 1 is an aerial view of the Greenidge Station with the locations of the intake and discharge indicated.

The Impingement and Entrainment Characterization Study (IECS) completed in 2010 (HDR, 2010) provides a qualitative description of the Greenidge intake from Seneca Lake, a Class B (T) waterbody, and discharge into Keuka Lake Outlet, a Class C (T) waterbody, that is tributary to Seneca Lake. As defined by NYSDEC, the best usage of Class B waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. Similarly, NYSDEC defines the best usage of Class C waters as suitable for fishing and shall also be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes. The symbol (T) means that the classified waters are trout waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout or trout waters applies to these waters.

The non-contact cooling water flow is obtained from Seneca Lake through an intake pipe elevated on wood pilings that extends from the pumphouse to a point 650 feet offshore, as shown in Figure 1 where the lake is 11 feet deep. The intake pipe opens facing downward and is surrounded by a 27 foot by 27 foot steel structure composed of 3/16 inch bars, 6 inches on center. 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. Plan view schematics of the intake and discharge are shown in Figure 2 as reproduced from the IECS report.

The discharge canal is 900 ft long and enters Keuka Lake Outlet 700 feet upstream of Seneca Lake. Service water for the facility comes from service water pumps that withdraw from the intake of Unit 3, a retired generator. Service water, therefore, increases the withdrawal of Seneca Lake water above what is taken for the Unit 4 cooling water pumps.



Figure 1. Location of Greenidge Station Intake & Discharge Canal

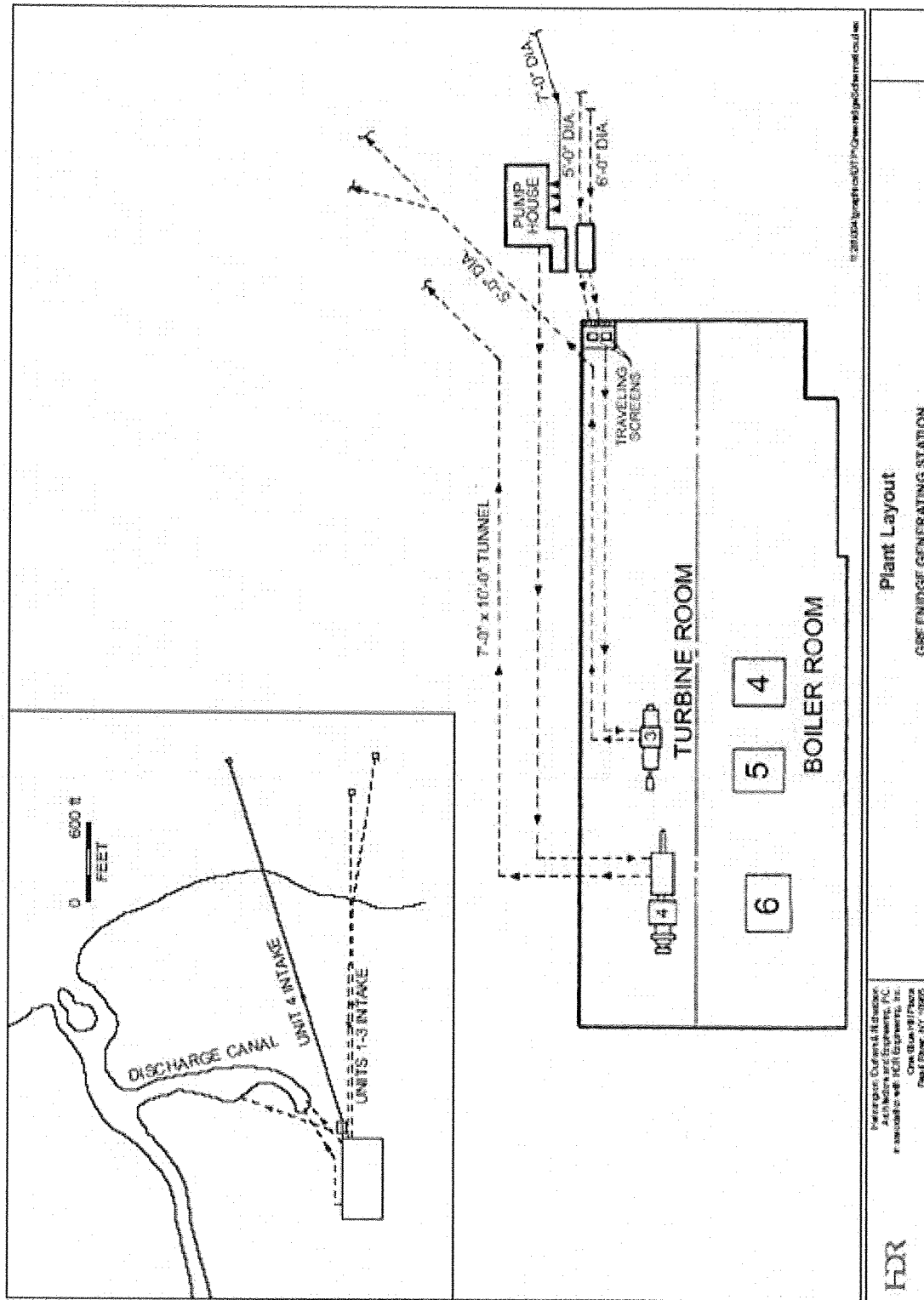


Figure 2. Routing of Cooling Water Flow through Greenidge Station

4. THERMAL MONITORING & MODELING PROGRAM

The primary goal of the proposed thermal discharge study is to provide information on the thermal discharge in order to develop a thermal mixing zone and to allow thermal criteria evaluation in Seneca Lake with respect to NYSDEC standards: 6 NYCRR Part 704.1 and Part 704.2. To support these goals, a thermal monitoring program is proposed to map the temperature conditions around the Greenidge Station cooling water discharge in Seneca Lake (near- and far-field) during various lake and meteorological conditions. In addition, application of a hydrothermal model is proposed to analyze the field study results. The use of a hydrothermal model will assist in analyzing the potential thermal effects of the Greenidge Station discharge at critical lake and discharge conditions as part of assessing compliance with the applicable NYSDEC thermal criteria and to develop discharge projections at increased ambient air temperatures.

4.1 Existing Data Compilation and Review

The existing data and information concerning operations of the Greenidge Station and Seneca Lake information will be compiled and reviewed to help design the lake temperature study and also to guide the modeling approach (i.e., extent of the modeling domain, computational grid resolution, selection of critical conditions for model projection scenarios, and development of model inputs). The following data will be reviewed:

- Plant discharge/intake structure design;
- Current plant intake/discharge flows and temperature;
- Lake water levels in the vicinity of the plant from the USGS gage on Seneca Lake at Watkins Glen (#04232400);
- Lake bathymetry, ambient temperature and current data (if available);
- Previous thermal plume monitoring studies, if any; and
- Hourly meteorological data measured at the Northeast Regional Climate Center (Penn Yan, NY) nearby to the Greenidge Station.

There are no previous thermal studies for the Greenidge Station. Lake temperature, conductivity, and dissolved oxygen data were collected during the biological monitoring surveys required in the SPDES discharge permit performed by HDR for the Greenidge Station (HDR, 2010). This data will be used along with limited current data collected using an Acoustic Doppler Current Profiler (ADCP) and detailed bathymetry available from the HDR study for a 4,100 by 3,500 foot area of the lake adjacent to the Greenidge Station.

Figure 3 presents the Greenidge Station daily operating conditions from 2005 through 2009. The top panel is the daily mean power generation and the second panel is the daily maximum cooling water discharge flow (daily maximum permitted discharge is 190 MGD). The third panel presents the daily maximum intake temperature (blue line), discharge temperature (red line), and the temperature difference (discharge-intake) (green line). For these operating years, the Greenidge Station was in compliance with their current SPDES discharge limitations. As the Greenidge Station has not been operating for about 6 years and has just recently started up (March 2017), no additional operating data is available at this time from what is presented in Figure 3. Actual operating data during the field surveys will be used in the hydrothermal modeling.

4.2 Lake Temperature Study

To assess the potential thermal impact in Seneca Lake due to the Greenidge Station thermal discharge, temperature mapping (tri-axial surveys) and *in-situ* temperature monitoring will be completed. The lake temperature surveys are proposed to be performed during the summer (i.e., mid-July to mid-September). The following two main components of the lake temperature study are proposed:

- It is proposed to map lake surface temperature (tri-axial surveys) around the Greenidge Station cooling water discharge into Keuka Lake Outlet and Seneca Lake in both the near- and far-field during three (3) separate survey events under prevailing wind conditions. The approximate spatial extent of the mapping is presented in Figure 4 with the Greenidge Station thermal plume mapped to within 0.5°F above the background lake temperature over a defined mapping area. It is anticipated that the temperature mappings can be completed during the initial deployment of the *in-situ* sensors, during the mid-point of the *in-situ* monitoring period, and during retrieval of the *in-situ* sensors. During the temperature mapping survey, ten (10) vertical castes of temperature will be obtained along the major axis of the thermal plume to determine the thickness of the thermal plume. The field surveys will provide surface temperature maps showing the lake temperature and temperature rise above the background lake temperature of the thermal plume in 0.5°F contours. The vertical temperature data will be presented graphically to assess the thickness and areal extent of the thermal plume.
- Ten (10) *in-situ* temperature moorings will also be deployed within the Greenidge Station thermal plume and in the Keuka Lake Outlet, including a background lake control site to continuously monitor temperature over a 2 week period that encompasses the surface temperature mappings. Initial estimates of the *in-situ* monitoring locations are presented in Figure 4. The *in-situ* temperature moorings will have six (6) sensors attached at evenly spaced vertical increments in the water column and will record temperature every 15 minutes.

The final locations for the *in-situ* monitoring will be determined after reviewing existing discharge and lake information. The collected temperature data will be presented graphically as a time-series for the various depths at each monitoring location.

- It is noted that the Greenidge Station discharge, as described in the HDR IECS report, enters Keuka Lake Outlet from the discharge canal. Keuka Lake Outlet flows for 700 feet and is tributary to Seneca Lake with three channels or pathways for the flow to enter the lake. Given the three channels the proposed summer/fall field surveys will consider this effect on the placement of the *in-situ* temperature moorings and tri-axial temperature mapping spatial extent.
- Keuka Lake Outlet data (USGS #04232482) will be obtained to quantify the upstream flow prior to confluence with the Greenidge Station discharge canal.

Temperature mapping readings and *in-situ* monitoring locations will be determined using GPS technology and a field log will be maintained to document sampling station locations, lake conditions, weather conditions, and general field notes to assist in analysis of the data. During the field work, intake and discharge cooling water temperature and flow will be recorded at the Greenidge Station to support analysis of the field data and quantify the cooling water discharge. Local meteorological conditions will also be obtained from the Northeast Regional Climate Center at Penn Yan, NY for the monitoring period or other nearby monitoring station. Specifically, wind information will be important in interpreting the temperature data collected as it effects movement of the thermal plume.

4.3 Thermal Model Development

A hydrothermal model for the Greenidge Station will be developed using existing information and data obtained from the lake temperature surveys. The approach will be based on a coupled CORMIX-ECOM modeling framework. The CORMIX initial dilution model will represent the near-field mixing process of the Greenidge Station thermal discharge under steady-state conditions in Seneca Lake. ECOM is a three-dimensional, time-dependent, far-field hydrothermal model that will represent the far-field mixing processes of the thermal discharge. The discharge plume characteristics in the lake calculated with CORMIX (e.g., horizontal and vertical location of the plume after the initial discharge induced turbulence dissipates) will be used to help assign the discharge characteristics in the far-field ECOM model. Using output from the CORMIX near-field

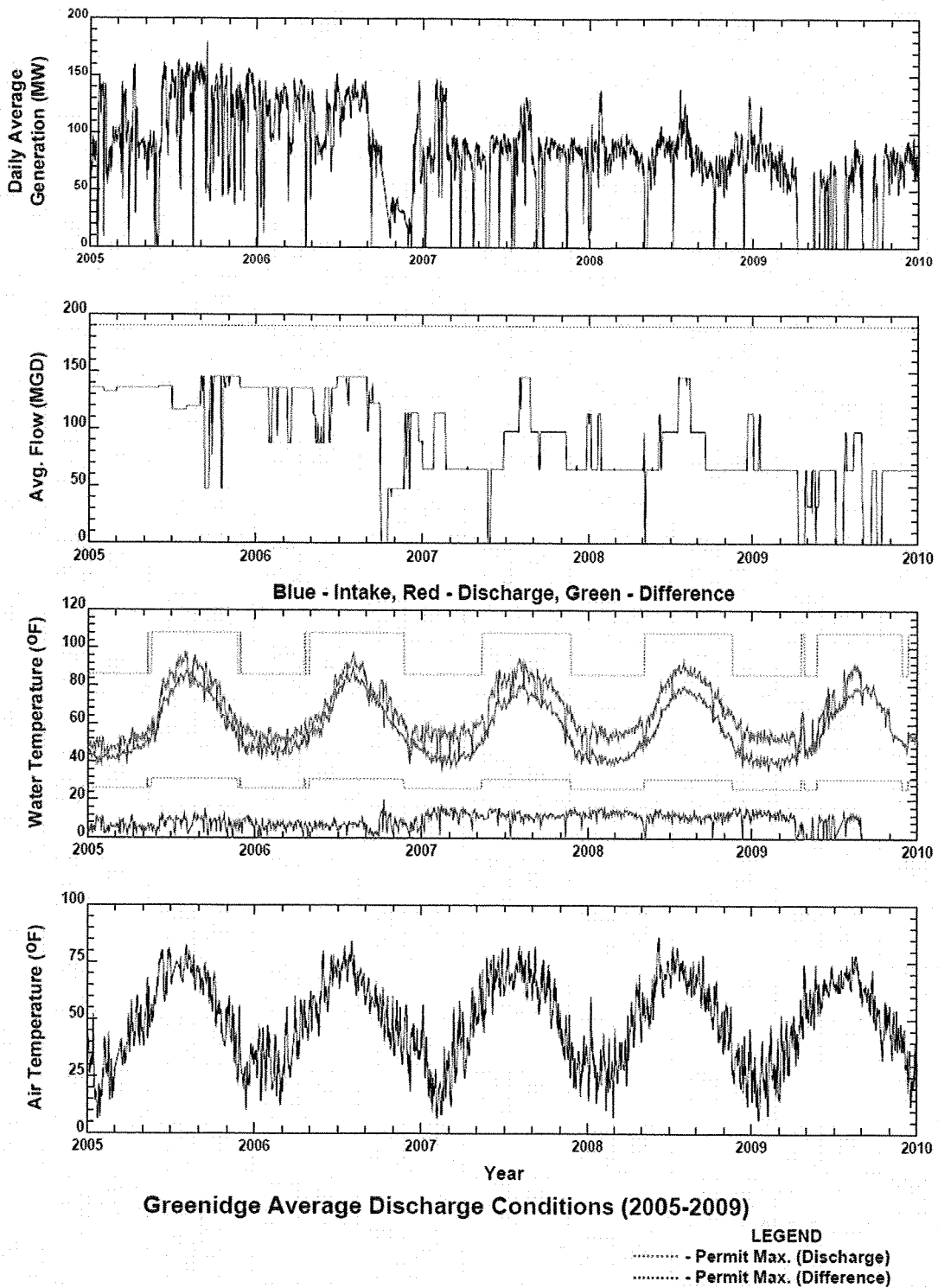


Figure 3. Greenidge Station Discharge Conditions (2005-2009)

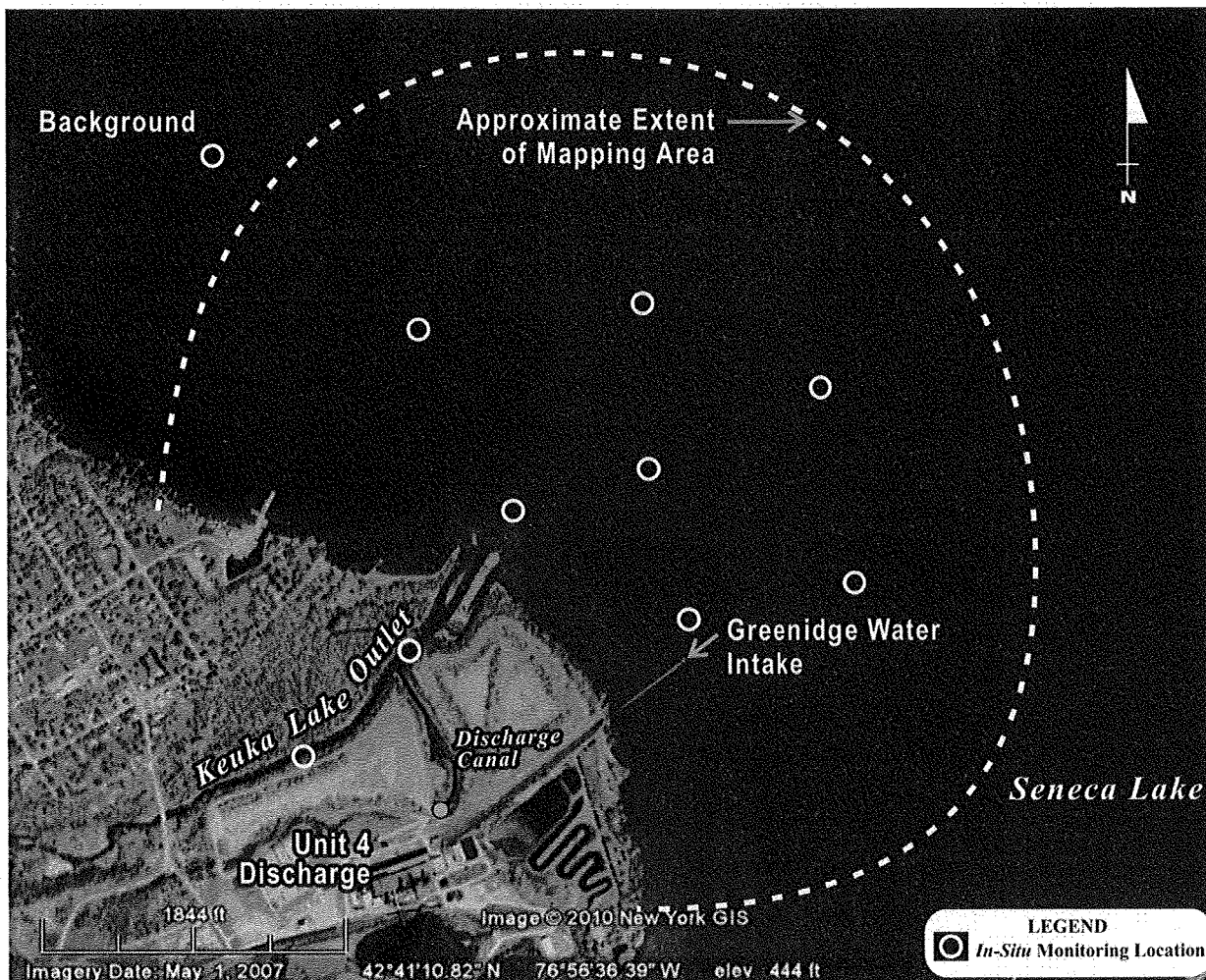


Figure 4. Proposed Greenidge Station Monitoring Area

model, the far-field ECOM model will be setup for the conditions observed during the field temperature surveys for model calibration. The ECOM model will be used to determine the behavior of the far-field thermal plume beyond the CORMIX near-field region. The coupled CORMIX-ECOM framework will be calibrated to the Seneca Lake conditions as measured during the field temperature surveys (i.e., model calibration period).

The coupled CORMIX-ECOM modeling system will include the following key physical processes: Greenidge Station operating conditions (intake and discharge flows and associated thermal load); Seneca Lake water level and temperature dynamics; tributary inflows; and atmospheric forcing mechanisms such as heating, cooling and wind stress. This methodology was developed and successfully applied to support the EPU related modifications to the SPDES permits for Constellation Energy's Ginna Nuclear Power Plant, Ontario NY, in 2005; Nine Mile Point in 2008; and to complete the Somerset Station Thermal Discharge Study in 2012.

The model development approach for either the near-field CORMIX or far-field ECOM model is basically the same and is outlined below. In general, either model is capable of calculating the mixing and dilution of the cooling water discharge in the lake as a function of the ambient and discharge conditions (e.g., meteorology, water depth, currents, density, discharge flow and temperature) with the CORMIX model applicable in the near-field and the ECOM model applicable in the far-field.

- The models will be developed using the following information: field survey data; Greenidge Station intake and discharge data; local bathymetry, and meteorology; and other information obtained through reliable sources.
- The discharge and field data will be used to develop model inputs for the field conditions observed. These model inputs will be used to calibrate the models to the observed data. Model calibration to the observed field data will be achieved by adjusting model coefficients (e.g., bottom friction, discharge characteristics, mixing parameters) within acceptable ranges so that an acceptable level of model calibration is achieved.
- After the model calibration is complete, the models will be setup to represent critical conditions and used to determine compliance with the applicable thermal criteria. This modeling case is typically termed model projections. The critical conditions will include both lake (e.g., summer and/or winter temperature conditions) and discharge (e.g., permitted flow and daily maximum temperature conditions).

- The model projections will be completed to determine the spatial extent (area) of the thermal plume and assess compliance with the NYSDEC thermal criteria.
- The model projections will verify whether the permitted Daily Maximum Discharge conditions (flow and temperature) for the Greenidge Station discharge meet all applicable thermal criteria.

4.3.1 Near-Field Thermal Model: CORMIX

The near-field analyses will be performed using the initial dilution model CORMIX to simulate the Greenidge Station discharge as a shoreline input (i.e., surface discharge) from the Keuka Lake Outlet into Seneca Lake. The following information will be used: receiving water characteristics (local water depth, density gradient, wind, and currents); and discharge characteristics (flow, density, and discharge configuration). The CORMIX model output will be compared to the observed data to develop an existing condition calculation and to calibrate the model. Output from the CORMIX model analyses will present effluent dilution, temperature and temperature rise as a function of distance from the shoreline discharge location. This information will be used to determine the model grid resolution near the shoreline for the far-field ECOM model.

4.3.2 Far-Field Thermal Model: ECOM

For this study, it is proposed to use the well known, tested and documented three-dimensional, time-variable hydrothermal model, ECOM, to perform the far-field thermal modeling. ECOM is a state-of-the-art hydrodynamic model which computes lake water elevation, temperature, and diffusive and advective transport processes. The transport and mixing of thermal loads introduced to open water are controlled by the discharge characteristics of the heated water and the circulation characteristics of the receiving water body. The fate of a thermal plume is strongly influenced by turbulent mixing created by surface wind stress and initial discharge momentum. At the same time, turbulent mixing leads to horizontal dispersion in the longitudinal and lateral directions, as well as to vertical dispersion throughout the water column. Heat exchange processes between the water column and the atmosphere, coupled with turbulent mixing due to wind and initial discharge momentum; determine the spatial extent and size of the thermal plume.

ECOM is an adaptation of the Princeton Ocean Model (POM), co-developed by Blumberg and Mellor (1980), and is used for computing the circulation of lakes, reservoirs, rivers, bays, estuaries, and coastal regions. Together, ECOM and POM are being used by over 3,000 research groups around the world for simulations on a variety of water bodies. Both the CORMIX and

ECOM model have been accepted by the USEPA, NYSDEC and other state and local agencies. ECOM has been used for Constellation Energy's Ginna and Nine Mile Point Stations; Somerset Station on Lake Ontario; the New York Power Authority's (NYPA) Poletti Power Plant in Astoria, NY; the Dominion Generation's Millstone (CT) and Chesterfield (VA) Power Stations; and Exelon Corporation's LaSalle, Dresden and Braidwood Power Stations in Illinois. In all of these studies, model capabilities were assessed through comparisons with measured data, which established a high confidence level that the model reproduced the dominant physics of the receiving water systems.

A numerical model grid will be designed to adequately address the thermal plume behavior near the Greenidge Station discharge. It is proposed to develop the model grid for all of Seneca Lake to avoid the need to establish model boundary conditions at an offshore location. The ECOM model will use a sigma coordinate system in the vertical direction that allows the model to have an equal number of vertical segments in all of the computational grid cells. For this study, a 10 layered sigma coordinate system will be used. In horizontal directions, an orthogonal curvilinear grid system will be used, which allows for finer grid resolution near the discharge locations and coarser grid resolution in the offshore region. After the model grid is designed, the model inputs will be developed from readily available information and the field program results, and will utilize model parameters obtained from similar thermal modeling studies.

Utilizing the information obtained during the field temperature surveys, existing information, and the near-field (CORMIX) modeling results, ECOM model inputs will be developed to analyze mixing and dilution associated with the Greenidge Station cooling water discharge to the lake. These model inputs will include: lake bathymetry; water elevations (if readily available); local meteorology (wind speed and direction, air temperature, cloud cover, relative humidity, pressure); thermal discharge flow and temperature; and lake temperature (initial and boundary). The model will then be calibrated using the temperature mappings and *in-situ* temperature data measured during the field study to be conducted during the mid-July to mid-September summer period.

4.3.3 Model Projection Scenarios

The calibrated ECOM far-field model will be used to determine the size and shape of the thermal plume ($\Delta T \geq 3^\circ\text{F}$) for the Daily Maximum Discharge condition under both critical winter and summer ambient scenarios. The model projection scenarios will include the typical and daily maximum thermal discharge conditions at critical receiving water conditions. For summer and winter critical conditions, historical plant intake temperatures and air temperature data measured near the Greenidge Station will be analyzed to develop 90th percentile temperatures. In addition, the projection conditions will also be established based upon an analysis of historical data for seasonal wind conditions.

The prior Greenidge Station SPDES discharge permit required three additional projection scenarios with the critical conditions as described above and incremental 2°F increases in air temperature over the calibration conditions (i.e., +2, +4 and +6°F). The approach proposed for these additional evaluations is to establish the equilibrium temperature of Seneca Lake due to the higher air temperature assigned. This will be accomplished by running the hydrothermal model for an extended time period of time (e.g., 60-90 days) to allow the lake to equilibrate with the higher air temperatures. The impact of the Greenidge Station discharge on the lake will then be determined based on the higher air/lake temperatures.

4.3.4 Regulatory Assessment Method

The proposed work plan was designed to address the NYSDEC thermal standards contained in 6 NYCRR §704.1 and §704.2 as presented in Table 1.

Table 1. Regulatory Assessment Method Summary		
NYSDEC Regulation	Narrative	Assessment Method
§704.1(a)	Thermal discharges shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife.	The temperature monitoring and thermal modeling will be used to assess compliance with the temperature standards (§704.2(b) (3) (i)). Compliance with the temperature standards will be the measure for assuring the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife.
§704.2(a)(1)	The natural seasonal temperature cycle shall be retained.	Since the Greenidge Station thermal discharge adds a relatively constant heat load to the lake intake water, the natural seasonal temperature cycle will be similar to the lake intake water. In addition, the thermal discharge will not alter the lake's natural seasonal temperature cycle.

Table 1. Regulatory Assessment Method Summary		
NYSDEC Regulation	Narrative	Assessment Method
§704.2(a)(2)	Annual spring and fall temperature changes shall be gradual.	Operation of the Greenidge Station thermal discharge is relatively constant and, therefore, any spring and fall temperature changes should be gradual.
§704.2(a)(3)	Large day-to-day temperature fluctuations shall be avoided.	Operation of the Greenidge Station thermal discharge is relatively constant and, therefore, any large day-to-day temperature fluctuations will be avoided.
§704.2(a)(4)	Development or growth of nuisance organisms shall not occur.	The Greenidge Station implements a zebra mussel control program to abate the development or growth of nuisance organisms.
§704.2(b)(3)(i)	Water temperature at the surface shall not be raised more than 3°F over the temperature that existed before the addition of heat of artificial origin.	The thermal model will be used to determine the spatial extent of the Greenidge Station thermal plume that is more than 3°F over the temperature that existed before the addition of heat of artificial origin. This will be assessed for the temperature survey conditions and also for permitted discharge conditions during both summer and winter lake conditions.
§704.3(a)	NYSDEC shall specify definable, numerical limits for all mixing zones.	A thermal mixing zone for the Greenidge Station will be developed using the Thermal Discharge Study results. This mixing zone dimension will be used to assess compliance with the temperature standards in §704.2(b) (3) (i).
§704.3(b)	Conditions in the mixing zone shall not be lethal in contravention of water quality standards to aquatic biota.	Assessment will be completed by complying with the temperature standards in §704.2(b) (3) (i).

Table 1. Regulatory Assessment Method Summary		
NYSDEC Regulation	Narrative	Assessment Method
§704.3(c)	The location of mixing zones for thermal discharges shall not interfere with spawning areas, nursery areas and fish migration routes.	Assessment will be completed based on previous biological studies completed at Greenidge Station.

5. THERMAL DISCHARGE STUDY REPORT

A final report will be developed that presents: the results of the field temperature study; model development, calibration to observed data, and application to the projection conditions; verification of the Greenidge Station Daily Maximum Discharge Temperature and mixing zone under varying operating conditions; and all assumptions and calculations used in the analyses. The report will include various tables and graphics for presentation of data, model output, lake and discharge conditions.

6. SCHEDULE

The following schedule is proposed for completing Thermal Discharge Study Work Plan for the Greenidge Station cooling water discharge to Seneca Lake.

- Submittal of an approvable Thermal Discharge Work Plan (this document) by December 31, 2017.
- Lake and the Keuka Lake Outlet two (2) week temperature surveys conducted in the two (2) month period between mid-July and mid-September.
- Thermal modeling of Greenidge Station discharge will commence upon receipt of the field survey report and data (anticipated within 1 month from completion of the field survey) with the submittal of a draft Thermal Discharge Study Report to NYSDEC four (4) months after completion of the temperature surveys.
- Meeting with NYSDEC on the draft Thermal Discharge Study Report two (2) months after submitting the draft Thermal Discharge Study Report.
- Final Thermal Discharge Study Report submitted to NYSDEC one (1) month after meeting with the NYSDEC to review the draft report.

7. REFERENCES

- Blumberg, A.F. and G.L. Mellor, 1980. "A Coastal Ocean Numerical Model" In: Mathematical Modeling of Estuarine Physics, Proceedings of an International Symposium, Hamburg, August 24-26, 1978. J. Sundermann and K.P. Holz, Eds., Springer-Verlag, Berlin, 1980.
- HDR, 2010. AES Greenidge Generating Station, Impingement and Entrainment Characterization Study. Prepared for AES Greenidge, LLC. April 29, 2010.