AES Greenidge

Design and Construction Technology Review

August, 2010

This Design and Construction Technology Review was prepared for AES Greenidge as a requirement of SPDES Permit # NY-0001325.

Prepared for:

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AES
Greenidge

August 13, 2010

Chuck Nieder
Steam Electric Unit Leader
New York State Department of Environmental Conservation
Division of Fish, Wildlife & Marine Resources
Bureau of Habitat, 5th Floor
625 Broadway
Albany, New York 12233-4758

Re: AES Greenidge, LLC
SPDES Permit Number NY-0001325

Dear Mr. Nieder:

Pursuant to the requirements contained in the above referenced State Pollution Discharge Elimination System Discharge Permit, enclosed for filing with the New York State Department of Environmental Conservation are two (2) copies of the AES Greenidge Design and Construction Technology Review. This report evaluates potential alternative intake technologies for the AES Greenidge cooling water system, with regard to minimizing adverse environmental impacts due to fish impingement and entrainment. It includes descriptions of conceptual designs, feasibility/practicability considerations, cost estimates, and biological benefit estimates for various alternatives. Upon Department approval of this report, a proposed suite of technologies or operational measures will be developed to meet the requirements of 6 NYCRR Part 704.5 and CWA §316(b).

We thank the Department in advance for its review of this submission and look forward to receiving any comments you may have.

Sincerely,

Douglas J. Roll

Douglas J. Roll, PE

cc:
Alan Cherubin (NYSDEC – Division of Water, Bureau of Water Compliance) - cover letter only
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1. Executive Summary

AES Greenidge received a renewed State Pollution Discharge Elimination System (SPDES) permit effective February 1, 2010, which required that the station evaluate alternative cooling water intake technologies to reduce impingement and entrainment of fish and shellfish, and submit a Design and Construction Technology Review (DCTR) by August, 2010. One month after approval of the DCTR, AES Greenidge must propose a technology or suite of technologies that will meet the target levels of impingement (entrapment of fish and shellfish on screen systems) and entrainment (passage of fish eggs and larvae into and through the cooling system) reductions set for the station in the SPDES permit.

Alternative technologies could reduce impingement and entrainment by managing the cooling water flow to use the minimum amount necessary, converting the station to closed cycle cooling, or installing technologies to reduce the involvement of fish and shellfish at the intakes. At AES Greenidge, potentially practicable alternatives include wedgewire screens, closed cycle cooling, variable speed pumps, and planned outages. Those alternative technologies found to be infeasible or impracticable for AES Greenidge include barrier nets, aquatic filter fabrics, velocity cap, light deterrents, sonic deterrents, fine mesh traveling screens with fish return, and partial closed cycle cooling.

Upon DEC approval of this report, AES will further analyze the availability of feasible alternatives with respect to 1) the reductions in impingement and entrainment that could be expected from the time the alternative could be implemented to the end of plant life (assumed to be at the end of AES' lease in 2028 for this analysis); 2) capital and operating costs of the alternative over the remaining plant life; 3) future projected capacity factors for Unit 4; 4) additional regulatory requirements that will affect unit profitability. To be an available technology, among other things, the alternative must not impact efficient operation of the facility; must have a cost not wholly disproportionate to the benefit; must not create large environmental impacts; and must not present hazards to the surrounding community. A recommended intake technology for AES Greenidge Unit 4 will be made, after considering all of these factors, in the Proposed Suite of Technologies and Operational Measures.

2. Introduction

A. Regulatory Framework

Section 316(b) of the Clean Water Act (CWA) (33 U.S.C. § 1326(b)) requires that the location, design, construction and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact. 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). The State of New York similarly requires that cooling water intake structures reflect the best technology available for minimizing adverse environmental impact (6 NYCRR §704.5).

In 2004, EPA promulgated the §316(b) Phase II rule to set national standards for minimizing adverse environmental impact from fish impingement and entrainment at large existing power plants. In 2007, the Second U.S. Circuit Court of Appeals issued a decision remanding several portions of the Phase II rule (See Riverkeeper II: *Riverkeeper, Inc. et al. v U.S. EPA*, 475 F.3d 83 (2d Cir. 2007)). In response, EPA suspended the rule, effectively leaving 316(b) considerations to the Best Professional Judgment of permitting agencies. In 2009, the Supreme Court overturned the Second Court's decision, sustaining key concepts of the Phase II rule, specifically the use of cost-benefit analysis in determining best technology available, allowing discretion in determining the extent of adverse environmental impact that should be reduced in setting performance standards for cooling water intake structures (See *Entergy Corp v Riverkeeper, Inc., et al.*, 556 U.S._, 129 S.Ct. 1498 (2009).

The NYSDEC does not currently have a policy or formal guidance for implementing 6 NYCRR Part 704.5, which states:

> *704.5 The location, design, construction and capacity of cooling water intake structures, in connection with point source thermal discharges, shall reflect the best technology available for minimizing adverse environmental impact.*

In recent years, the state has been using performance goals and information requirements similar to those of the former Phase II rule. In former Deputy Commissioner Stark's 2005 letter to USEPA, she explained that the process implemented by NYSDEC would be consistent with the Phase II rule (40 CFR Parts 9, 122 et al.), which set national performance standards based on waterbody type for reducing impingement mortality by 80 to 95 percent and entrainment of organisms by 60 to 90 percent, compared to a calculation baseline. However, Deputy Commissioner Stark also indicated that New York's requirements would, as permitted by law, be more protective than the federal standard because NYSDEC

- would seek to impose reductions in impingement mortality and entrainment that are at the higher end of the Phase II performance standard ranges
- would continue to use an economic standard of costs wholly disproportionate to environmental benefits rather than the "significantly greater" standard of the Phase II rule
- would not use the restoration provisions of the Phase II rule as a way to meet the performance standards, and
- would not consider site-specific permit standards that are "as close as practical to the applicable % reduction performance standards considering cost calculations."

In March of 2010, NYSDEC issued a draft policy that would prescribe the reductions in impingement mortality and entrainment required to minimize the adverse environmental impact caused by industrial facilities having a cooling water intake structure in connection with a point source thermal discharge. This policy proposes closed-cycle cooling or its equivalent as the performance goal for the best technology available (BTA) to minimize adverse environmental impact. It appears that performance goals for both entrainment and impingement mortality could be higher than the recently established requirements of AES Greenidge's SPDES permit. In conjunction with the draft policy, draft procedures for the determination of Best Technology Available under 6 NYCRR Part 704.5 and Section 316(b) were also proposed. Generally, the steps would be 1) identifying feasible alternatives; 2) determining which alternatives meet the standards for resource protection; 3) considering whether each alternative's costs of minimizing are wholly disproportionate to the resource benefits; 4) identifying which alternative most effectively minimizes adverse environmental impacts; and 5) explaining the selection of the preferred alternative. If finalized, implementation of these policies and procedures may require further analysis.

The AES Greenidge Station currently operates under SPDES Permit No. NY-0001325, with the most recent effective date of modification February 1, 2010. The permit includes several Biological Requirements for compliance with §704.5, including completion of an Impingement Mortality and Entrainment Characterization Study, this Design and Construction Technology Review, a Proposed Suite of Technologies and Operational Measures, a Technology Installation and Operation Plan, and a Verification Monitoring Plan. These required demonstrations follow the general organizational structure of the former Phase II rule for implementing § 316(b).

The AES Greenidge Impingement and Entrainment Characterization Study (IECS) was submitted to NYSDEC on April 29, 2010. It consists of an IECS report (HDR 2010d), and three supporting documents: the AES Greenidge Generating Station 2006 Ichthyoplankton and Entrainment Studies (HDR 2010a); the AES Greenidge Generating Station 2006-2007 Impingement Study (HDR 2010b); and the AES Greenidge Generating Station 2006-2007 Finfish Community and Waterbody Studies (HDR 2010c). These studies were prescribed by the Proposal for Information Collection (HDR 2006) under the former EPA Phase II rule.

This Design and Construction Technology Review (DCTR) evaluates potential technologies and operational measures for meeting the requirements of the SPDES permit, 6 NYCRR Part 704.5, and §316(b). The AES Greenidge SPDES permit and its accompanying Biological Fact Sheet expound on the required content of the DCTR. Within one month of the Department's approval of the DCTR, a Proposed Suite of Technologies and Operational Measures must be proposed to meet performance requirements of at least 60% entrainment reduction and 80% impingement reduction from baseline.

B. SPDES Permit

AES Greenidge's current SPDES permit includes several requirements for the Design and Construction Technology Review. By EDP + 6 months, the permittee must submit an approvable Design and Construction Technology Plan (DCTP) that includes:

a. Tables showing the average monthly and annual cooling water use and net generation of the facility in MWhr
b. An estimate of the abundance of fish entrained through the station's cooling water intake system at current operating conditions, and at full flow calculation baseline conditions over the one year study period. In addition, estimates of the abundance of fish that would have been impinged had the station operated all units with intake screens containing 3/8 inch mesh, are to be included.;
c. An analysis of all feasible technologies and/or operational measures capable of being installed and implemented at Greenidge Generating Station to minimize impingement and entrainment of fish, including the use of closed cycle cooling. For each alternative, the following information shall be included:
    i. A detailed description of the alternative (including preliminary drawings and site maps, if appropriate);
    ii. A discussion of the engineering feasibility of the alternative;
    iii. An assessment of the mitigative benefits in reducing impingement mortality (if applicable) and entrainment abundance for all life stages of fish through utilization of the alternative;

iv. A breakdown of all applicable costs including costs associated with capital improvements, operation and maintenance, and construction downtime;

v. An estimate of the time required to implement the alternative; and

vi. An evaluation of any adverse environmental impacts to aquatic biota, habitat, or water quality that may result from construction, installation, and use of the alternative.

Then, within 1 month of the Department's approval of the DCTP, the permittee must submit, for Department review and consideration, a Proposed Suite of Technologies or Operational Measures (PSTOM) that meets the requirements of 6 NYCRR Part 704.5 and adheres to the following requirements:

a. The reductions in entrainment resulting from existing and proposed technologies and/or operational measures can be no less stringent, and if possible, should be substantially better than 60 percent from the full-flow calculation baseline;

b. If applicable, reductions in impingement mortality resulting from existing and proposed technologies and/or operational measures are to be no less stringent, and if possible, should be substantially better than 80 percent from the full-flow calculation baseline.

Based on this and other relevant information, the Department will select technologies and/or operational measures that meet the requirements of 6 NYCRR Part 704.5 and will modify the SPDES permit to require the use of these selected technologies and/or operational measures. Subsequent to these selections, AES will develop a Technology Installation and Operation Plan and a Verification Monitoring Plan in accordance with permit requirements.

The Biological Fact Sheet issued with the permit states that each technology evaluation must include consideration of location, design, construction, and capacity issues. The fact sheet further stipulates the following technologies are to be evaluated at this facility:

1. Closed Cycle Cooling: full and partial retrofit
2. Modified Traveling Intake Screens (including fine mesh panels) and Fish Return System
3. Wedgewire Intake Screens
4. Barrier Net
5. Aquatic Filter Barrier
6. Variable Speed Pumps
7. Unit Outages and/or Flow Management Procedures
8. Behavioral Deterrent Devices

3. AES Greenidge Facility

A. Station Description

AES Greenidge is located in Yates County, New York on the western shoreline of Seneca Lake (Figure 3-1). AES acquired the steam electric generating station from New York State Electric & Gas Company in 1999. The station formerly consisted of six coal-fired boilers and four turbine generators. Units 1 and 2 were constructed during the 1930s, and taken out of service in 1985. Unit 3, which operated from 1950 through 2009, had a capacity of 54 MW and used 34.2 kgpm cooling water. AES chose to retire Unit 3 from service in December 2009 due to the costs of air emission controls required under a consent decree, and anticipated costs of intake modifications to satisfy 6NYCRR §704.5 and Clean Water Act §316(b). Unit 4, which began operation in 1953, has a generating capacity of 107 MW, and has a calculated circulating water pump flow rate of 68.0 kgpm.

The Unit 4 turbine is a GE tandem compound reheat steam turbine, which drives a 13,800 volt hydrogen-cooled GE electrical generator. The Unit 4 boiler, a Combustion Engineering tangentially-fired, balanced draft design, utilizes pulverized coal and wood biomass (providing potentially up to 10% of the fuel by heat input) to produce 780,000 lb/h steam flow at 1465 psig and 1005 °F. There is also a natural gas reburn system capable of providing up to 20% of the heat input; however, the reburn system is not currently in use The station's multi-pollutant emission control system includes combustion modifications, hybrid SNCR / SCR, urea-based in-furnace selective non-catalytic reduction, single-bed in-duct selective catalytic reduction, circulating fluidized bed dry scrubber, and a baghouse.

Unit 3 and Unit 4 have separate cooling water systems (Figure 3-2). Cooling water for Unit 4 enters the station from Seneca Lake via a 7 ft diameter suction pipe extending from the pumphouse to a point 650 feet offshore (Figure 3-3). The intake pipe is elevated above the lake on wood pilings (Figure 3-4) and angled down at the lake end. The pipe withdraws water from a 27-ft x 27-ft steel intake structure composed of 3/16 in. bars on 6 in. centers in about 11 feet of water. The approach velocity at the bar rack is about 0.14 fps. There are no traveling screens for Unit 4. Reversing valves on the condenser automatically wash out any debris that might accumulate on the condenser tube face.

The three Unit 4 circulating water pumps (Figure 3-5) 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 30,400 gpm, one-half of the circulating water required by the condenser. Flow tests conducted by NYSEG in 1995 indicate actual flows were approximately 22.67kgpm per pump. Reported flows are calculated as 22.67 kgpm for one pump operation, 45.3 kgpm for two pump operation, and 68.0 kgpm for three pump operation. Outside of the summer months, only two of the three pumps are operated simultaneously.

The Unit 4 condenser, manufactured by the Westinghouse Electric Corporation, has 50,000 square feet of cooling surface made up of 9098 3/4" O.D. No. 18 BWG Admiralty metal tubes. The tubes have an effective length of 28 ft. 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 to permit the water flow through the tubes to be reversed as necessary to remove impinged organisms and debris.

After passing through the Unit 4 condenser, cooling water discharges into a common 54" diameter steel pipe which connects to a concrete tunnel 41" x 61" in cross-section which extends to the north wall of the turbine room basement. At this point the tunnel divides into two 42" diameter steel pipes connecting to the temperature activated circulating water backwash valves. Water then flows through a 7 x 10-foot tunnel to the discharge cannel. The discharge canal, which is approximately 900-feet long, empties into the Keuka Outlet about 700-feet upstream from Seneca Lake.

Unit 3 was equipped with two circulating water pumps with a combined maximum intake capacity of 34.2 kgpm. Unit 3 was serviced by two intake pipes which lie on the lake bottom. A 6-foot-diameter pipe extends 550 feet offshore to a water depth of approximately 8 feet and an 8-foot-diameter pipe extends 710 feet offshore to a water depth of approximately 10 feet. A steel cage, consisting of 1/2-inch bars on 12-inch centers, covers each intake pipe opening to screen out large debris. At the shoreline, the 6-foot and 8-foot pipes are joined into 5-foot and 6-foot diameter concrete pipes, respectively, which extend to the chlorination building. The pipes then combine into a single gravity-fed intake tunnel (seven feet in diameter) that leads to the traveling screens. Trash racks, composed of 1/4-inch bars on 3-inch centers are located 7 feet in front of the traveling screens.

The traveling screens (Figure 3-6) consist of wire panels with 3/8-inch square open mesh, and were operated automatically by a system of pressure differential controls. Fish and debris collected on the traveling screens were washed to the discharge canal. While the Unit 3 intake structure piping and screening components are still in place at the facility, they are now only used to support the service water pumps.

Service water is supplied to AES Greenidge by four house service water pumps (rated at 550 gpm per pump), two hydrogen cooling pumps (rated at 120 gpm per pump), and a dual Hydro-jet pump (rated at 1,300 gpm). All service water is withdrawn from the Unit 3 intake downstream of the traveling screens. The Unit 3 intake also supplies water to a fire pump that is for emergency use only. No service water pump withdraws water from the Unit 4 intake. All of the Unit 3 service water pumps were operational prior to the shutdown of Unit 3, and are currently still in operation. Intermittent operation of the traveling screens is required as a part of the service water supply. There is no detailed record of service water use available for the facility.

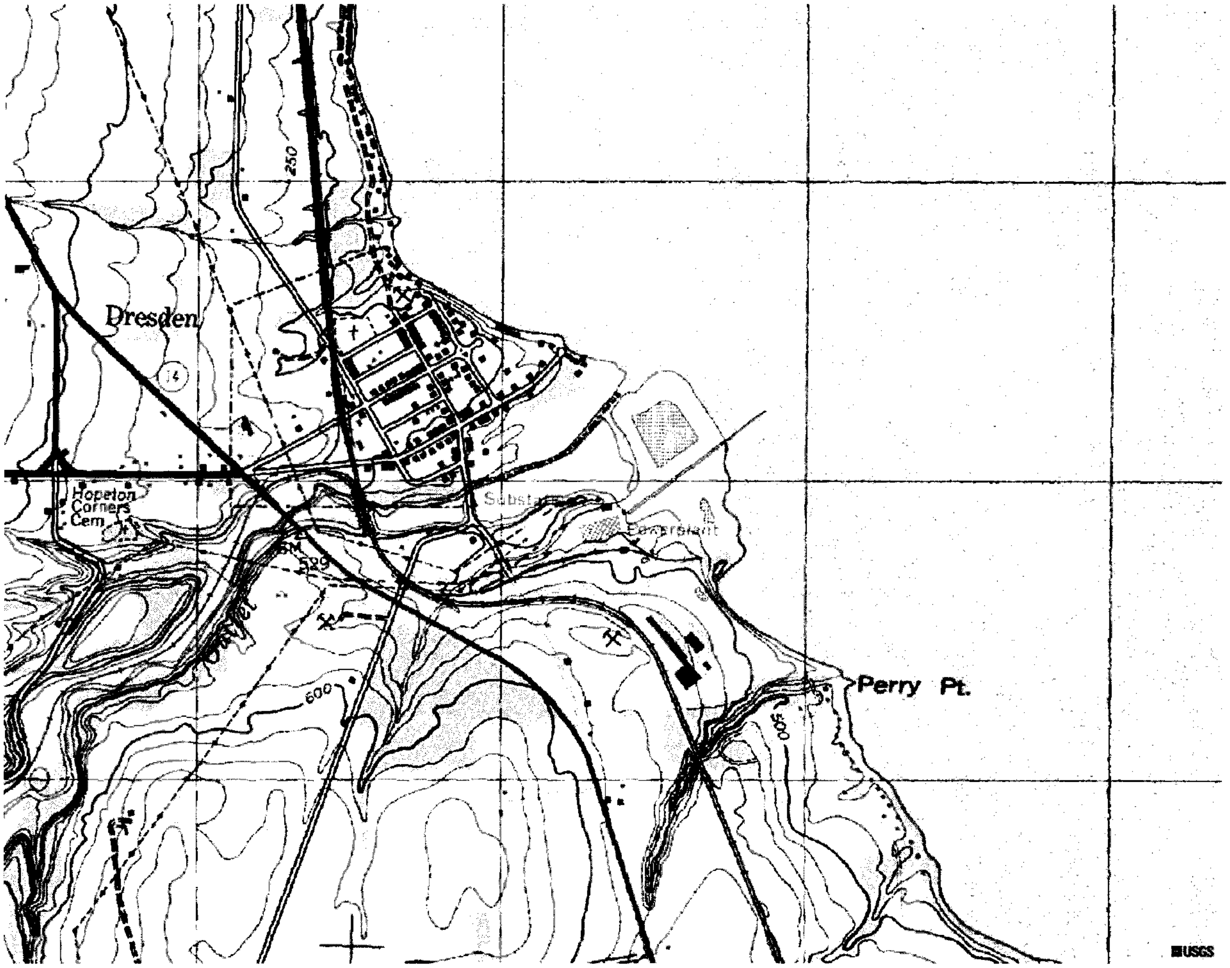


Figure 3-1 Topographic map of area surrounding AES Greenidge (USGS Dresden 7.5-minute quadrangle, 1978)

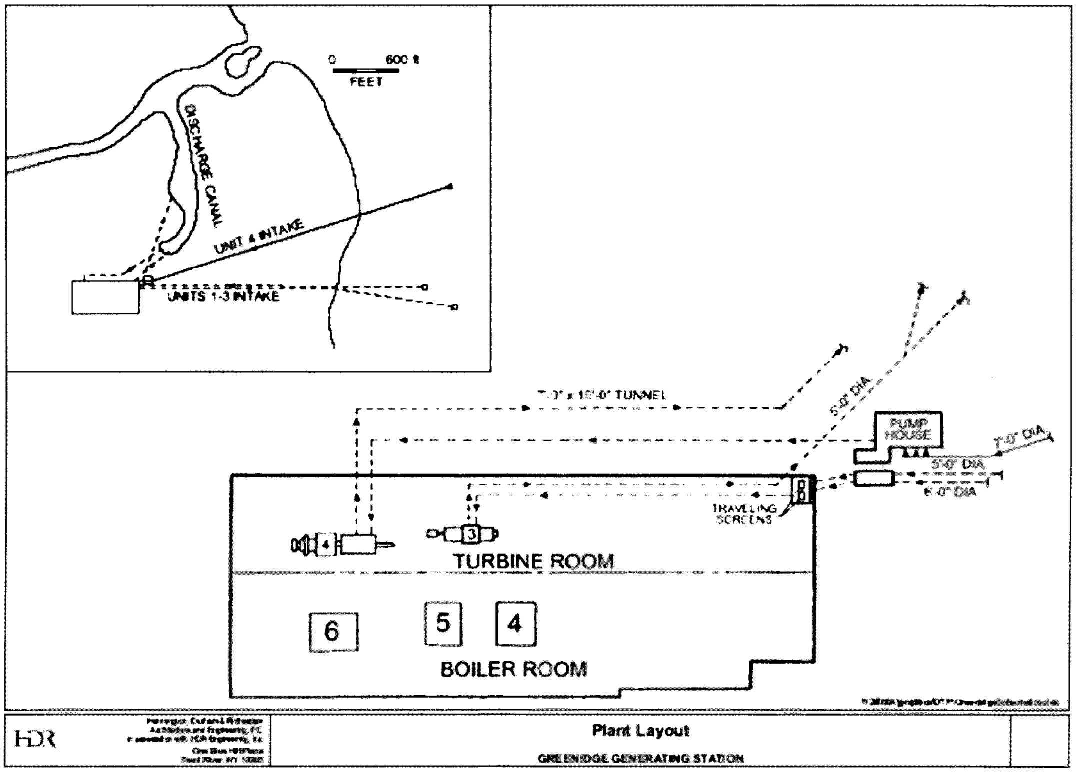


Figure 3-2 AES Greenidge Cooling Water System Schematic Diagram

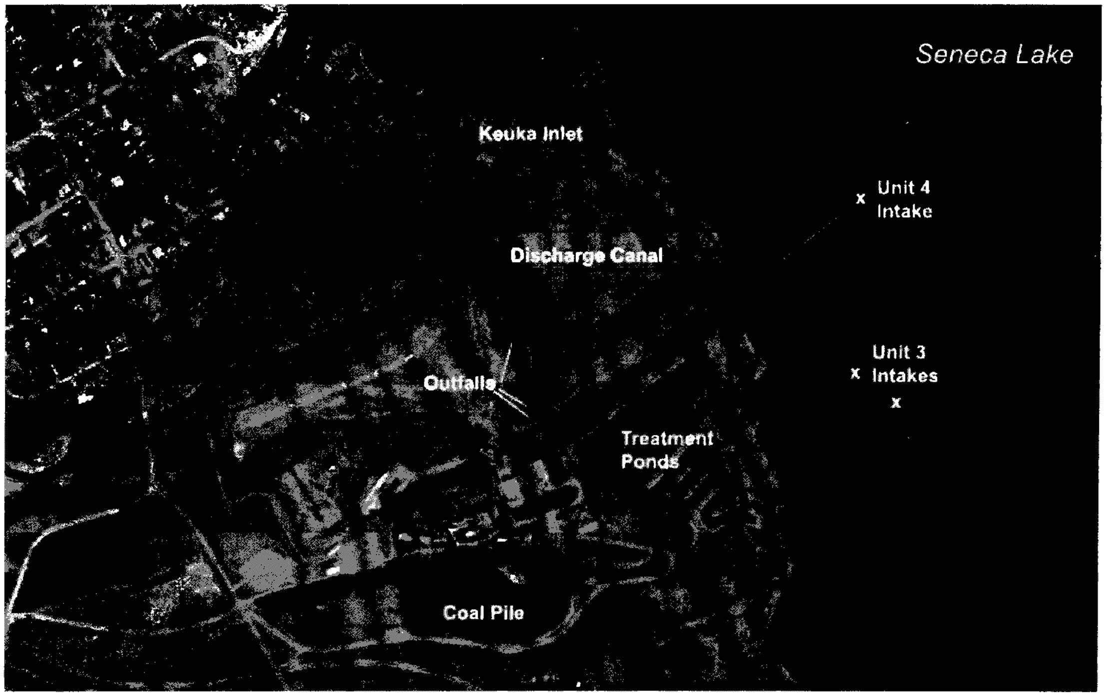


Figure 3-3 Aerial View of the AES Greenidge Generating Station

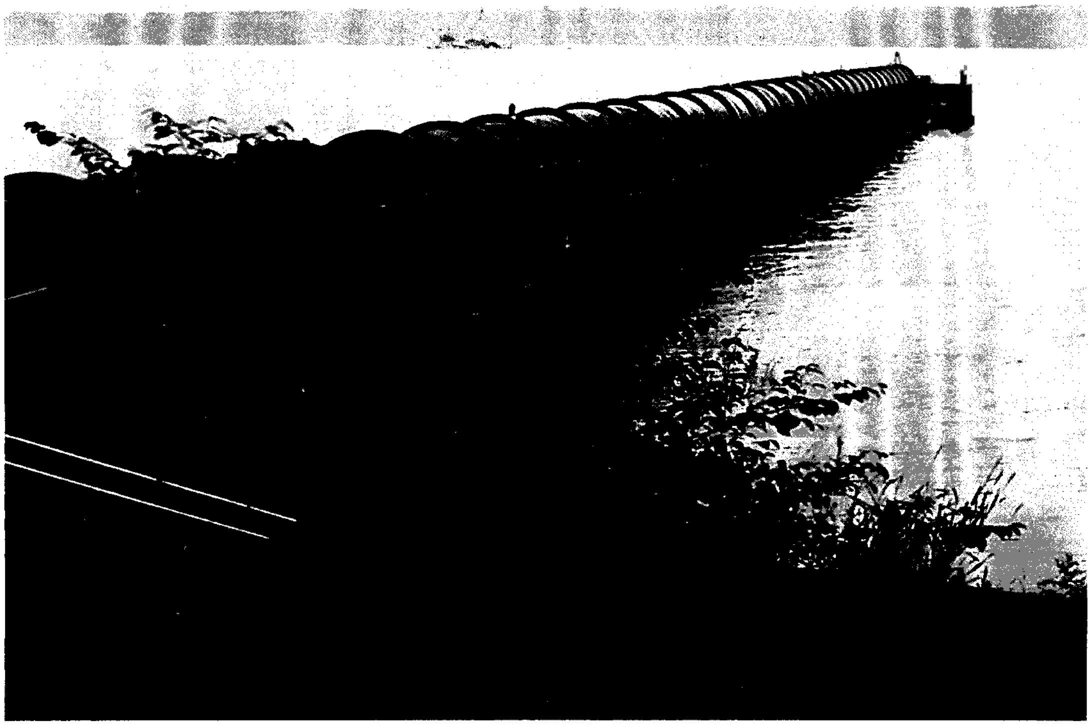


Figure 3-4 AES Greenidge Unit 4 intake pipe

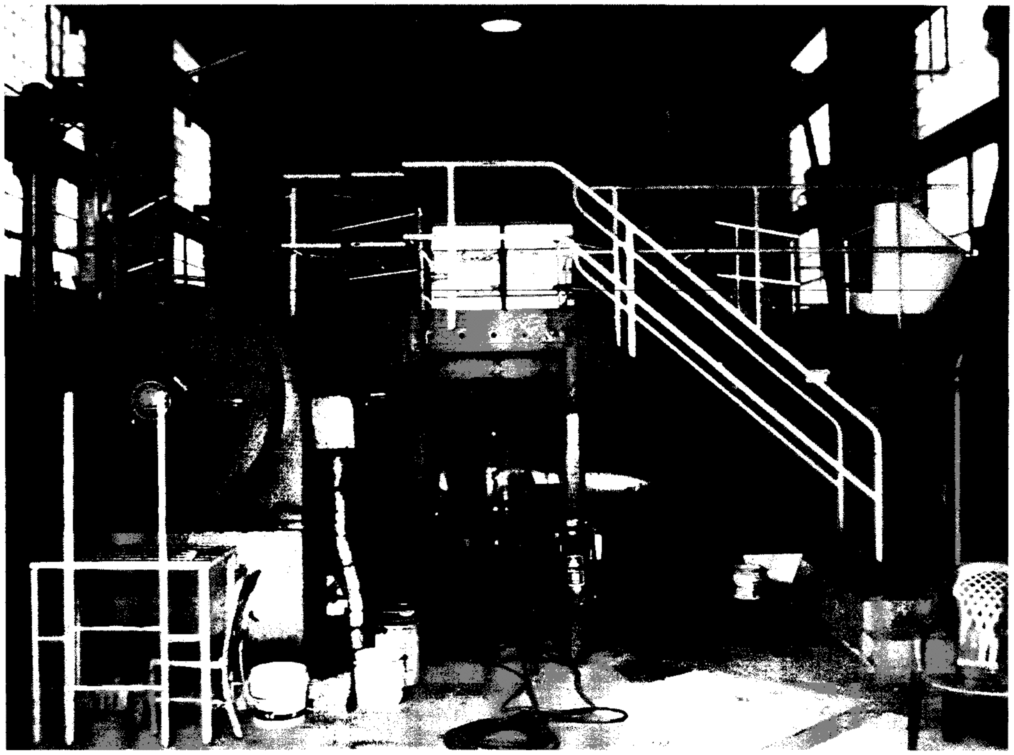


Figure 3-5 AES Greenidge Unit 4 circulating water pump A

Figure 3-6 AES Greenidge Unit 3 traveling screen #2

B. Operation

Historically, the AES Greenidge Station operated as a base load facility. More recently, it operates as a merchant plant, generating electricity when its production costs are less than the market price of electricity in the New York Independent System Operator's day-ahead and hour-ahead markets. Seasonally, generation in recent years has been highest during the summer, and lowest in the spring and fall (Figure 3-7). On a daily basis, average generation is highest between 9:00 a.m. and 7:00 p.m. (Figure 3-8). Annual net generation produced between 2005 and 2009 averaged over 723,000 MWh. Annual capacity factors fell steadily over that time period, from 66% in 2005 to 30% in 2009 (Figure 3-9)

In 2005, AES entered into a Consent Decree, whereby it was agreed that by December 31, 2009, Greenidge Unit 4 would install NO_x ,SO_2, and particulate control technology, repower, or cease operations; and Greenidge Unit 3 would install emission control technology equivalent to Best Available Control Technology (BACT), be repowered, or cease operations. During each of the years 2007, 2008 and 2009, Greenidge Unit 3 was additionally subject to an annual operating limit of 1400 hours. For Unit 4, AES implemented the Multi-Pollutant Control Project. However, due to the costs of installing BACT for air emissions and to help minimize impacts of cooling water withdrawal, AES chose to cease operation of Unit 3 on December 31, 2009.

Typically, Unit 3 and Unit 4 each used two pumps during routine operation. During the summer months, a third pump on Unit 4 is utilized to maximize generating efficiency. When a unit goes offline for maintenance or repair, its circulating pumps typically do not operate. There are no variable flow controls on the cooling water system or pumps. Flow volumes (Figure 3-10) are calculated based on hours of pump operation. Nominal flow values are 17.1 kgpm per pump on Unit 3, and 22.67 kgpm per pump on Unit 4. Actual flow rates will vary with head depending on the number of pumps in operation, lake elevation, and condenser tube obstructions. The most recent circulating water pump flow tests were conducted in 1995.

Previously, when the Greenidge station had multiple operational units, winter operating parameters were followed to prevent the incidence of cold shock to fish acclimated to warmer temperatures in the discharge canal. These included not voluntarily removing all units from service between mid-November and mid-April, and following shutdown procedures for reducing load, providing additional dilution water prior to shutdown, and ceasing cooling water flow as soon as possible following shutdown. The permittee is still required to submit a schedule to NYSDEC in mid-October each year for planned outages between mid-November and mid-April.

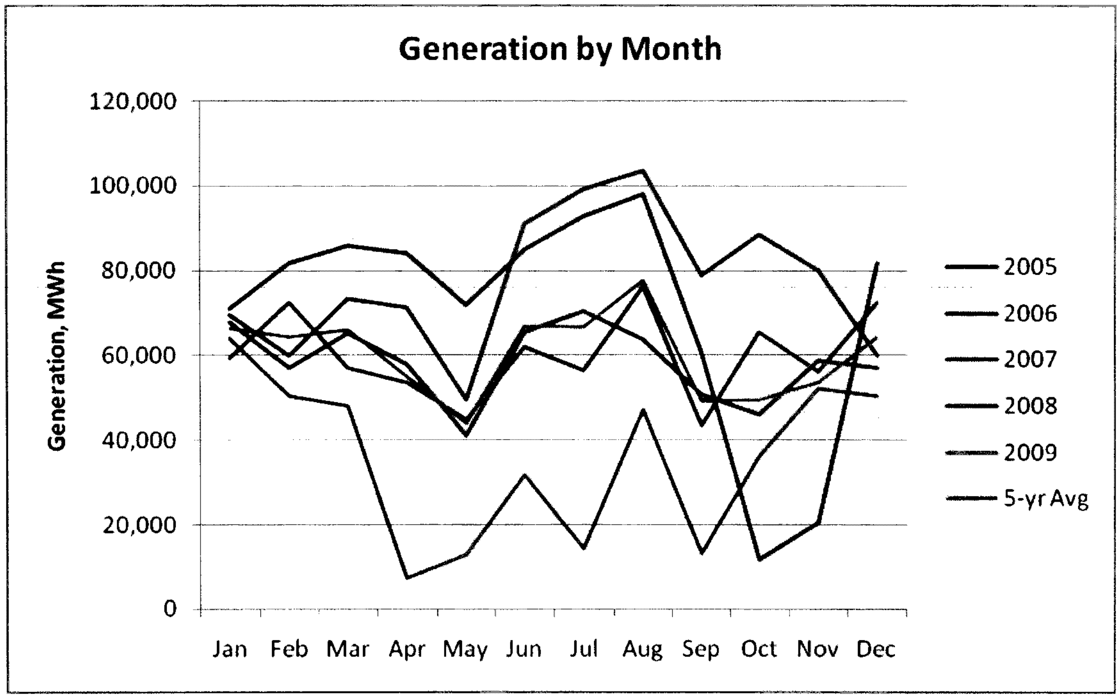


Figure 3-7 AES Greenidge Generation by Month 2005-2009

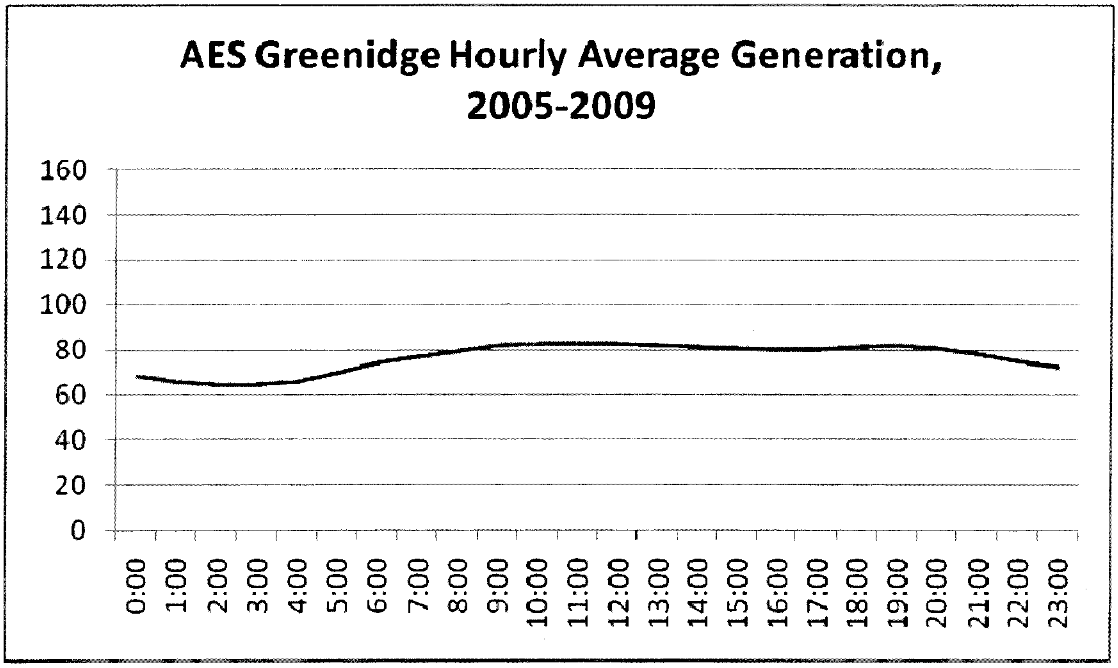


Figure 3-8 AES Greenidge Diel Fluctuation in Average Hourly Net Generation in MW, 2005-2009

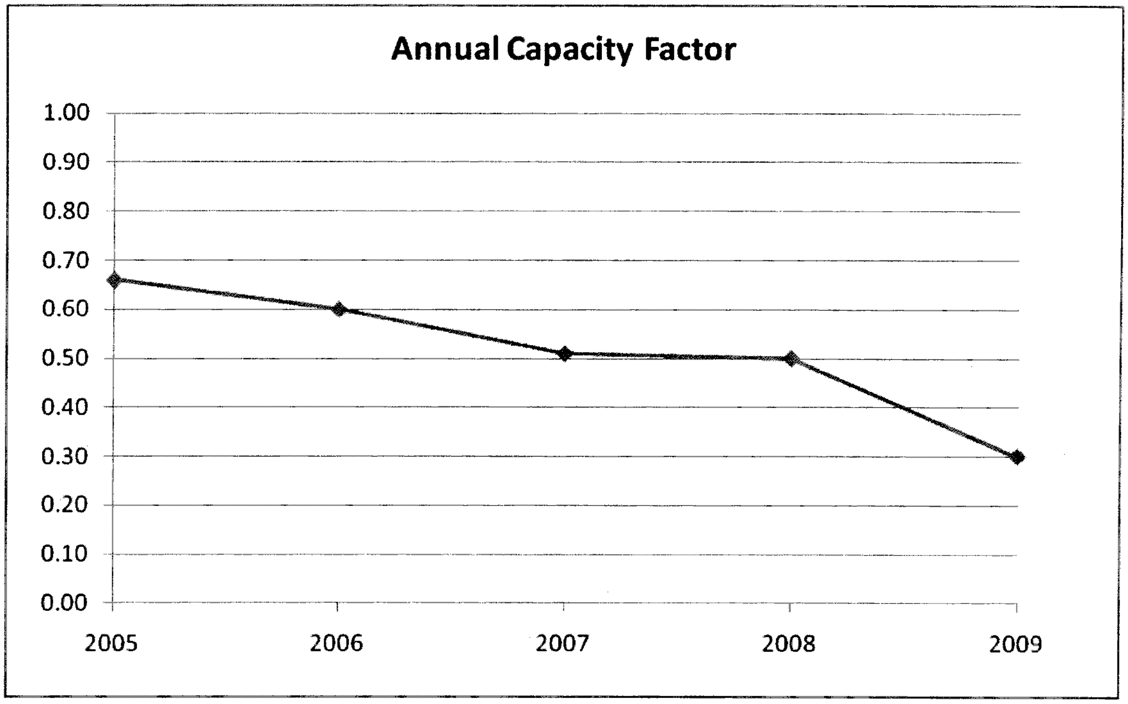


Figure 3-9 AES Greenidge annual capacity factor, 2005 - 2009

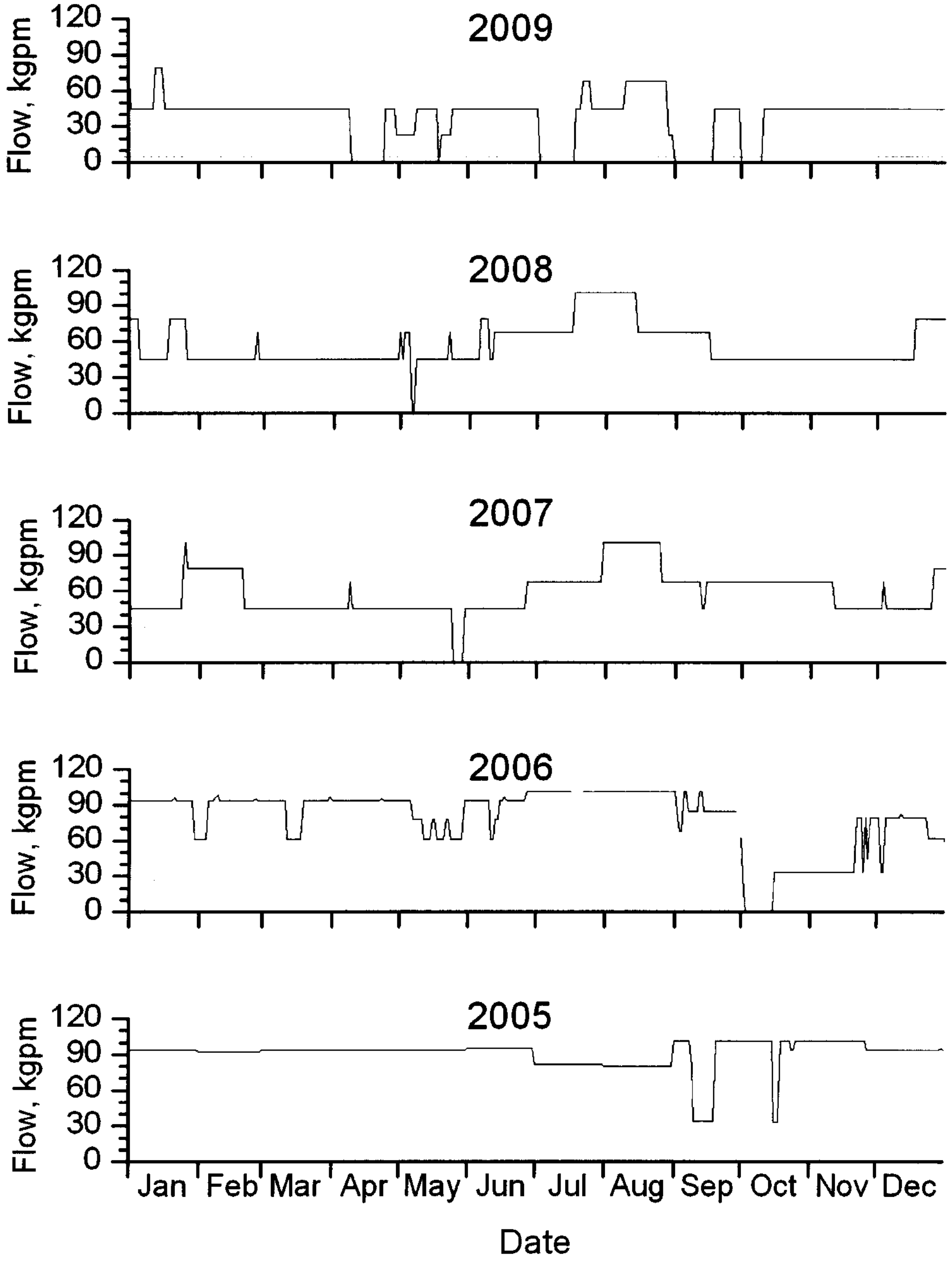


Figure 3-10 AES Greenidge Calculated Cooling Water Flow, 2005 – 2009. Data from Jan-Aug 2005 available only as monthly averages.

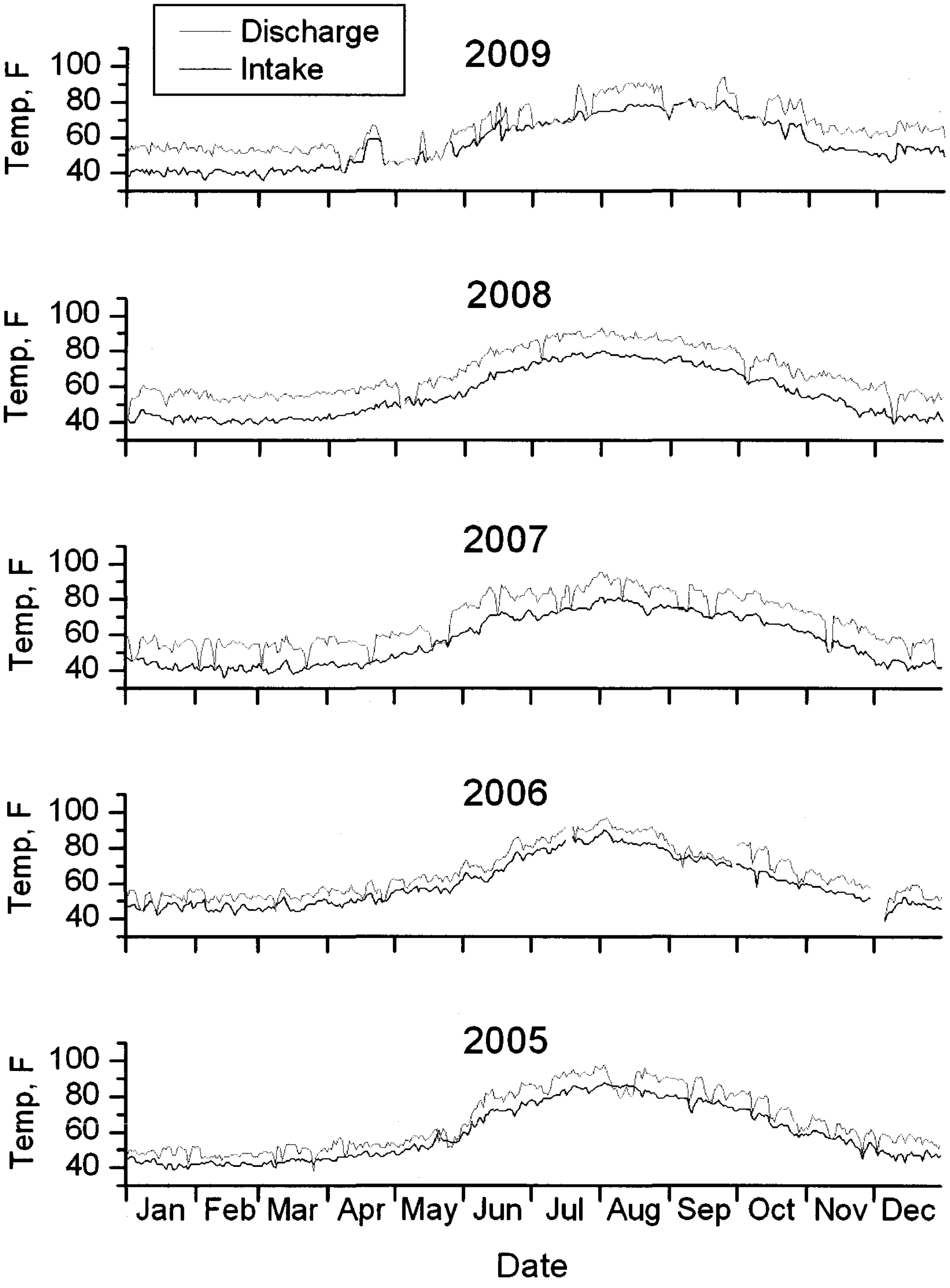


Figure 3-11 AES Greenidge average daily cooling water temperatures 2005 – 2009.

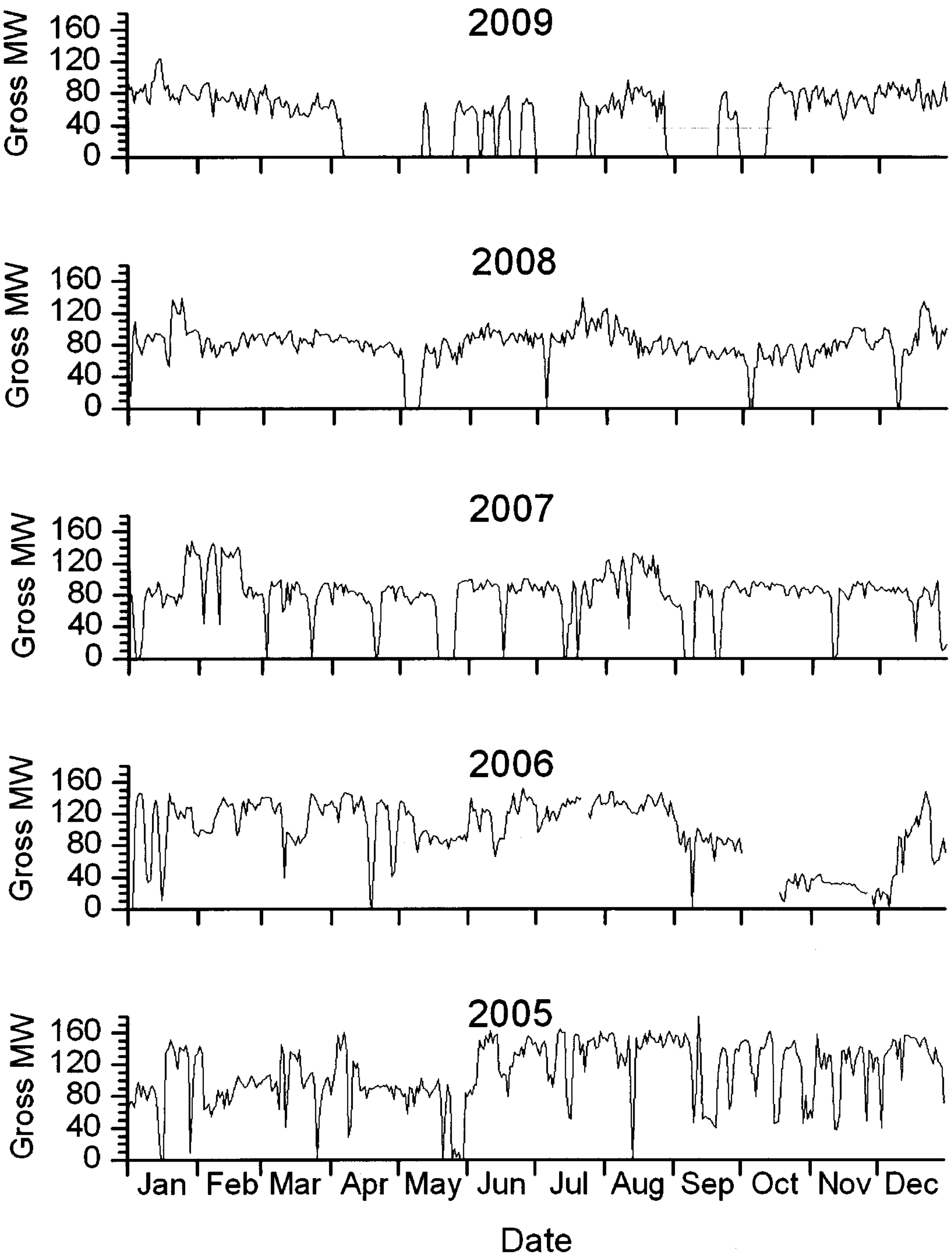


Figure 3-12 AES Greenidge Generation, 2005 – 2009

C. Entrainment and Impingement Description

This section includes a description of the source waterbody, Seneca Lake, characteristics of predominant aquatic species, and a summary of impingement and entrainment at the AES Greenidge generating station. The previously submitted Impingement and Entrainment Characterization Study (HDR, 2010d) described current levels of impingement and entrainment at AES Greenidge based on 2006-2007 studies. Salient information is provided here as a precursor to biological benefit analysis of the technology alternatives.

1) Source Water Body

Seneca Lake lies within Seneca, Yates, and Schuyler counties, New York. It is part of the Seneca-Oneida-Oswego River system that eventually drains to Lake Ontario. The city of Watkins Glen is located at the southern end and Geneva is located at the north end near where the lake drains to the Seneca River /Cayuga-Seneca Canal.

Seneca Lake is the largest of the Finger Lakes by volume, holding over 4.2 trillion gallons of water. The surface area of the lake is approximately 66.3 square miles. At its deepest point it measures 651 feet deep, with an average depth of 290 feet. It measures 35.1 miles north to south. The lake is 3.2 miles across at its greatest width, with an average width of 1.9 miles. This glacial lake lies in a long, narrow valley between ridges which reach up to 900 feet above sea level. Normal water surface elevation is 445 ft (135.6 m) above mean sea level. The water level of the lake is regulated by control structures at a dam in Waterloo, NY, located about five miles downstream from the lake outlet. Seneca Lake is drawn down about two feet in late fall for maximizing storage during the period of heavy spring runoff. Water levels are at their lowest in the winter and are allowed to rise slowly in the spring with snowmelt and runoff in anticipation of summer recreation and navigation needs.

Seneca Lake features a V-shaped bottom, with relatively steeply sloping sides. The bottom of the lake drops off precipitously from the east and west shores and is relatively uniform and symmetric around the lake centerline. In the vicinity of the Greenidge intakes, there is a shallow shelf area that extends over a thousand feet into the lake before dropping off sharply (Figure 3-13).

The Seneca Lake drainage basin is about 50 miles long and 10 miles wide, covering an area of 707 square miles. It drains a predominantly agricultural and forested watershed, discharging to the north via the Seneca River. This includes the Keuka Lake drainage basin, which drains into Seneca Lake via the Keuka Outlet. The watershed drains parts of five counties, and encompasses 44 municipalities. Approximately 70,000 people reside in the Seneca Lake drainage basin.

The Keuka Lake Outlet, which flows into Seneca Lake in close proximity to the Greenidge station, is the largest tributary. Wilson, Reeder, and Kashong creeks flow into the northern portion of Seneca Lake. Big Stream and Plum Point creeks flow into the southern portion of Seneca Lake. Numerous other small streams, intermittent streams, and gullies drain from the west and east directly to Seneca Lake. Stream flow patterns are typically seasonal, with high flows in March and April, and low flows in August and September. Groundwater inflows are also significant. An estimate of Seneca Lake's average hydraulic retention time is 20 years (Halfman & O'Neill 2009). The retention time is long due to the large volume of the lake in relation to water inputs.

Water movement within the lake is influenced by thermal stratification and winds. Stratification occurs when solar radiation sufficiently warms the surface of the lake to create a layer of less dense water (epilimnion) above a region of rapid temperature transition (the metalimnion, which includes the thermocline) and a zone of colder denser water (hypolimnion) below. When surface waters cool in the fall, the density difference diminishes, allowing the lake waters to mix again by wind energy. During most winters Seneca Lake remains well mixed and essentially isothermal, with little ice cover.

Winds contribute to water movement through drift currents, internal waves, and internal seiche oscillations. During stratification, winds can push the warm surface water toward one end of the lake (drift current), causing a slight tilt of the lake surface and movement of warm surface water in a downwind direction, with movement of cooler subsurface waters toward the other end of the lake. When winds stop, the water will rock back and forth in the basin (seiche oscillation) until the surface elevation and thermal density gradients return to equilibrium. These internal oscillations result in periodic changes in the depth of the thermocline, which are more pronounced at the northern and southern ends of the lake.

The lake is heavily used for recreational boating and fishing, and is a source of drinking water for several communities around the lake. Seneca Lake is a focus of the tourism industry in surrounding communities. Designated uses under New York's water quality standards vary for portions of Seneca Lake classified as either AA or B fresh surface waters. The water quality standards that protect the best uses for these classes are also protective of fish survival and propagation. Most of the lake is also designated (T) for trout waters, with more stringent standards for dissolved oxygen and ammonia. The best usages of Class AA waters are as a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The Keuka Lake Outlet in the area of Greenidge Station discharges is designated B(T), and Seneca Lake within a 1 mile radius of the Keuka Outlet, which includes the areas of the Greenidge Station intakes, is designated B(TS). The best usages of Class B waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish propagation and survival. The TS designation means suitable for trout spawning. Seneca Lake is listed on the NYSDEC Priority Waterbody List due to water supply concerns relating to salt levels within the lake.

Water quality indicators are moderate to good (Halfman & Bush 2006), and the lake supports a moderately high level of biological productivity. Limnological parameters indicate that Seneca Lake is borderline oligotrophic / mesotrophic. The mean total phosphorus concentration, chlorophyll-a concentration, and Secchi Disk depth recorded during the latter 1990s are 9.8 ug/l, 2.4 ug/l, and 6.0 m, respectively (Callinan 2001). Phosphorous is the limiting nutrient for primary productivity. During the 1990s, total phosphorous and chlorophyll-a levels generally declined, while water clarity increased. Reversal of the lake's downward trend in trophic status coincided with the introduction and proliferation of zebra mussels. Hypolimnetic waters within Seneca Lake appear to remain well oxygenated throughout the growing season (Callinan 2001). Seneca Lake waters are moderately hard with measurements between 140-150 mg/L CaCO3. Measurements of pH (although variable with depth, season, and time of day) are consistently within the neutral to slightly alkaline range (Callinan 2001). Seneca Lake has a relatively high chloride ion concentration for a freshwater lake, at 150 mg/L.

Because Seneca Lake thermally stratifies each year, it provides habitat for both cold water and warm water fish communities. Traditionally, lake trout, smallmouth bass and yellow perch have been the mainstays of the Seneca Lake fishery. In the decades since the first survey of the lake in 1927, other species have also contributed prominently, including rainbow trout, brown trout, landlocked Atlantic salmon, northern pike and largemouth bass. Alewives, known to be abundant in Seneca Lake at the time of the first survey, and smelt, introduced in 1909, have provided a dependable forage base for salmonids. Seneca Lake's fishery has been supplemented in recent years by annual stockings of hatchery-reared lake trout, brown trout and landlocked salmon.

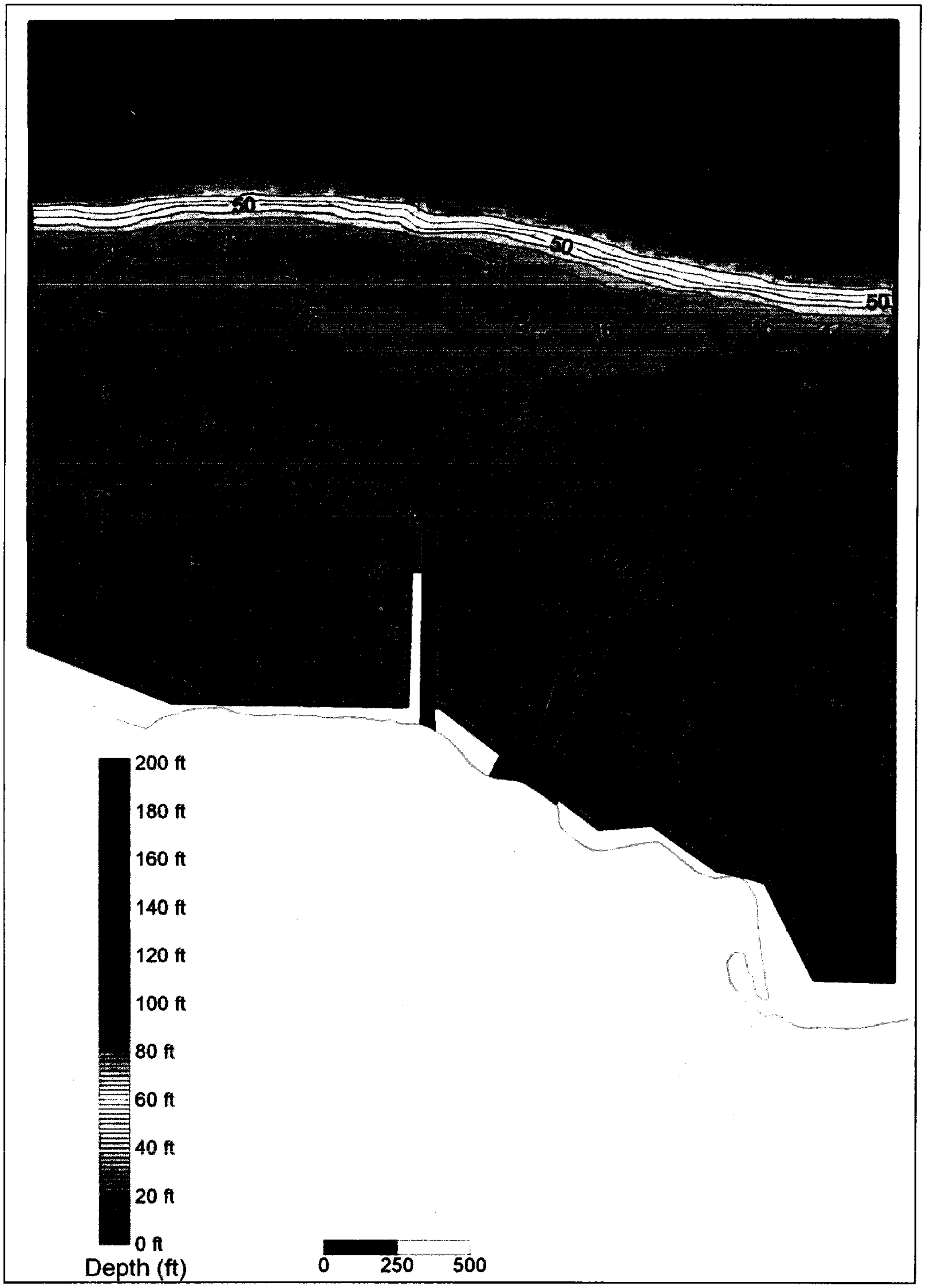


Figure 3-13 Seneca Lake bathymetric contours near AES Greenidge

2) Aquatic Species

Phytoplankton form the basis of the lake's biological productivity. These free-floating algae are the predominant primary producers, converting sunlight and nutrients into organic matter. They provide food for zooplankton and other animals higher in the food chain. Seneca Lake's phytoplankton community includes a diverse assemblage of species representing all major taxa. Over 150 taxa of algae have been identified in the lake (NYSEG 1977). The dominant phytoplankton are various forms of diatoms, which are phytoplankton that secrete siliceous frustules (shells). *Asterionella* dominates in the spring and *Fragillaria* dominates in the fall. *Certaium*, a green algae, may dominate in the summer months with occasional but brief blooms of blue green algae (*Anabaena*) and microscopic plants (*Ecballocystis*).

The dominant zooplankton are copepods, a class of organisms belonging to the phylum Crustacea. Along with benthic freshwater shrimp, rotifers and daphnia, copepods are the first-order consumers. The latter are an important source of food for young lake trout ages 1 to 4 years, whereas the former are eaten by forage fish which, in turn, are eaten by older lake trout (Halfman 1999). The abundance of zooplankton within Seneca Lake fluctuates between summer and winter. Rotifer and copepod (Crustacea) taxa co-dominate the zooplankton community in winter, which is typical of large oligotrophic lakes (NYSEG 1977).

Alewife and rainbow smelt make up a large part of the Seneca Lake fish community's forage base. Popular sport fishes include lake trout, yellow perch, smallmouth bass, rainbow trout, brown trout, landlocked Atlantic salmon, northern pike, and largemouth bass. The fishery is supplemented by annual stocking of lake trout, brown trout and landlocked salmon. There is also an active program to suppress sea lamprey, which negatively affect the lake's salmonid populations. Unidentified sunfish, brown bullhead, banded killifish, bluegill, and pumpkinseed were the most frequently encountered species in 2006 AES Greenidge impingement sampling, while alewife, white sucker, and banded killifish were most common fish species in entrainment samples. The following paragraphs describe some characteristics of the more commonly encountered species near AES Greenidge.

Ameiurus spp.

There are four species of bullhead within the genus *Ameiurus* that have been documented in New York State waters: white catfish, black bullhead, yellow bullhead and brown bullhead

(Smith 1985). Of these, only yellow and brown bullhead are likely to occur in Seneca Lake. Spawning occurs from spring to early summer. Both males and females may contribute to nest construction and care of eggs and young, but usually that duty is just the male's. Nests can be in holes in river or lake banks, in the open, or under rocks and other submerged objects. The female is clasped by the male and is stimulated to deposit a mass of sticky eggs. The male or both parents guard the nest and protect the young for a time. Young catfish form tight schools and separate individually only to hide when they have been frightened. Adult catfishes are most active at night. When they are active in daytime, it is generally in muddy, clouded water. They have poor vision and use the sense of smell and the taste buds on the skin, lips and barbels to find food (Steiner 2000). Growth in the first year of life is rapid with fish reaching 50 to over 100 mm by the end of the summer (Smith 1985).

The *Ameiurus* species collected during August 2006 ranged from approximately 30 to 80 mm and therefore can all be assumed to be age-0 fish. Collectively, these data indicate that rearing of *Ameiurus* yearlings occurs in shoreline areas in the vicinity of AES Greenidge. Older juveniles and adults were not encountered in any of the April through October finfish sampling efforts, suggesting they are not particularly abundant in the area (HDR 2010c).

Bluntnose Minnow

Bluntnose minnow is a relatively ubiquitous minnow in New York State. The species is found in a variety of lotic and lentic habitats and is often very abundant in weedy areas (Smith 1985). Bluntnose minnow spawn from the end of May to near the end of July and sometimes later in the summer in cold water habitats (Smith 1985). Most do not build nests for spawning, but scatter eggs randomly. Minnows may eat animal life, like insects, small crustaceans, clams, smaller fishes and fish eggs, or they may consume plants, like algae and other organic matter. The species is relatively small, with few individuals exceeding 100 mm.

Bluntnose minnow collected in 2006 beach seines were typically 40 to 80 mm in most months. Individuals smaller than 40 mm (not less than 10 mm) were present in July and August while individuals great than 80 mm (not exceeding 89 mm) were present in relatively low numbers in September only. It appears that age-1+ fish were present during all months of sampling while age-0 became susceptible to the gear in July and were collected as late as October. Bluntnose minnow collected in bottom trawl collections ranged in length from 30-50 mm in April and May and are therefore likely age-1+ fish. Collections in October included 40 to 49 mm and 80 to 89 mm bluntnose minnow suggesting age-0 and age-1+ fish were present in the sampling location during this time of year. Overall, bluntnose minnow appears to be a common species in the nearshore finfish community in the vicinity of AES Greenidge (HDR 2010c). The species is relatively abundant in both juvenile and adult life stages. Bluntnose minnow is an important food source for higher trophic level fishes including certain gamefish.

Banded Killifish

Banded killifish, a member of the topminnow family, are common and found throughout New York State. Banded killifish are commonly found in weedy shallows of lakes and ponds and slower moving parts of streams. This species is relatively small, rarely growing longer than 120 mm. Banded killifish spawn in spring with reports as late as September, (Froese and Pauly 2007) or when temperatures reach 70 degrees (Steiner 2000). The male chooses a site and defends it against other males and intruders. As the male pursues a female, the female emits one egg, which stays attached to the female's body by a fine strand. When the male pursues the female even more persistently, they come together and the female then emits up to 10 eggs, which also stay attached for a short period. The eggs then fall to the bottom. The spawning pair separates, and when the female moves off, the male pursues her again. This behavior continues until some 50 eggs are deposited in about five minutes. Neither the male nor the female guards the nest or the eggs, which hatch in about three days. Killifish feed at the surface, mid-water and near the bottom on midge larvae and insects. The larger fish consume insects, mollusks and worms (Steiner 2000). By the end of their first summer, age-0 fish reach a length of between 20 and 58 mm (Smith 1985).

Banded killifish were the second most abundant species in beach seine samples (20.5% of the total collected) and third most abundant in the bottom trawl samples (7.9% of the total). Banded killifish were collected during each month of sampling of the beach seine (April through October). Catches were lowest in April and May and highest in August and September. Individuals captured ranged in length from approximately 10 to 99 mm over the period of sampling. Age-1+ appeared to be present during all months of sampling while age 0 first appeared in July, were abundant in August, and remained in the sample area through the end of sampling in October. Banded killifish were only collected during April and October with the bottom trawl (based on April through July and October samples) and only in August with the pelagic trawl (April through October sampling). Catches in the pelagic trawl were too small to be informative about length frequency. In bottom trawl samples, fish collected in April appear to be age-1+ fish ranging from 30-60 mm. Age-0 banded killifish were comprised the collection in October and ranged from 30-50 mm. There was no catch in the intervening months suggesting the fish were inshore during this period. Banded killifish are a particularly abundant species in the vicinity of AES Greenidge and use both nearshore and offshore habitats throughout their life history (HDR 2010c).

Lepomis spp., Pumpkinseed and Bluegill

Of the six *Lepomis* species found in New York State, pumpkinseed and bluegill are the most common. Early life stage of these two species can be difficult to differentiate in the field. As a result, field sampling programs often report catches for *Lepomis* species, pumpkinseed and bluegill. Bluegills spawn during a longer period than most sunfish, from May, through August. The males fan small, saucer-like depressions in sand and gravel as nests, and vigorously guard the eggs and hatched young. Large numbers of nests are often in the same area and form colonies. One female may deposit as many as 38,000 eggs in a nest. Bluegill eggs hatch in two to five days. Because several females have contributed, there may be more than 60,000 young fish produced from a single nest. Bluegills may overpopulate their habitat, resulting in smaller and slower-growing fish. As generalized feeders, bluegills eat aquatic insects, crustaceans and minnows, and they have been known to eat aquatic plants. The bluegill feeds only in the daytime and throughout the water column. It may grow to a foot long and up to two pounds, although nine inches is an average (Steiner, 2000). Pumpkinseeds spawn in late May to early June. The males clear small, saucer-shaped nests on the bottom in water three feet deep or less. Pumpkinseeds nest in small groups of up to three nests, but these groups of nests can be very close. The nests may have several thousand eggs each, which have been deposited by several females. Although the nest is guarded, other males may rush in and fertilize eggs. It takes about three days for the eggs to hatch, and each nest may produce more than 14,000 young pumpkinseeds. Pumpkinseeds may hybridize with bluegills and green, redbreast, long-ear and other sunfish. They feed heavily on snails and have special throat structures for doing so. Pumpkinseeds feed mostly on the bottom of a stream or pond, where they also eat burrowing and other aquatic insects (Steiner, 2000).

During 2006 sampling, the three *Lepomis* categories accounted for 1.3%, 5.5% and 1.0% of the total beach seine collections and 56.3%, 0.0% and 2.0% of bottom trawl collections, respectively. A single *Lepomis* species was collected in the pelagic trawl accounting for 50% of the total catch in that gear. *Lepomis* species were moderately abundant in bottom trawls in April through June and most abundant in October, while bluegill were present only in May. Beach seine catches were different in that no *Lepomis* species, bluegill or pumpkinseed was collected in April and May. Catches of pumpkinseed, the most abundant of the three taxa in beach seine catches peaked in July and August. *Lepomis* species peaked in August while bluegill has similar high catch values in July and August. Pumpkinseed collected in beach seines displayed a relatively wide range of lengths (40 – 229 mm) present in the sample area. June collections showed a number of age classes present (age 0 to possibly age 3), likely related to the spawning season as both pumpkinseed and bluegill spawn from early to late summer (i.e., as early as May to as late as August). July through September collections showed abundant lengths from 60 to 110 mm likely representing primarily age-1+ and some age 0 fish. In bottom trawls, *Lepomis* species were all less than 60-mm representing the age-0 and age-1 fish that cannot be differentiated as either pumpkinseed or bluegill. Age-0 and small age-1 *Lepomis* species appear to be present during April through June. By October it appears that age-0 fish predominated in the catches, measuring between 20 and 60 mm.

Based on numerical dominance in the trawl collections, *Lepomis* appear to be an important component of the fish community in the vicinity of AES Greenidge. Nearshore areas are used for spawning and rearing of young of these species while it appears that the majority of age-0 *Lepomis* move offshore (~30-foot depth contour) in the fall (HDR 2010c).

Slimy Sculpin

Slimy sculpin is one of four freshwater sculpin species found in New York State. Slimy sculpin occur in lakes and streams and are associated with bottom habitats. In lakes, slimy sculpin inhabit offshore areas at depth typically over 20 feet and in some waterbodies deeper than 300 feet. Sculpins spawn in early spring. The eggs are frequently laid on the underside of a rock, in a sticky mass. The male guards the nest as the eggs develop. They hatch in two or three weeks (Steiner 2000). Slimy sculpin are small, typically measuring less than 120 mm as adults (Smith 1985).

Consistent with their preference for deep water habitats in lakes, slimy scuplin were only collected in bottom trawl during 2006 sampling. Slimy sculpin accounted for 9.3% of the total collected with that gear and catches were limited to the months of April through June. Slimy sculpin collected in bottom trawls ranged from 50-90 mm in April through June collections and are therefore expected to be comprised of age-1 and older fish (HDR 2010c).

Spottail Shiner

Spottail shiner is one of the numerous Notropis species, or eastern shiners, found in New York State. Spottail shiner are found in a variety of habitats including large lakes and rivers and small streams. Spawning is thought to take place in June or July, typically at the mouth of streams. Ovarian egg counts range from 100 to 2,600 depending on size of the female (Smith 1985). Adults are small, typically measuring less than 150 mm.

Spottail shiner were the third most abundance species in beach seine samples (accounting for 10.4% of the total catch) and seventh in bottom trawl samples (accounting for 3.3% of the total catch). Spottail shiner were very abundant in beach seines in June with few or no individuals collected in other months. In bottom trawls, individuals were only collected during May. Spottail shiner generally ranged from 30 to 79 mm during April through October sampling, with a single large individual (120 – 129 mm) collected in July. Age-0 spottail shiner may be present as early as June and were relatively abundant in August. Too few individuals were collected in bottom trawls to examine length frequency. Spottail shiner likely represent an important food resource for higher trophic level fishes (HDR 2010c).

Tessellated Darter

Tessellated darter is one of the numerous Etheostoma species, or smooth-belly darters, found in New York State. Tessellated darters are one of the more common of these species and are found throughout the state. This species occurs in both lentic and lotic habitats, but has a preference for quieter areas (Smith 1985). Tessellated darters spawn in the spring, around May or June. The female deposits adhesive eggs on the tops and sides of rocks. The female quivers as she drops her eggs, and the male fertilizes the eggs as he swims slowly over them. After spawning, the female leaves the nest, while the male remains to guard the eggs. The male aerates the eggs either by swimming upside down, fanning them with his pectoral fins, or by holding his position with the pectoral fins and fanning with his tail. The eggs take about three weeks to incubate at 65 degrees. Tessellated darters feed mostly on small insects and crustaceans at first. As the fish grow, they consume bigger insects (Steiner 2000). Tessellated darters stay relatively small, occasionally reaching 110 mm in length (Frose and Pauly 2007).

Tessellated darter was the fifth most abundant species in bottom trawl collections (contributing 6.0% to the total catch) and 12th in the beach seine collections (contributing 0.7% to the total collected). Tessellated darter were collected in all months of sampling with the bottom trawl except July, with no month standing out as a distinct peak. In beach seine sampling, tessellated darter were collected in every month with peak abundance occurring in August. Tessellated darter ranged from 40 to 70 mm over the course of bottom trawl sampling. Given that tessellated darters are thought to spawn in May and June, these fish appear to be age-1 fish present in the sampling area during April through June with age-0 and age-1 fish present in October. Based on 2006 sampling, it appears that tessellated darter is a moderately abundant species in the vicinity of AES Greenidge (HDR 2010c).

3) AES Greenidge Impingement and Entrainment

Impingement and entrainment studies were conducted at AES Greenidge in 2006 and 2007. Results of those studies were reported in the Impingement and Entrainment Characterization Study Report (HDR 2010d), and three supporting documents: the AES Greenidge Generating Station 2006 Ichthyoplankton and Entrainment Studies (HDR 2010a); the AES Greenidge Generating Station 2006-2007 Impingement Study (HDR 2010b); and the AES Greenidge Generating Station 2006-2007 Finfish Community and Waterbody Studies (HDR 2010c). Due to standardization of the 2006 flow calculations, revised estimates of actual and full flow entrainment and impingement are presented in Appendix F of this document.

Because AES Greenidge Unit 4 has no screens, fish (potentially including eggs, larvae, juveniles, and adults) that enter the Unit 4 cooling water intake are ultimately entrained through the facility. Some fish may be impinged on the condenser tube face for a period of time, but backwashing of the condenser will ultimately convey these fish to the discharge. The configuration of Unit 4 also does not allow for entrainment or impingement sampling upstream of the circulating water pumps. As a result, entrainment and impingement sampling at AES Greenidge has been conducted at Unit 3 and these data are used as the basis for characterizing potential entrainment and impingement for Unit 3 and Unit 4, where "impingement" at Unit 4 as reported herein represents potential entrainment of juvenile and adult fish at that unit. (HDR, 2010b).

Current and Full Flow Annual Impingement

An annual total of 9,645 (with a 95% confidence interval of 4,059 - 15,529) fish and crayfish were estimated to have been impinged at AES Greenidge based on the 2006-2007 study (See Appendix F). This estimate, which accounts for the total cooling water intake volume at Unit 3 and Unit 4, was comprised of 8,477 fish and 1,168 crayfish. Of this total, 3,853 organisms (approximately 40%) were attributable to the Unit 3 intake flow and 5,792 organisms (approximately 60%) were attributable to Unit 4. Total impingement peaked in January and February with those months contributing 3,325 and 1,358 organisms to the total, respectively. The three lowest monthly impingement estimates occurred in the spring with March, April, and May contributing 32, 250, and 225 organisms to the total, respectively.

Lepomis species were impinged in the greatest number with a total estimate of 3,475 individuals. Pumpkinseed and bluegill, which are of the genus *Lepomis,* contributed an additional 651 and 939 organisms to the total, respectively. When taken together, *Lepomis* accounts for 53% of the total estimated annual impingement. Other taxa contributing to impingement included brown bullhead (1,227), crayfish (1,168), banded killifish (1,010), alewife (542), largemouth bass (226), and bluntnose minnow (107). All other taxa contributed less than 1% to the estimated total impinged.

Under full rated flow of the circulating water pumps (102.2 kgpm), it is estimated that annual impingement at AES Greenidge would be 16,452 individuals, of which 14,911 (91%) are fish and 1,541 (9%) are crayfish. Impingement would be highest during the months of January (5,187) and October (2,893) and lowest during March (48) and April (323). In terms of the fishes, sunfish species would be impinged at the highest annual rate (7,042/year), followed by banded killifish (1,884/year), brown bullhead (1,863/year), bluegill (1,438/year) and pumpkinseed (1,122/year); all other fishes would be impinged at a rate of less than 1,000/year.

Current and Full Flow Annual Entrainment

A total of more than 532,000 early life stage fish (with a 95% confidence interval of 52,100 – 1,189,800) were estimated to have been entrained at AES Greenidge during April through September, 2006. Of the total, 181,000 (34%) individuals are attributable to the flow from the now retired Unit 3 while 351,600 (66%) are attributable to Unit 4. The total combined Units estimate, which accounts for the total cooling water intake flows (i.e., Unit 3 and Unit 4 cooling water intake volumes), is comprised of approximately 208,000 eggs, 23,000 yolk-sac larvae, 143,900 post-yolk-sac larvae, 46,300 unidentified-life stage (YS/PYS) larvae, and 111,400 juveniles. Total entrainment peaked in June (183,000 organisms) and July (205,500). Alewife eggs, banded killifish juveniles and post-yolk-sac white sucker larvae were entrained in the greatest number with a total of 140,300, 81,900, and 80,000 respectively. Other species and life stages contributing to entrainment were post-yolk-sac banded killifish (24,700), unidentified life stage sucker larvae (25,100) and unidentified eggs (57,000). All other species and life stages contributed less than 17,000 individuals to the estimated total entrainment.

Under full rated flow of the circulating water pumps (102.2 kgpm) during April through September, an estimated 662,900 early life stage fish would be entrained at AES Greenidge. Of these months, entrainment would be highest during June (24,900) and July (210,600). June entrainment would include a number of species, but be comprised mostly of alewife eggs (77%) while June entrainment would be distributed primarily among banded killifish juveniles (40%) and post yolk sac larvae (12%) and unidentified eggs (24%). Alewife (eggs only) would be entrained in the largest numbers (187,800) followed by white sucker (141,900) and banded killifish (109,200); all other taxa would be entrained at a rate of approximately 40,000 or less per year.

Table 3-1 Minimum, Average and Maximum Length (mm) and Weight (g) for Taxa Collected in Impingement Samples at AES Greenidge Generating Station, 2006-2007

Common Name	ScientificName	Length (mm)			Number Measured	Weight (g)			Number Weighed
		Min	Avg	Max		Min	Avg	Max	
Alewife	*Alosa pseudoharengus*	84	144	164	25	2	18	25	26
Banded Killifish	*Fundulus diaphanus*	30	66	91	39	1	3	6	40
Basses and Sunfishes	Centrarchidae spp.	57	57	57	1	3	3	3	1
Bluegill	*Lepomis macrochirus*	42	54	106	26	1	2	20	26
Bluntnose Minnow	*Pimephales notatus*	55	60	75	4	1	2	3	4
Brown Bullhead	*Ameiurus nebulosus*	46	81	317	49	1	24	469	49
Bullheads and Catfishes	Ictaluridae spp.				0	426	426	426	1
Crayfish	Astacidae	26	63	96	60	1	9	29	60
Lamprey species*	Petromyzontidae spp.				0	406	406	406	0
Largemouth Bass	*Micropterus salmoides*	45	97	237	6	1	69	388	6
Pumpkinseed	*Lepomis gibbosus*	46	68	158	31	1	9	97	31
Rock Bass	*Ambloplites rupestris*	51	53	55	2	2	3	3	2
Smallmouth Bass	*Micropterus dolomieu*	56	63	70	2	2	3	4	2
Spottail Shiner	*Notropis hudsonius*	57	79	108	3	2	6	12	3
Sunfish species	*Lepomis* spp.	38	46	75	158	1	1	9	158
Unidentified	Unidentified	40	40	40	1	1	1	1	1
Yellow Perch	*Perca flavescens*	243	284	325	2	140	305	470	2

*estimated weight

Table 3-2 Mean Monthly Impingement Density (Number per million m³) at AES Greenidge Generating Station, 2006-2007

Common Name	Scientific Name	Mean Monthly Impingement Density (Number per million m^3)*												Monthly Average
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Sunfish species	*Lepomis* spp.	197.0	8.3		1.4	3.7			2.7	7.1	119.1	34.6	36.0	**34.2**
Brown Bullhead	*Ameiurus nebulosus*	3.5	63.6				2.8		10.9	4.2	11.5	15.5	2.8	**9.6**
Banded Killifish	*Fundulus diaphanus*	43.7			6.9			1.5	1.1		9.7	36.6	11.1	**9.2**
Crayfish	Astacidae				8.3	11.2	31.8	22.1	3.9	6.2	4.1	3.2		**7.6**
Bluegill	*Lepomis macrochirus*	34.7	13.7	2.8							3.0		30.4	**7.0**
Pumpkinseed	*Lepomis gibbosus*		30.5		2.8			4.2	1.1	1.7	14.3	11.1	2.8	**5.7**
Alewife	*Alosa pseudoharengus*					2.5	6.9	25.6						**2.9**
Largemouth Bass	*Micropterus salmoides*	14.6						1.4	2.2		1.4			**1.6**
Bluntnose Minnow	*Pimephales notatus*								1.6	4.2	1.5	2.8		**0.8**
Smallmouth Bass	*Micropterus dolomieu*	6.9												**0.6**
Spottail Shiner	*Notropis hudsonius*						2.8	1.3						**0.3**
Bullheads and Catfishes	Ictaluridae spp.					3.7								**0.3**
Rock Bass	*Ambloplites rupestris*									2.1	1.5			**0.3**
Yellow Perch	*Perca flavescens*							1.5			1.5			**0.2**
Basses and Sunfishes	Centrarchidae spp.					2.1								**0.2**
Lamprey species	Petromyzontidae spp.									2.1				**0.2**
Unidentified	Unidentified								1.1					**0.1**
Total Monthly Impingement		**300.3**	**116.2**	**2.8**	**19.4**	**23.3**	**44.2**	**57.6**	**24.7**	**27.5**	**167.5**	**103.7**	**83.0**	**80.8**

*blank cells have a value of zero

Table 3-3 Minimum, Mean and Maximum Length (mm) of Yolk-sac Larvae (YS), Post-yolk-sac Larvae (PYS), Unidentified-lifestage Larvae (YS/PYS) and Juvenile (JUV) Collected in AES Greenidge Generating Station Entrainment Samples, 2006

Common Name	Scientific Name	LifeStage	Month	Length (mm)			Number Measured
				Min	Mean	Max	
White Sucker	*Catostomus commersonii*	PYS	April	13.5	13.7	13.9	3
		YS	May	13.7	13.7	13.7	1
		PYS	May	13.7	14.0	14.4	2
		YS/PYS	May	13.8	13.8	13.8	1
Darters	Etheostoma spp.	YS	June	4.3	4.8	5.3	2
Yellow Perch	*Perca flavescens*	PYS	June	6.7	6.7	6.7	1
Banded Killifish	*Fundulus diaphanus*	PYS	July	7.7	8.9	11.0	3
		JUV	July	14.3	16.1	20.3	8
Carp	*Cyprinus carpio*	JUV	July	25.3	25.3	25.3	1

Table 3-4 Mean Monthly Entrainment Density (Number per 100 m^3) at AES Greenidge Generating Station, 2006

Common Name	Scientific Name	Life Stage	Entrainment Density (Number per 100m^3)*						Average
			Apr	May	Jun	Jul	Aug	Sep	
Alewife	*Alosa pseudoharengus*	EGG			1.12				**0.19**
		YS							
		PYS							
		YS/PYS							
		JUV							
Banded Killifish	*Fundulus diaphanus*	EGG							
		YS							
		PYS				0.15			**0.02**
		YS/PYS							
		JUV				0.49			**0.08**
Brook silverside	*Labidesthes sicculus*	EGG			0.05				**0.01**
		YS							
		PYS							
		YS/PYS							
		JUV							
Bullhead Species	*Ameiurus* spp.	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV						0.10	**0.02**
Carp	*Cyprinus carpio*	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV				0.10			**0.02**
Carps and Minnows	Cyprinidae spp.	EGG			0.05				**0.01**
		YS			0.05				**0.01**
		PYS				0.10			**0.02**
		YS/PYS							
		JUV							
Darters	Etheostoma spp.	EGG							
		YS			0.10				**0.02**
		PYS							
		YS/PYS							
		JUV							
Suckers	Catostomidae spp.	EGG							
		YS							
		PYS							
		YS/PYS	0.20						**0.03**
		JUV							
Unidentified	Unidentified	EGG			0.05	0.29			**0.06**
		YS							
		PYS					0.10		**0.02**
		YS/PYS				0.10			**0.02**
		JUV							
White Sucker	*Catostomus commersoni*	EGG							
		YS		0.05					**0.01**
		PYS	0.29	0.44					**0.12**
		YS/PYS		0.05					**0.01**
		JUV							
Yellow Perch	*Perca flavescens*	EGG							
		YS							
		PYS			0.05				**0.01**
		YS/PYS							
		JUV							
Total Entrainment Density		**EGG**			**1.27**	**0.29**			**0.26**
		YS		**0.05**	**0.15**				**0.03**
		PYS	**0.29**	**0.44**	**0.05**	**0.24**	**0.10**		**0.19**
		YS/PYS	**0.20**	**0.05**		**0.10**			**0.06**
		JUV				**0.58**		**0.10**	**0.11**
		ALL	**0.49**	**0.54**	**1.47**	**1.22**	**0.10**	**0.10**	**0.65**

*blank cells have a value of zero

4. Alternative Technology Review

AES Greenidge presents a relatively unusual set of conditions for minimizing fish and shellfish entrainment and impingement mortality. Both units have offshore, but not deepwater, intakes. Unit 3 has conventional traveling screens; however, on December 31, 2009 Unit 3 was retired. At Unit 4, which is expected to have moderate capacity factors in the future, the intake pipe is supported on piles above the lake's surface, and draws water into the plant by suction. The mouth of the intake faces downward near the lake's bottom, and is surrounded by bar racks that prevent large debris from entering the intake pipe. There are no traveling screens on Unit 4 and because of the suction lift that must be maintained in the intake system, it would not be practicable to install them. The following sections evaluate potential technology options for AES Greenidge which may reduce impacts to fish due to the withdrawal of cooling water at the facility.

Over the last 5 years, generation at the station peaked at a capacity factor of 66% in 2005, and declined to 30% in 2009. Future operating patterns for AES Greenidge are uncertain, but the evaluation of alternatives will be done based on the cooling water flows from each of the last five years, then averaged to obtain the expected percent reductions in entrainment and impingement losses. Only Unit 4 flows will be used to evaluate alternatives because Unit 3 is now retired.

Estimated equivalent age 1 impingement losses at AES Greenidge Unit 4 have ranged from 4,423 to 8,003 (Table 4-1, Figure 4-1). The average percent reduction from the full flow levels ranged from 33% to 64%, with a recent 5-year average of 49%. The reductions from baseline levels are due primarily to the retirement of Unit 3, reduced operating levels and use of less than full flow at Unit 4 in the cooler months.

Estimated equivalent age 1 entrainment losses at AES Greenidge have ranged from 14,765 to 43,905 (Table 4-1, Figure 4-2). The average percent reduction from the full flow levels of entrainment range from 37% to 68%, with a recent 5-year average of 47%.

Table 4-1 Estimated baseline equivalent age 1 losses from impingement and entrainment at AES Greenidge, and estimated 2005-2009 losses with current technology.

	Unit 4 - Current Tech			
	Baseline	Technology Performance		
	Equivalent Age 1 Loss		Equivalent Age 1 Loss	Average % Reduction
Impingement	11,753	Best year	4,423	64
		Worst year	8,003	33
		5-year mean	5,783	49
Entrainment	66,045	Best year	14,765	68
		Worst year	43,905	37
		5-year mean	37,629	47

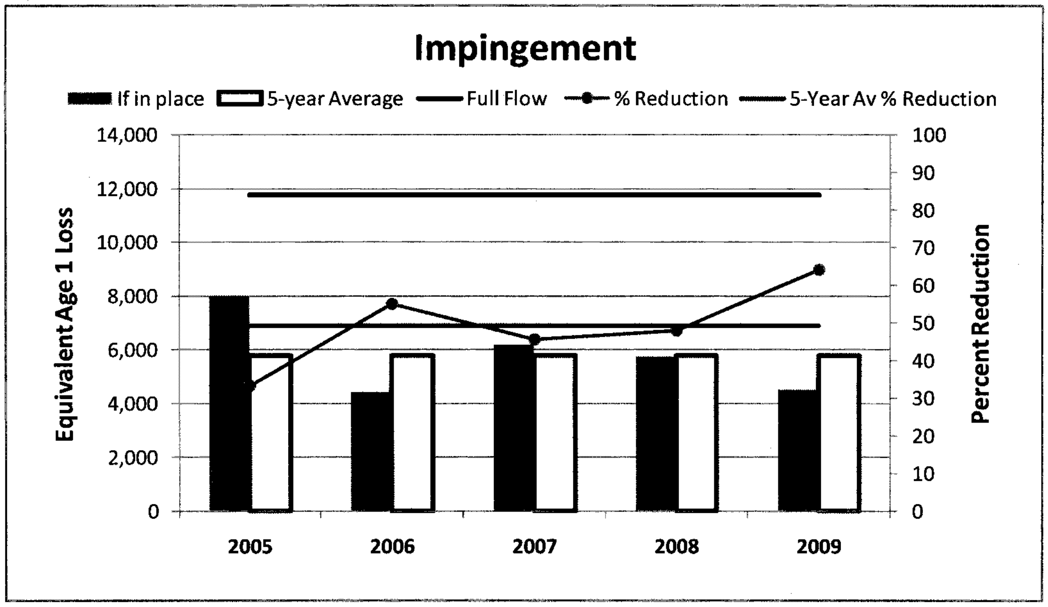


Figure 4-1 Estimated annual equivalent age 1 impingement loss from 2005-2009 at AES Greenidge Unit 4 based on actual operation, and average percent reduction from baseline levels.

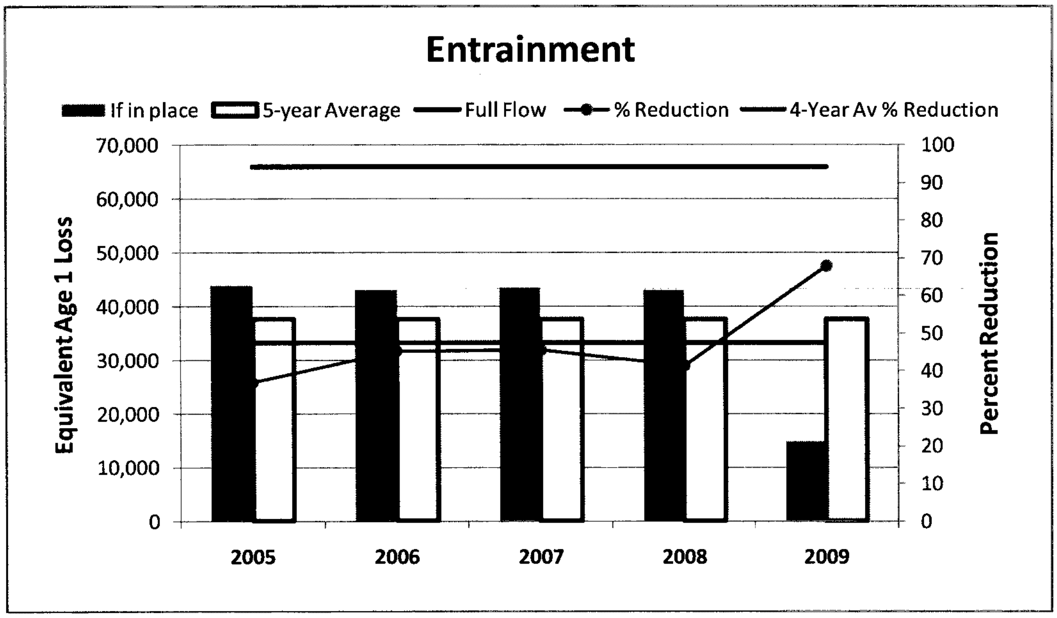


Figure 4-2 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge Unit 4 based on actual operation, and average percent reduction from baseline levels.

A. Reduced Involvement Technologies

1) Exclude from Intake Structure

a. Barrier net

i. Description

Barrier nets are a physical exclusion system that, depending on mesh size, prevents organisms above a certain size from entering a plant's intake. Barrier nets have proven very effective at reducing impingement, and therefore impingement mortality, at several locations on different waterbody types with successful deployment dependent on site physical and water quality conditions and facility operating conditions. Barrier nets are best suited for deployment in quieter waters, typically small to medium-sized lakes and protected riverine or estuarine areas (USEPA 2004).

Selection of the net construction material and mesh size is primarily determined by site-specific factors, such as bathymetry, water velocity, and debris-loading potential (clogging and bio-fouling). Under conditions of severe debris loading, barrier nets are designed to collapse, permitting water to flow over the top of the net. Biological factors, including species, size, and spatial and temporal distribution patterns must be considered in determining the location, length and mesh size of the barrier net. Barrier nets may not be useable during winter conditions in colder climates where ice accumulation on the net is likely. The net can become embedded in surface ice, and may tear when the ice breaks up or begins to move. Ice formation will also impede the ability to perform routine maintenance such as debris removal or cleaning. In colder climates, nets can be temporarily removed during anticipated periods of ice formation, or they can be completely submerged to a depth where ice formation is not expected to occur. Air bubbler systems have been deployed in certain cases to prevent or minimize ice formation on barrier nets.

A 600-foot, 0.95-cm Delta mesh multifilament nylon barrier net has been deployed seasonally in front of the intake at the Bowline Point Generating Station in Haverstraw, New York (Hudson River) since 1976 to reduce fish impingement. Subsequent monitoring demonstrated a 90% to 95% reduction in impingement of target species, primarily white perch (*Morone Americana*) and striped bass (*Morone saxatilis*) during the late fall through spring months (October through May) when it is installed. Some problems with debris accumulation (macroalgae and leaf litter) on the net were documented during early deployment years (e.g., 1982 and 1987 to 1988), temporarily causing the net to lift off the river bottom, resulting in higher impingement rates. However, these problems were usually corrected within 24 hours (Hutchison and Matousek 1988) and modified deployment techniques have limited problems during the most recent years.

Other power generation facilities that have successfully used barrier net technology to reduce impingement include the J.P Pulliam Station in Wisconsin (Fox River), where an impingement reduction of 90% over conventional traveling screens was reported when the barrier net was installed; the Ludington Pumped Storage Plant on Lake Michigan, which has reported an effectiveness of 80% to 96% since deployment of a 2.5-mile long barrier net in 1991; the J.R. Whiting Plant, located on Maumee Bay, Lake Michigan, which reported a 98% reduction in impingement over a four-year period (1980 through

1984); and the Chalk Point Generating Station located on the Patuxent River in Maryland. The latter is an unusual application in that it was deployed primarily to reduce impingement of blue crabs (*Callinectes sapidus*), and has done so by 84% (USEPA 2004).

ii. Conceptual Design

A 3/8-inch mesh or similarly sized barrier net could be designed to encircle the Unit 4 intake with the objective of reducing impingement mortality. The net would be supported by intermediate piles, bottom anchors, and top floatation. A breakaway panel could be installed to reduce damage to the nets and support systems if severe debris loading occurred. However, impingement at AES Greenidge is highest during October through February. The potential for ice formation during this period, combined with cold water temperatures and the attendant safety concerns for maintenance workers, would make the operation of a net during the impingement period problematic. Given these considerations and the fact that a barrier net would not be effective in reducing entrainment, a detailed conceptual design of the barrier net has not been developed.

iii. Feasibility/Practicability Determination

In the recent impingement monitoring survey (2006-2007) conducted at AES Greenidge, 79% of mean impingement density over a 12-month period was documented to occur during the months of October through February. Much of this period coincides with the period when potential icing would occur during extended plant shut down. Such icing would compromise the performance of the net and safety of workers performing maintenance on the net. In addition, the net would provide no reduction in entrainment losses. Given these considerations and the fact that there are other more feasible alternatives such as wedgewire screens that address both entrainment and impingement, barrier nets are not considered further in this review of candidate technologies.

iv. Time required to implement

Not applicable.

v. Costs

Not applicable.

vi. Adverse environmental impacts

Not applicable.

b. Aquatic Filter Barrier

i. Description

The Gunderboom® Marine Life Exclusion System™ ("MLES" or "Gunderboom") is a relatively new type of barrier system intended to screen all life stages of fish by using a filtering fabric with a small pore size and a low filtration velocity. The Gunderboom is comprised of polyester fiber strands pressed into a water permeable fabric mat and has considerable potential for reducing ichthyoplankton entrainment and impingement. The Gunderboom has an air purge system installed between the filtering fabric layers to permit automatic cleaning of silt and debris. The system is designed to completely surround the intake structure, away from the shoreline, and to be fully sealed against the waterbody bottom and shoreline structures, so that all intake water passes through the fabric at a low velocity (LMS Engineers 1997).

The first and only full plant deployment of the MLES was conducted at the Lovett Generating Station, located on the Hudson River in Stony Point, Rockland County, New York, starting in April of 2004. Pilot testing and limited scale deployment of the Gunderboom was begun at Lovett in the mid-1990s, and yielded significant reductions in entrainment (up to 82% from 1999 to 2001). Preliminary data on the effectiveness of the full-scale (2004 and later) MLES deployment at Lovett indicates 80% to 90% effectiveness. Operational difficulties associated with Gunderboom deployment at

Lovett have included tearing, barrier overtopping and clogging of the filter curtain; however, these have all been addressed with subsequent design modification throughout the testing phase. Although the results documented at Lovett are promising, corroboration of the effectiveness of the system in a non-tidal application would be needed prior to consideration of the use of this technology elsewhere.

ii. Conceptual Design

Assuming a filtration rate of 5 gpm per square foot, an Aquatic Filter Barrier (AFB) for AES Greenidge Unit 4 would need to have a surface area of approximately 14,000 square feet in order to accommodate the 68 kgpm flow of the unit. At an average depth of 14 feet, this would require 1,000 linear feet of material which would be deployed so as to encircle the intake with a diameter of about 320 feet. If the barrier could be successfully deployed during the period April through August, it would be effective in reducing entrainment losses at the facility. However, it would probably have to be removed annually in the fall and reinstalled in the spring in order to avoid ice damage during extended plant shutdown. Consequently it would most likely not provide significant reduction in impingement mortality.

An air bubbler system would need to be installed between layers of the fabric in order to slough off sediment and vegetative matter that would accumulate on the barrier's surface as water was filtered through it. However, in contrast to the Hudson River where an AFB was successfully deployed and operated at the Lovett Generating Station, Seneca Lake does not have strong tidal currents or other predominant currents that would carry material away from the barrier's surface after operation of the air bubbler system. During the 2006-2007 sampling at the facility, several plant operators relayed observations that from mid-May through the end of September (especially in July) submerged aquatic vegetation (SAV) growth is heavy, reaching to within a foot of the water surface, and it is visible at the surface in some areas. Because the water depth where the AFB would be installed is relatively shallow, SAV loads on the barrier could be heavier than could be handled by the air bubbler system causing the boom's float line to become submerged and thus allowing overtopping as was observed on occasion at Lovett. In addition, heavy timbers, tree trunks up to 20+ feet, were often encountered by crews during biological sampling at the facility. Unless a bar rack system was installed around the AFB to prevent these timbers from impacting the fabric, substantial breaching of the barrier could result, requiring repair or replacement. Given these potential operational problems, the lack of any prototype deployment in a similar environment and the fact that an alternative technology, fine slot wedgewire screens is available, a detailed conceptual design was not developed for the AFB.

iii. Feasibility/Practicability Determination

As discussed in the preceding section, the lack of demonstrated feasibility of the AFB in a waterbody like Seneca Lake, the anticipated operational problems and/or the costly measures needed to avoid them coupled with the seasonal nature of the AFB deployment leads to serious questions regarding its feasibility and practicability at AES Greenidge. This uncertainty coupled with the availability of a feasible technology, wedgewire screens, which has the same mitigative potential for entrainment and is operational year-round, thus addressing impingement as well, leads to the conclusion that the AFB does not warrant further evaluation as an alternative intake technology at this facility.

iv. Time required to implement

Not applicable.

v. Costs

Not applicable.

vi. Adverse environmental impacts

Not applicable.

vii. Mitigative benefits

Not applicable.

c. Velocity Cap

i. Description

A velocity cap is a plate or reinforced concrete cover that is placed over the vertical inlet of an offshore intake. This cover causes the inflow of cooling water to be withdrawn from a horizontal rather than vertical direction. This provides an environmental benefit by (1) drawing water from cooler strata in the summer so less flow is needed, (2) drawing water from strata where fish densities may be lower, and (3) generating a horizontal flow that fish can more readily detect and avoid.

Velocity caps have been installed at a number of offshore intake structures and are considered successful at reducing impingement both because they are located off shore and because of the horizontal flow. Reductions in entrainment are not typically associated with velocity caps because entrainable fish eggs and larvae generally have limited or no swimming abilities. The intake's distance offshore, however, may result in potentially large reductions in entrainment relative to the same intake sited at the shoreline.

Velocity caps are often used in conjunction with other fish protection devices to reduce impingement, resulting in limited information on their performance when used alone. Facilities using velocity caps on offshore intake structures include San Onofre, El Segundo, Redondo Beach and Huntington Beach, in California; Nine Mile Point, Fitzpatrick, Ginna, and AES Somerset in New York; Edgewater in Wisconsin; Nanticoke in Ontario, Canada; Seabrook in New Hampshire; and St. Lucie in Florida (USEPA 2004). The few quantitative investigations that have been conducted to assess the efficacy of velocity caps in reducing fish impingement have been conducted in marine/estuarine systems on the U.S. West coast and in the United Kingdom.

A series of early field trials on the efficacy of velocity caps in reducing fish impingement was conducted at the Huntington Beach Generating Station in California during the 1950s. A velocity cap was installed at Huntington Beach after modeling and full-scale tests at the nearby El Segundo Generating Station demonstrated the potential for this technology to reduce impingement. Total fish impingement at El Segundo was measured from July 1956 to June 1957, and these data were compared to impingement measured the following year (July 1957 to June 1958) after installation of a velocity cap. Total impingement was reduced from 272 tons in year 1 to 15 tons in year 2, a reduction of 95% (Weight 1958).

The University of Washington's College of Fisheries conducted what is perhaps the most comprehensive study of the efficacy of velocity caps on reducing impingement (Johnson *et al.* 1980, Thomas *et al.* 1980). The majority of the field trials for this study was conducted at Huntington Beach during 1979-1980 and included more than 120 hourly estimates of impingement and source water fish abundance, including 70 observations during full flow test conditions with the velocity cap in place. Both day and night trials were conducted, with significantly greater impingement reduction documented to occur during the day. The intake tunnel at Huntington is buried beneath the sea floor, and draws seawater from an intake port located approximately 5 feet above the sea floor, fitted with a low-profile horizontal velocity cap. An average reduction in impingement of 82% was attributed to the velocity cap during the entire 2-year study period, and this value has been recommended for use as credit towards meeting the Phase II performance standard for reducing impingement mortality by 80-95% at the Huntington Beach station (Tenera Environmental 2006). Efficacy values for individual trials ranged from 53% (year 1, night) to 99% (year 2, day). The average efficacy reported for year 1 was 72% and the average for year 2 was 93%.

Two power stations in the United Kingdom, Sizewell and Dungeness, have velocity caps at one of two intakes. Impingement reduction rates of 50% and 62%are reported from the capped intakes relative to the uncapped intakes at Sizewell and Dungeness, respectively (USEPA 2004).

ii. Conceptual Design

Water depths at the existing AES Greenidge Unit 4 intake average <15 feet. This relatively shallow depth is not sufficient for a velocity cap to be effective. As discussed below, in order to make the cap effective the intake would need to be extended 1,000 feet or more so it could be installed in deeper waters.

iii. Feasibility/Practicability Determination

AES Greenidge Unit 4 withdraws water through an intake pipe that extends several hundred feet offshore. Because the intake pipe is in relatively shallow water (<15 feet), the water withdrawn by a retrofitted velocity cap would still come from the warmer epilimnion layer. As a result there is no reason to expect that the cap would markedly change the species and number of early life stage fish entrained, with some potential for reductions in impingement due to the horizontal withdrawal. In order to make the cap potentially more effective in reducing fish losses, the Unit 4 intake pipe could be extended to a deeper portion of the lake, e.g., to the 30-foot depth contour; however, this would require extending the pipe 1,000 feet or more. A substantial pump upgrade would be required to provide the necessary head to pump water the additional distance. Given the lake's bathymetry, the magnitude of changes that would be required to implement a velocity cap, the fact that its effectiveness in reducing entrainment is unknown for the species entrained at Unit 4, and because alternative more effective, less costly technology options are expected to be available (e.g., wedgewire screens), this alternative is not being advanced to the next level of evaluation.

iv. Time required to implement

Not applicable.

v. Costs

Not applicable.

vi. Adverse environmental impacts

Not applicable.

vii. Mitigative benefits

Not applicable.

d. Light Deterrence System

i. Description

Underwater light deterrence systems have been evaluated as a means of reducing impingement rates at power generation facilities. Both continuous (e.g., mercury vapor) and flashing (strobe) light systems have been tested. Strobe lights have been evaluated in terms of their efficacy in repelling or guiding fish away from water intakes, as well as toward bypasses for transport to safe release locations. In general, flashing light has been demonstrated to produce stronger avoidance reactions than continuous light; however responses vary among species tested, developmental stage, and light adaptation levels (EPRI 1994). Brown (2000) reviewed previous application of strobe light technology and concluded it can be effective in some situations, particularly with salmonids. Sager *et. al.* (2000) documented the results of studies conducted on the diversion effectiveness of strobe and strobe light-bubble curtain systems on white perch, spot, and menhaden. They concluded that strobe light systems may reduce impingement rates but must be evaluated based on site specific needs and conditions.

Underwater strobe lights have been evaluated under field and laboratory conditions, with variable results. Field testing was conducted at a Lake Ontario offshore test facility, near Pickering Nuclear Generating Station; at the Roseton Generating Station located on the Hudson River; and at the York Haven Hydroelectric Project (EPRI 1989, 1992) located on the Susquehanna River. The dominant species evaluated during the Lake Ontario tests was alewife. Additional information was obtained on white perch and rainbow smelt. Information on the influence of underwater strobe lights on several fish species was obtained at Roseton, including blueback herring, alewife, white perch, spottail shiner, and striped bass (*Morone saxatilis*). No significant exclusion potential was determined for underwater strobe lights for any species of fish at the Lake Ontario test site or at Roseton.

At the York Haven Hydroelectric Project, the species of concern was out- migrating American shad (*Alosa sapidissima*). An underwater strobe light system was determined to be effective at minimizing turbine entrainment by directing the fish to a nearby bypass structure.

An evaluation of the effects of strobe lights on reducing impingement at AES Cayuga was conducted in 1993 and 1994 and again in 1995 and 1996 (Ichthyological Associates 1994, 1997). Trout perch (*Percopsis omiscomaycus*) and white sucker (*Catostomus commersoni*) were effectively repelled by strobe lights during both studies; during the 1993 to 1994 study, strobe lights also effectively repelled yellow perch. In 1995 to 1996 slimy sculpin (*Cottus cognatus*) and alewife were effectively repelled by the strobe lights. Juvenile rainbow smelt were unaffected by the lights in 1993 and 1994; however the second study documented that juvenile smelt were attracted to the lights. Adult smelt were attracted to the lights during both studies.

Mercury vapor lights have also been evaluated as a behavior-modifying device, primarily as a fish attractant. Studies have been conducted at the Hadley Falls Hydroelectric Project on the Connecticut River, and at the York Haven Hydroelectric Project on the Susquehanna River (EPRI 1992). The results of these studies indicate that mercury vapor lights function as an effective fish attractant, useful in attracting fish to a bypass or to areas not under the influence of the water intake structure. However, because species-specific responses may include either repulsion or attraction, careful consideration must be given to use of mercury lights; one species may benefit, while another may be subject to greater rates of impingement or entrainment.

Few studies have evaluated the effect of light deterrents on Centrarchidae, the taxa that comprises the majority of impingement at AES Greenidge. A study of caged test fish on the Menominee River in Wisconsin was conducted to determine whether stimuli produced by three different light deterrent systems could elicit avoidance or attraction responses in fish (EPRI 1988). Fish response to light deterrents was evaluated by alternating the operation of single lights located at each end of the rectangular test cage. The study of strobe lights found an avoidance reaction from walleye, and a weak avoidance reaction for largemouth bass and yellow perch. No response to strobe lights was reported for smallmouth bass, sunfish (bluegill and pumpkinseed) and rainbow trout. Study results for both mercury light and high-pressure sodium lights showed no discernable response to these light systems for the species evaluated: sunfish, walleye, rainbow trout, largemouth (this species was not evaluated for high-pressure sodium lights) and smallmouth bass.

ii. Conceptual Design

A conceptual design for a light deterrence system at AES Greenidge was not developed because previous studies indicate limited effectiveness for the primary taxa impinged at AES Greenidge.

iii. Feasibility/Practicability Determination

The numerically dominant taxonomic group in impingement at AES Greenidge is Centrachidae (basses and sunfishes, including *Lepomis* spp.) and previous studies of light deterrent effectiveness on this taxon reported little to no effectiveness. Alewife (representing less than 7% of impingement at AES Greenidge) would potentially be repelled by strobe lights at AES Greenidge but additional studies would need to be conducted on-site to determine effectiveness of strobe light systems at this particular facility. Because previous studies show little to no effectiveness for light deterrents for the primary taxa subject to impingement at AES Greenidge, this technology is determined to be impracticable at this facility and is not evaluated further.

iv. Time required to implement

Not applicable.

v. Costs

Not applicable.

vi. Adverse environmental impacts

Not applicable.

vii. Mitigative benefits

Not applicable.

e. Sonic Deterrence System

i. Description

Sonic deterrence systems (either mechanical or electronic) have been evaluated as a means of potentially reducing impingement mortality in the vicinity of cooling water intake structures. High or low-frequency sound produced underwater may either deter fish from the vicinity of intake structures, or attract them to nearby diversion systems, with subsequent transport to safe areas. Fish species vary widely in their ability to respond to underwater sound. In some species the effect is marked; others exhibit little or no behavioral modification in response to underwater sound generation. Sonic deterrence systems are only useful in reducing impingement of juvenile and adult fish, as larvae and early juveniles have not yet developed hearing organs.

Mechanically produced low-frequency sound has been evaluated as a technique to reduce alewife impingement at the Pickering Nuclear Generating Station on Lake Ontario (Haymes and Patrick 1986). Low-frequency pneumatic devices were evaluated at an offshore test structure in Lake Ontario (EPRI 1989), and at the intake of the Roseton Generating Station on the Hudson River (CHG&E 1999). No consistent deterrent capability was demonstrated by these devices.

High-frequency sound produced by electronic systems has been tested on caged fish species, including alewife, blueback herring, and white perch (Dunning *et al.* 1992; Nestler *et al.* 1992), and low frequency sound was tested on several salmon and trout species at the Ludington Pumped Storage facility on Lake Michigan and at a hydroelectric facility on the St. Josephs River (Loeffelman *et al.* 1991). Results of the high-frequency caged fish tests indicated that alewife and blueback herring had an immediate and long-lasting response to high frequency sound. A full-scale, high-frequency sound deterrent system was evaluated at the James A. FitzPatrick Nuclear

Power Plant on Lake Ontario (Ross *et al.* 1996). When the system was operating, the density of fish near the intake decreased by as much as 96%, and the number of alewife impinged decreased by as much as 87%. The sound system was effective at keeping fish away from the intake structure during day and night, with an effective exclusion range exceeding 80 meters. Similar studies conducted at the Pickering Station in Ontario reduced alewife impingement and entrainment rates by 73% to 76% in 1985 and 1986. Rainbow smelt and gizzard shad were not effectively deterred. At the Arthur Kill Generating Station in New York City, pilot and full scale tests produced similar results to those documented for alewife at the Pickering and Fitzpatrick stations. Gizzard shad were also significantly deterred at Arthur Kill (USEPA 2004). At the Crescent and Visher Ferry Hydroelectric projects, located on the lower Mohawk River in New York, an underwater acoustic system effectively moved out-migrating blueback herring away from the turbine intake area, which resulted in lower turbine entrainment (Ross 1999).

Studies conducted in Norway in the early 1990s indicated that several species, including salmonids, detect and respond to infrasonic sound (Karlsen 1992a, 1992b). However, it appears that the fish must be within a few meters of the sound source to induce a behavioral response (Knudsen *et al.* 1994, 1997).

ii. Conceptual Design

A conceptual design for a sonic deterrence system at AES Greenidge Unit 4 cannot be developed at this time because there is insufficient data available regarding the response of sunfish, the predominant group of species in impingement, to sound.

iii. Feasibility/Practicability Determination

The low effectiveness observed for the pneumatic devices associated with mechanically produced low-frequency sound coupled with mechanical reliability problems suggests that this type of device would not be an effective means of reducing impingement mortality at AES Greenidge. Electronic high-frequency acoustic deterrence systems, however, have somewhat greater promise, at least for alosids and possibly other pelagic species. Infrasonic sound generating devices do not appear to have any potential applicability at AES Greenidge.

It should be noted that the U.S. Navy operates a sonar test facility in the area; sonic fish protection devices could potentially interfere with the sonic and acoustic testing conducted at the Naval facility. Based on the limited applicability and effectiveness of sonic deterrents, and lack of information regarding their effect on the numerically dominant species of concern (sunfish family), this technology will not be considered in further detail for implementation at AES Greenidge.

iv. Time required to implement

Not applicable.

v. Costs

Not applicable.

vi. Adverse environmental impacts

Not applicable.

vii. Mitigative benefits

Not applicable.

f. Passive (Cylindrical) Screens with Wedgewire Mesh

i. Description

Passive screens with wedgewire mesh have a "V" or wedge-shaped cross section which is welded to a frame to form a slotted screening element. They are fabricated using a single continuous wire wrapped spirally around an array of internal support rods, producing a very strong cage like structure with very high open area. The continuous slot is plug resistant because it widens inwardly. Screens can be produced with various slot widths, generally ranging from about 0.5 mm to 10 mm.

Wedgewire screens reduce entrainment and impingement at water intakes due to their small screen slot sizes and low velocities (USEPA 2004). The design objective is to cause fish contacting the wedgewire surface to roll off the screen and be carried away from the intake with the prevailing current. Effectiveness of wedgewire screens is dependent on the following conditions: 1) sufficiently small screen size to block passage of early life stage fish; 2) low through slot velocity; and 3) ambient cross current flow. Bio-fouling and suspended sediment accumulation can cause problems for wedgewire screen systems. However, passive (cylindrical) screens with wedgewire mesh may be fitted with a pneumatic cleaning system, which utilizes a measured burst of air from inside the screen pod to remove debris, offering an advantage over other fixed screens and barrier nets.

Wedgewire screens have been effectively used at many water intakes throughout the United States and in other countries. Large-scale deployments are limited to a few electrical generation facilities while small-scale deployments number in the hundreds and can be found at many industrial cooling water intakes and other non-cooling water intakes (agriculture, aquaculture, etc).

The largest wedgewire screen installation is currently located at the Oak Creek Power Facility in Milwaukee, Wisconsin (Enercon 2010). This facility is capable of withdrawing 2.25 BGD from Lake Michigan via an offshore intake located approximately 1.5 miles from shore. The offshore intake is fitted with twenty-four (24), 8-ft diameter, 9.5-mm slot size wedgewire screens. The system was designed to provide a through-slot velocity of less than 0.5 fps with a 16% margin against fouling. The intake tunnel measures 9,200 ft in length and was bored through the bedrock. Due to the distance of the intake offshore, there is no airburst or other mechanical cleaning system associated with this installation. However, because of the low productivity characteristics of Lake Michigan and the copper-nickel alloy used to minimize zebra mussel colonization, this system is expected to operate with reliability. The offshore intake and wedge-wire screens were installed in 2009, such that long-term operational feasibility has yet to be established for this facility. Notably, the old shoreline intake remains available for use in the event that the wedge-wire screens are clogged by ice, debris and/or fish.

Other large-scale installations of wedgewire screens are at the J.H. Campbell Station on Lake Michigan and the Eddystone Station on the tidal freshwater reach of the Delaware River (EPRI 1999). These facilities use large slot-width (6.4 mm to 10 mm) wedge-wire screens that are capable of excluding larger juvenile and adult fish, but not eggs, larvae, and early juveniles. The single unit at the J.H. Campbell facility is capable of withdrawing 576 MGD. While no data are available for prior to installation of wedge-wire screens, studies indicate impingement was eliminated after installation of wedge-wire screens. At Eddystone, two units withdraw over 500 million gallons of cooling water each day from the Delaware River. Over a 20-month period prior to installation of the wedgewire screens, it was determined that over 3 million fish were impinged at this facility. Following installation of passive wedge-wire screens on both Eddystone intakes, impingement was essentially eliminated.

Factors that will influence the biological effectiveness and operational feasibility of fine-slot wedge-wire screens (such as bio-fouling, debris clogging, and ice formation) have not been studied in detail. At both Campbell and Eddystone, periodic cleaning of the wedge-wire screens is required, but no major operational constraints have been reported to date. An automatic airburst cleaning system is used to minimize bio-fouling at Eddystone; the Campbell wedge-wire screen assemblies are manually cleaned using water jets. Large water withdrawals require multiple screen assemblies. These may take up considerable space on the bottom of the source waterbody, potentially resulting in interference with navigation or other waterbody issues. In areas where the screens may encounter fast moving submerged debris, deflecting baffles or screen nosecones may be fitted to minimize potential damage.

There are many examples of wedgewire screen installations for facilities withdrawing volumes of water less than 100 MGD, including some sited in the Hudson and East Rivers. The Bethlehem Energy Center (BEC), located on the west bank of the Hudson River near Albany, utilizes a closed-cycle cooling system with make-up water drawn from the Hudson River. The BEC intake is fitted with 2-mm wedgewire screens and a seasonal aquatic filter barrier (April 1 through July 31) to eliminate impingement mortality and reduce entrainment associated with its withdrawal of 8 MGD. The BEC wedgewire screens are cantilevered off the face of the intake structure and utilize passive cleaning and pressurized air backwashes to keep the screens free of debris. More recently, BEC has forgone the seasonal Gunderboom deployment because of operational issues associated with filter material degradation and tearing.

The Athens Combined Cycle Generating Facility is capable of withdrawing up to 0.18 MGD from the Hudson River near the Town of Athens at approximately River Mile 115 (19 miles south of the Lafarge facility). This facility withdraws cooling water from two intake pipes extending 580 feet from the western shoreline and approximately 24 feet below mean low water, landward of the federal navigation channel. The cooling water withdrawal point is 6 feet above the river bottom. The openings of the pipes are covered with 3.2-mm slot size wedge-wire screens to mitigate impingement and entrainment with an air burst system to facilitate cleaning of the screens.

The Charles Point Resource Recovery Facility, formerly known as Westchester RESCO, is located at Charles Point on the east bank of the Hudson River near the Town of Peekskill, New York at approximately River Mile 44 (Enercon 2010). This waste to energy facility is capable of withdrawing 55 MGD from the Hudson River for use in its once-through cooling water system. The intake utilizes 2.0-mm wedge-wire screens located 800 ft offshore. The eight (8) 54-inch diameter screens are constructed of copper nickel alloy and arranged in four pairs on T-stands approximately 5-ft above the river bottom. This wedge-wire screen system is utilizes an airburst system that discharges twice daily and an annual dive team inspection to keep the screens clean and operational. Frazil ice events have been reported for this facility on a frequency of approximately every two to three years when extreme cold temperatures and low river water levels occurred. The airburst system has been successful in clearing the frazil ice from the screens.

The Brooklyn Navy Yard Cogeneration Facility withdraws 50 to 72 MGD of cooling water, depending on season, from the East River and Wallabout Bay. This facility utilizes debris screen panels to keep large debris out of the intake and 2-mm slot wedge-wire screens to mitigate impingement and entrainment. Because of the debris load in the source water body, divers are contracted during spring, summer, and fall to clean both the debris and wedge-wire screen systems. The debris screens are easier to clean because of their flat surfaces and larger mesh size compared to the cylindrical wedge-wire screens with their small slot size.

ii. Conceptual Design

Passive wedge-wire screens with slot sizes of 0.5, 1.0, 2.0 and 9.0-mm are considered in this evaluation of passive wedgewire screens. The submerged wedgewire screens would be installed at the end of the current Unit 4 intake pipe. The design includes an auxiliary pneumatic cleaning system which uses a measured burst of air from inside the screens to remove debris and an implosion diaphragm to protect the screens and pumps should occlusion of the screens occur. Table 4-2 presents preliminary design parameters provided by Johnson Screens for several wedge-wire screens of specific slot sizes at Unit 4 to accommodate the maximum intake flow capacity of 68 kgpm.

The existing intake system at Unit 4 is serviced by a 7-foot diameter intake pipe which is elevated on wood pilings and extends from the pumphouse to 650-feet offshore at a water depth of 11 feet. The pipe is connected to an elbow whose opening faces down into the water column and the elbow opens into a 27-foot x 27-foot steel structure composed of 3/16-inch bars on 6-inch centers for debris exclusion. The existing intake would be modified by removing the steel cage, extending the L-shape pipe to lay the pipe on the lake bottom and attaching a flange at the end to connect the screen manifold pipe and a series of passive wedge-wire screens. Refer to Figure 4-3 and Figure 4-4 for a preliminary design of the passive wedgewire screen installation for Unit 4.

The passive screens with wedgewire mesh would be made of Z-Alloy material to minimize bio-fouling and colonization of zebra mussels in particular. Spacing between screens would need to be at least one half of the screen diameter. Each screen unit would be connected to an air supply line from an airburst cleaning system which supplies air from a dedicated on-shore compressor. The screen manifold would be fastened to the lake bottom.

There are some concerns worth noting regarding operation of passive screens at AES Greenidge. During the 2006-2007 sampling at the facility several plant operators relayed observations that from mid-May through the end of September (especially in July) submerged aquatic vegetation (SAV) growth is heavy, reaching to within a foot of the water surface, and it is visible at the surface in some areas. The water depth where the passive screens would be located is relatively shallow (i.e., approximate 10-ft at extreme low lake levels). Consequently, detailed engineering may need to consider the use of a greater number of smaller diameter screens than is shown in Table 4-2.

There may also be some issues regarding operating passive screens in an environment with high debris such as leaf loading during fall months and SAV during summer months. Additionally, heavy timbers, tree trunks up to 20+ feet, were often encountered by crews during the biological sampling at the facility. Such heavy timbers could damage the screens. As a result, it may be necessary to install a bar rack system around the screens in order to protect them from such large debris. The final design for the wedgewire screens will require a build height that would avoid interference with potential ice formations, currents, and varying lake elevations.

Table 4-2 Preliminary Design of Passive Wedge-wire Screens for Unit 4 at AES Greenidge

Slot Width (mm)	Number of Screens	Screen Model	Screen Overall Length (inch)	Air-burst Tank Size (gallon)	Air-burst Air Line Size (inch)
0.5	8	T-66HC	239	5000	12
1.0	6	T-60HC	225	3800	10
2.0	6	T-54HCE	183	2560	8
9.0	4	T-48HCE	161	2200	8

iii. Feasibility/Practicability Determination

Limited field evaluations of passive wedgewire screens indicate the potential for this technology to reduce or eliminate impingement mortality and, at smaller slot sizes, entrainment at power generating facilities in a variety of marine, estuarine and freshwater environments. Screens with 9 mm slot size would exclude anything that would be impinged on a conventional 3/8-inch traveling screen and would be designed to have a through-screen velocity of less than 0.5 fps resulting in negligible impingement. The degree of entrainment reduction provided depends on the slot size of the screens. (Refer to Section vii below for the estimated mitigative benefit of each slot sizes in reducing entrainment and impingement). It is expected that installation of wedgewire screens at the Unit 4 is feasible from an engineering perspective. The final design, however, would have to operate at the relatively shallow water depths in this area of the lake, have a cleaning system for debris loads, have a build height to accommodate varying lake levels and currents, and include necessary buoys and signage to warn boaters of underwater structures and airburst activity.

Importantly, passive cylindrical wedge-wire screens are designed to be located in current velocities that promote screen cleaning (i.e., sweeping) and often, as is the case for the conceptual design provided in this document, include an auxiliary pneumatic cleaning system which uses a measured burst of air from inside the screen to remove debris. As discussed in the previous section, there are some concerns regarding operation of passive screens at AES Greenidge. In particular, SAV growth is heavy and potentially very heavy during summer months in the vicinity of the intake and leaf loads may also be high during the fall. The June 26 and 27, 2007 hydrodynamic survey conducted in the vicinity of the AES Greenidge intake documented ambient current velocities in the vicinity of the intake of typically less than approximately 0.2 m/s (0.66 fps) and ranging from 0.0 to 1.0 m/s (0.0 to 3.3 fps). Current direction varied from 0 to 360 degrees. As a result, sweeping velocities are expected to be present in the project area and often above the approach and through-screen velocities (approximately 0.25 and 0.5 fps, respectively), but the direction of the current will not be reliably parallel to the screen face which would be optimal for passive cleaning of the screens. As a result, heavy debris loads of SAV and/or leaf litter has the potential to inundate the screens and overwhelm the airburst cleaning system to the point of clogging the screens entirely. This potential is likely increased on the small slot size alternatives. Because of this, a pilot study is recommended to evaluate operational feasibility of passive wedgewire screens before a commitment to the full installation is made. The evaluation would focus primarily on estimating head loss at the screens that may result from debris and/or ice loads and possible biofouling. Results would be used to determine operational feasibility of the technology, potential cleaning frequencies, best cleaning practices, and potential for increases in head loss over time. The estimated cost of such a study is in the order of $300,000 to $400,000.

iv. Time required to implement

Implementation of wedge-wire screens at AES Greenidge would begin with finalizing the design and procurement of materials and contractors. Permitting needed to install the screens could require up to one year. The total time required for permitting, contracting, procurement of materials and construction is expected to be two to three years. The installation of the passive wedgewire screen system would require shutdown or modification of normal plant operations. The estimated downtime based on the USEPA Technical Development Document is approximately 6 weeks.

v. Costs

The direct capital costs would include passive screens with wedgewire mesh and air burst system equipment, screen and air supply pipe installations, mobilization and air supply equipment housing/electrical/controls. The estimated annual O&M costs assume year-round operation and include added frequencies of air-burst backwash, annual inspection and manual surface cleaning due to anticipated bio-fouling at the proposed location. The indirect costs associated with the implementation of a passive screen system would include permitting requirements for underwater construction, a two-year verification monitoring plan to monitor effectiveness of the installed intake technology, and a loss of revenue due to construction downtime. The effects on generation efficiency could be positive, negative, or neutral depending on how flows into the intake are modified by the screen system. No change in efficiency was assumed for costing purposes.

Total capital costs are estimated to range from approximately $2.1 million for 9 mm slot size screens to $3.7 million for 0.5 mm slot size and require $45,000 for permitting, $450,000 for a 2-year verification monitoring study, and lost revenue of $4.9 million for construction downtime. Annual operation and maintenance costs would be $40,000 for the 2.0 and 9.0-mm slot sizes and $68,000 for 0.5 and 1.0-mm slot sizes. A pilot study to evaluate operational feasibility, particularly necessary for the smaller slot sizes (e.g., 0.5-mm), would cost approximately $350,000. Detailed estimated costs for 0.5, 1.0, 2.0 and 9.0 mm wedgewire screens are shown in Appendix C.

vi. Adverse environmental impacts

Passive wedgewire screens would be located at the off-shore submerged location of the existing intakes and the air supply compressor would be in an on-shore location such as the existing pump house or a small shed; therefore, there would be no visual (i.e., aesthetic) impacts. However, there would be potential interference with navigation of boats on the lake. Warning signs and buoys would be needed in order to prevent potential damage of the screens due to boat anchoring or boating hazards. There would also be aquatic habitat loss due to installation of the screen manifold on the lake bottom.

vii. Mitigative benefits

Intake designs incorporating wedge-wire screens have the potential to reduce both impingement and entrainment of fish relative to conventional 3/8-inch (9.25-mm) mesh traveling screens through incorporation of fine slot-size screens (e.g., 2-mm) and low through-slot velocities (e.g., < 0.5 fps). The fine slot-size screen works to exclude fish too large to pass through the screen from entering the intake, thus reducing entrainment. Those fish that are excluded and have developed swimming ability (e.g., juvenile and adult fish) have the potential to either avoid or swim off the screens resulting in reductions in impingement. Life stages that have limited swimming ability (e.g., larvae) similarly may be able to escape when the through-slot velocity is close to or less than the water velocities parallel to the screen surface (sweeping velocity). Under these conditions fish may sense the flow into the screen and exhibit an avoidance response, or upon contacting the wedge-wire surface may exhibit an escape response or roll off the screen and be carried away from the intake with the prevailing current. The extent of impingement and entrainment reduction afforded to each fish species and life stage is a function of slot width, through-slot velocity, sweeping velocity, swimming capability, and behavioral response. The below provides estimated fractional reductions in impingement and entrainment attributable to the 0.5, 1.0, 2.0 and 9.0-mm slot-size alternatives relative to what would occur if 3/8-inch mesh traveling screens were in place at AES Greenidge.

Impingement Reductions

Fractional reductions in impingement mortality compared to the hypothetical 3/8-inch traveling screens at AES Greenidge are estimated to be 1.0 (or 100%) across all species and life stages due to the 0.5 fps or less through-screen velocity design criterion used in the conceptual design of the passive wedgewire screens of all slot sizes. Under this condition, all fish that would have been impinged on a 3/8-in mesh conventional screen are expected to be able to swim away from or off the wedgewire screens. This is supported by the United States Environmental Protection Agency (USEPA) position that at through-screen velocities of 0.5 fps or less there is no need to take additional measures to reduce impingement losses because fish would be able to avoid impingement under this condition (USEPA 2004).

Entrainment Reductions

Entrainment is different from impingement because some (or all) fish entrained through conventional 3/8-in (9.5-mm) traveling screens may, depending on slot size, also pass through wedge-wire screens, with smaller slot sizes generally excluding a large proportion of fish. In the case of the 9.0-mm slot wedgewire screens, minimal or no exclusion of entrainable size organisms is expected because of the similarity in slot size to conventional 3/8-in traveling screens. In the case of the 0.5, 1.0, and 2.0-mm slot size wedgewire, a portion of the fish that would pass through 3/8-in traveling screens would be expected to be excluded, and swim off or be swept off the screens by the ambient currents and thus not be entrained or impinged.

For entrainment, fractional reductions are presented for each species and life stage documented in AES Greenidge entrainment sampling conducted during April through September 2006. The estimated reductions for these species and life stages were developed from consideration of screen selectivity (i.e., different slot sizes will exclude different sizes of fish; slot selectivity is species and life stage specific) as well as fish mobility and sweeping velocities present in the vicinity of the AES Greenidge intake. Fractional reductions for entrainment were estimated using the following two-step process: Step 1 - evaluate screen selectivity; and Step 2 - evaluate the potential for fish to swim off or be swept off the screens.

Screen Selectivity and Percent Exclusion

The fraction of each species and life stage excluded by each of the wedge-wire screen slot sizes evaluated was estimated based on the length ranges for each species and life stage measured in the 2006 AES Greenidge entrainment study. Egg fractional exclusion ($F_{e,eggs}$) was computed as:

$$F_{e,eggs} = \left(1 - \left(SNDF\left(\frac{SS - D}{SD}\right)\right)\right)$$

where:

SNDF = the standard normal cumulative distribution function

SS = slot or mesh size (mm)

D = average egg diameter (mm)

SD = standard deviation of egg diameters.

If the standard deviation was not available, it was estimated as 1/6th the observed range of egg diameters. For the remaining life stages the minimum size retained was calculated based on Turnpenny (1981). Turnpenny (1981) calculates the maximum screen opening size (in mm) that would provide exclusion (*M*) as:

$$M = \frac{L_s}{0.0209L_s + 0.6564 + 1.199F}$$

where:

L_S = standard length (mm)

F = Fineness Ratio = L_S / D

D = body depth (mm).

Rearrangement of this equation for L_S yields:

$$L_s = \frac{(0.6564 + 1.199F)M}{1 - 0.0209M}$$

Where site-specific length data were not available, simple linear interpolation was used to estimate the percent exclusion for non-egg life stages, e.g., if the minimum exclusion size (M) is 5.1 mm and the life stage ranges from 4 mm to 15 mm, then estimated exclusion was (1- (5.1-4)/(15-4)) x 100 = 90%.

The proportion of lengths for each species, life stage, and month greater than or equal to L_S was assumed to be able to excluded from entering the intake (i.e., they were not entrained). The proportion of lengths less than L_S was assumed to be entrained and not survive.

Percent Reduction Accounting for Swim-off Capability and Sweeping Velocities

Of those species and life stages estimated to be excluded based on the preceding analysis, only those that can swim off the screens or be swept off by ambient currents are saved by the technology. A swim-speed model from Turnpenny (1988) was used to evaluate the potential for non-egg life stages to be able to swim off the screens. The model incorporates species-specific swim speed coefficients (i.e., tail aspect ratio), length data and ambient water temperature data to determine minimum escape length $L_{S(esc.)}$ for each fish as:

$$L_{S(esc.)} = \mathrm{V_A} / (\alpha + 0.58\mathrm{T})$$

where:

$L_{S(esc.)}$ = min. escape standard length (mm)

V_A = approach velocity = 0.5 fps x OA

T = temperature (°C); as measured in the 2006 entrainment samplings

α = 1.9065*AR+2.9099

AR = h^2/S

h = maximum height (mm) of the caudal fin

S = surface area of caudal fin (mm^2)

OA = fractional screen open area

The approach velocity was estimated based on the open area of the screen and the through-slot velocity of 0.5 fps or less incorporated into each conceptual design. Fractional screen open areas used were 0.22, 0.36, 0.53, and 0.69 for 0.5, 1.0, 2.0, and 9.0 mm slot sizes, respectively. The proportion of lengths for each species, life stage, and month greater than or equal to $L_{S(esc.)}$ was assumed to be able to swim off of the screens and thus survive (i.e., they were neither entrained nor impinged). The proportion of lengths less than $L_{S(esc.)}$ was assumed to be impinged on the face of the wedge-wire screens and not survive (i.e., they were not entrained, but impinged).

Eggs are different from all other life stages because they are non-motile and thus must be both excluded by the screens and experience ambient currents sufficient to sweep them off the screens in order be protected by the technology. Egg entrainment at AES

Greenidge is comprised primarily of alewife eggs (70% of egg entrainment and 28% of the total organisms entrained); other taxa include brook silverside, carps and minnows and unidentified. EPRI (2003) conducted a laboratory evaluation of potential entrainment and impingement of egg and larval fishes on wedge-wire screens. The study evaluated eight species, including alewife, as well as 0.5, 1.0 and 2.0-mm wedge-wire screens and a range of slot and channel (ambient) velocities and screen orientations parallel and perpendicular to the channel current. A general conclusion reached in the study is that the mean percent of fish lost to entrainment and impingement was less than 50%, with rates as low as 0 to 10% for tests that included the highest approach velocity and lowest through-slot velocity.

For alewife, the test results showed no impingement of alewife eggs on 0.5 and 2.0-mm wedge-wire screens (the only slot-sizes evaluated for this species) and entrainment percent losses ranging from 10 to 53%. The larger slot size (2.0-mm) produced higher entrainment rates than the smaller slot size (0.5-mm) and higher channel velocities resulted in lower entrainment for both mesh sizes. The results for alewife eggs from EPRI (2003) are provided as Figure 4-5. Importantly, channel velocities were equal to or lower than the slot velocities in all cases in the EPRI (2003) study. The June 26 and 27, 2007 hydrodynamic survey conducted in the vicinity of the AES Greenidge intake documented ambient current velocities in the vicinity of the intake of typically less than approximately 0.2 m/s (0.66 fps) and ranging from 0.0 to 1.0 m/s (0.0 to 3.3 fps). Current direction varied from 0 to 360 degrees. As a result, ambient currents in the vicinity of the AES Greenidge are expected to be, on average, near and sometimes greater than the 0.5 fps through-slot velocity incorporated in the conceptual designs (albeit of variable orientation relative to the screen face). The EPRI (2003) study provides important data and results regarding the evaluation of wedge-wire screen mitigative benefits for a number of species and for alewife eggs in particular. Based on this study, the following percent reductions in alewife egg entrainment are assumed herein:

Slot Size (mm)	Total Fractional Reduction in Entrainment
0.5	0.60
1.0	0.52
2.0	0.50
9.0	0.00

These estimated fractional reductions in entrainment can be characterized as conservative in that they rely on the higher percent loss reported in EPRI (2003) from the suite of tests conducted and assume some impingement of alewife eggs would occur on the 0.5 and 1.0-mm slot-sizes even though EPRI (2003) documented impingement to be zero. For all other species, those eggs that were excluded from entering the intake were conservatively assumed to be impinged and not survive.

Table 4-3, Table 4-4, and Table 4-5 provide the estimated fractional reductions estimated as described above for 0.5, 1.0 and 2.0-mm wedge-wire screens respectively. As expected, the smaller the slot size the greater the fractional reductions in entrainment afforded by the installation of wedge-wire screens. A table of fractional reductions for the 9.0-mm case is not included because no reduction in early life stage entrainment is estimated for this slot-size.

Table 4-3 Estimated reductions in early life stage entrainment at AES Greenidge based on installation of 0.5-mm wedge-wire screens (relative to 3/8-in mesh conventional traveling screens)

Common Name	Scientific Name	Life Stage	Fractional reduction in entrainment losses*					
			Apr	May	Jun	Jul	Aug	Sep
Alewife	*Alosa pseudoharengus*	EGG			0.60			
		YS						
		PYS						
		UID						
		JUV						
Banded Killifish	*Fundulus diaphanous* spp.	EGG						
		YS						
		PYS				1.00		
		UID						
		JUV				1.00		
Brook silverside	*Labidesthes sicculus*	EGG			0.00			
		YS						
		PYS						
		UID						
		JUV						
Bullhead Species	*Ameiurus* spp.	EGG						
		YS						
		PYS						
		UID						
		JUV						1.00
Carp	*Cyprinus carpio*	EGG						
		YS						
		PYS						
		UID						
		JUV				1.00		
Carp and Minnow species	*Cyprinidae* spp.	EGG			0.00			
		YS			1.00			
		PYS				1.00		
		UID						
		JUV						
Darters	*Etheostoma* spp.	EGG						
		YS			1.00			
		PYS						
		UID						
		JUV						
Suckers	*Castostomidae* spp.	EGG						
		YS						
		PYS						
		UID	1.00					
		JUV						
Unidentified	Unidentified	EGG			0.00	0.00		
		YS						
		PYS					1.00	
		UID				1.00		
		JUV						
White Sucker	*Castostomus commersoni*	EGG						
		YS		1.00				
		PYS	1.00	1.00				
		UID		1.00				
		JUV						
Yellow Perch	*Perca flavescens*	EGG						
		YS						
		PYS			1.00			
		UID						
		JUV						

*blank cells have a value of zero or are not applicable

Table 4-4 Estimated reductions in early life stage entrainment at AES Greenidge based on installation of 1.0-mm wedge-wire screens (relative to 3/8-in mesh conventional traveling screens)

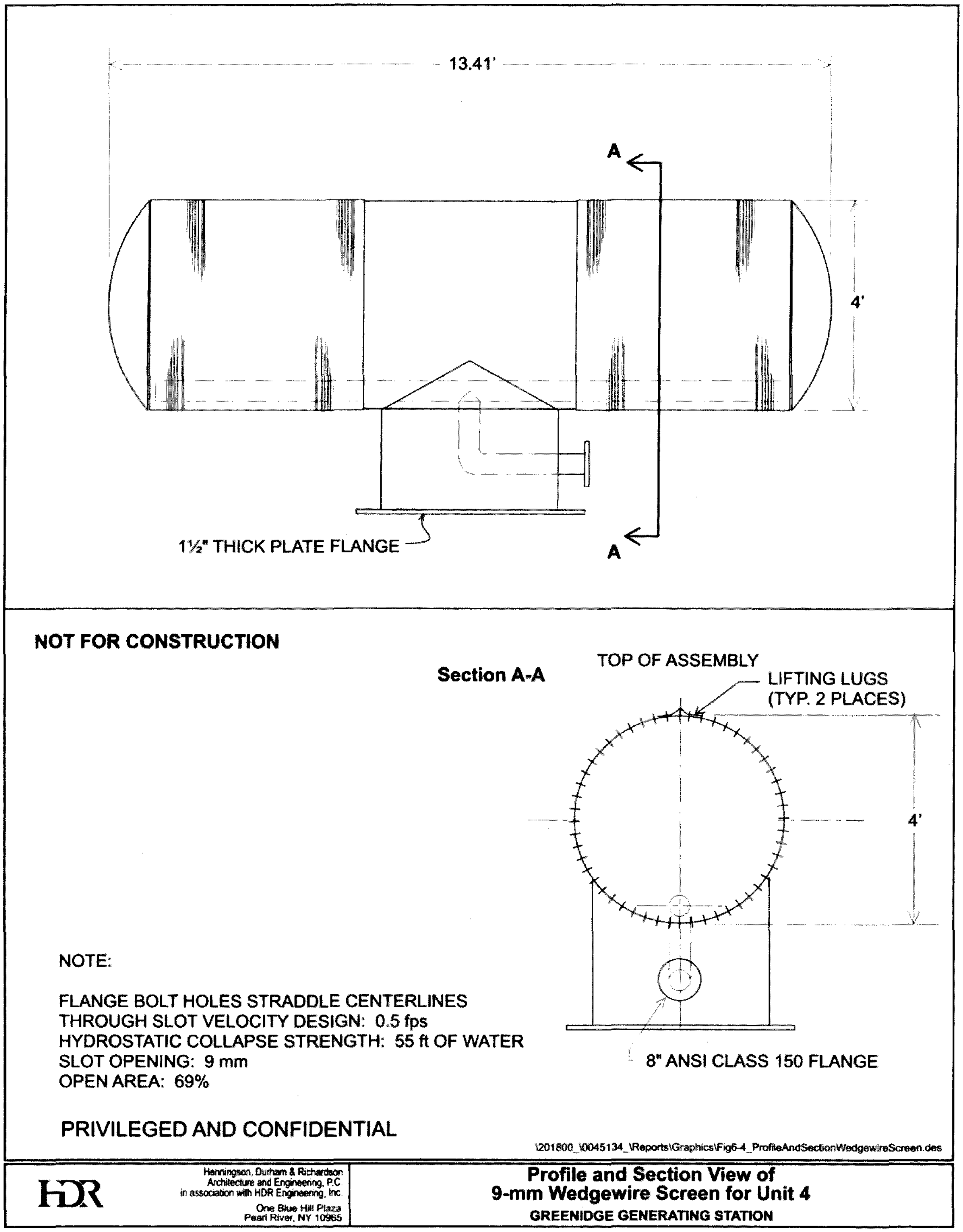
Common Name	**Scientific Name**	**Life Stage**	**Fractional reduction in entrainment losses***					
			Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Alewife	*Alosa pseudoharengus*	EGG			0.52			
		YS						
		PYS						
		UID						
		JUV						
Banded Killifish	*Fundulus diaphanous* spp.	EGG						
		YS						
		PYS				0.68		
		UID						
		JUV				1.00		
Brook silverside	*Labidesthes sicculus*	EGG			0.00			
		YS						
		PYS						
		UID						
		JUV						
Bullhead Species	*Ameiurus* spp.	EGG						
		YS						
		PYS						
		UID						
		JUV						1.00
Carp	*Cyprinus carpio*	EGG						
		YS						
		PYS						
		UID						
		JUV				1.00		
Carp and Minnow species	*Cyprinidae* spp.	EGG			0.00			
		YS						
		PYS				1.00		
		UID						
		JUV						
Darters	*Etheostoma* spp.	EGG						
		YS						
		PYS						
		UID						
		JUV						
Suckers	*Castostomidae* spp.	EGG						
		YS						
		PYS						
		UID	1.00					
		JUV						
Unidentified	Unidentified	EGG			0.00	0.00		
		YS						
		PYS					1.00	
		UID				1.00		
		JUV						
White Sucker	*Castostomus commersoni*	EGG						
		YS		1.00				
		PYS		1.00				
		UID		1.00				
		JUV						
Yellow Perch	*Perca flavescens*	EGG						
		YS						
		PYS			1.00			
		UID						
		JUV						

*blank cells have a value of zero or are not applicable

Table 4-5 Estimated reductions in early life stage entrainment at AES Greenidge based on installation of 2.0-mm wedge-wire screens (relative to 3/8-in mesh conventional traveling screens)

Common Name	Scientific Name	Life Stage	Fractional reduction in entrainment losses*					
			Apr	May	Jun	Jul	Aug	Sep
Alewife	*Alosa pseudoharengus*	EGG			0.50			
		YS						
		PYS						
		UID						
		JUV						
Banded Killifish	*Fundulus diaphanous* spp.	EGG						
		YS						
		PYS						
		UID						
		JUV				0.30		
Brook silverside	*Labidesthes sicculus*	EGG			0.00			
		YS						
		PYS						
		UID						
		JUV						
Bullhead Species	*Ameiurus* spp.	EGG						
		YS						
		PYS						
		UID						
		JUV						1.00
Carp	*Cyprinus carpio*	EGG						
		YS						
		PYS						
		UID						
		JUV				1.00		
Carp and Minnow species	*Cyprinidae* spp.	EGG			0.00			
		YS						
		PYS						
		UID						
		JUV						
Darters	*Etheostoma* spp.	EGG						
		YS						
		PYS						
		UID						
		JUV						
Suckers	*Castostomidae* spp.	EGG						
		YS						
		PYS						
		UID						
		JUV						
Unidentified	Unidentified	EGG			0.00	0.00		
		YS						
		PYS						
		UID						
		JUV						
White Sucker	*Castostomus commersoni*	EGG						
		YS						
		PYS						
		UID						
		JUV						
Yellow Perch	*Perca flavescens*	EGG						
		YS						
		PYS						
		UID						
		JUV						

*blank cells have a value of zero or are not applicable



NOT FOR CONSTRUCTION

NOTE:

FLANGE BOLT HOLES STRADDLE CENTERLINES
THROUGH SLOT VELOCITY DESIGN: 0.5 fps
HYDROSTATIC COLLAPSE STRENGTH: 55 ft OF WATER
SLOT OPENING: 9 mm
OPEN AREA: 69%

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HDR
Henningson, Durham & Richardson
Architecture and Engineering, P.C.
in association with HDR Engineering, Inc.
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Pearl River, NY 10965

Profile and Section View of
9-mm Wedgewire Screen for Unit 4
GREENIDGE GENERATING STATION

Figure 4-3 Unit 4 Wedge-wire Screen Profile and Section Views

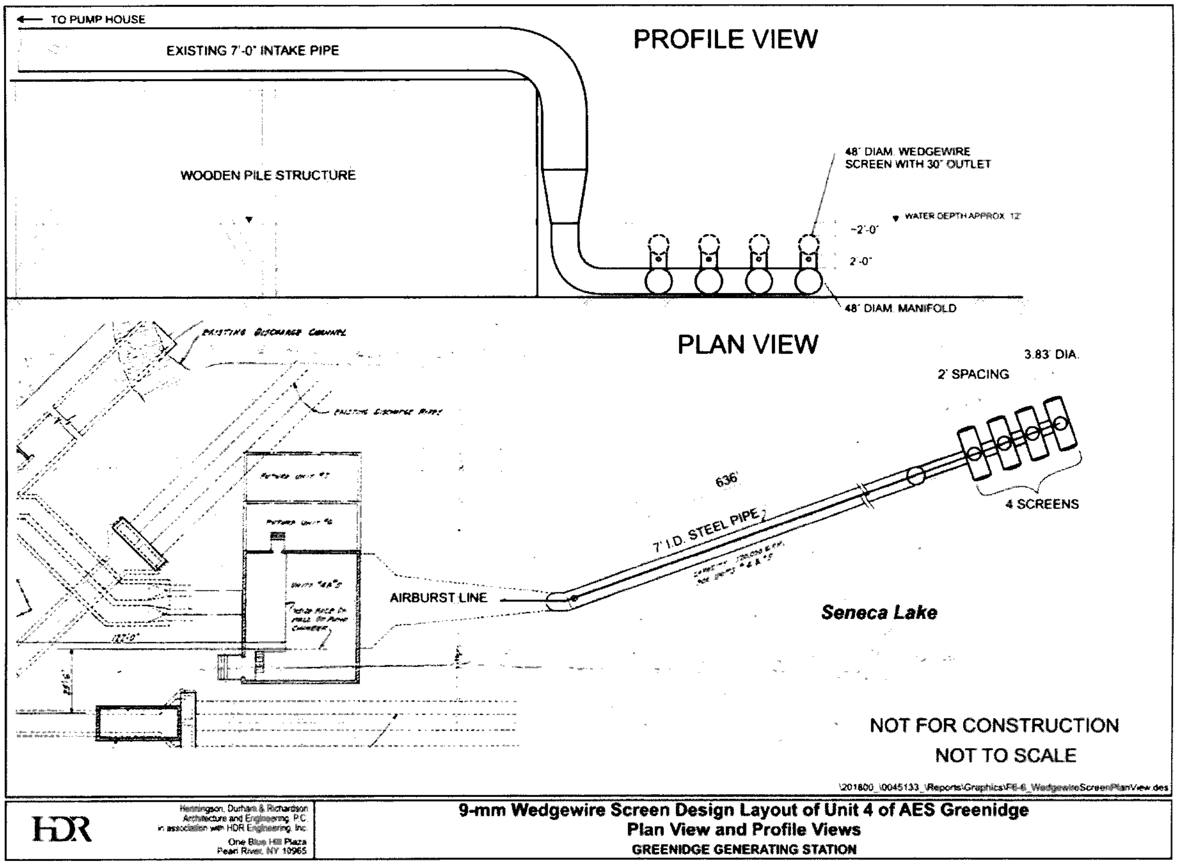
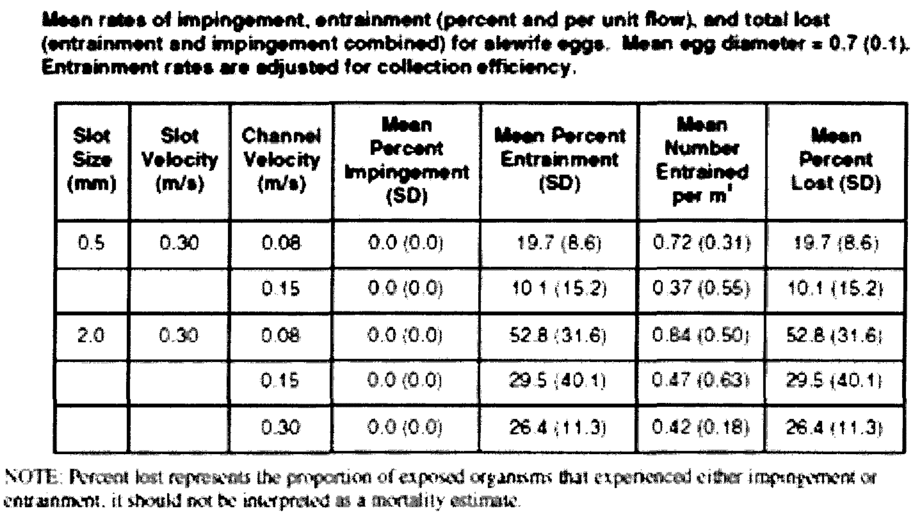


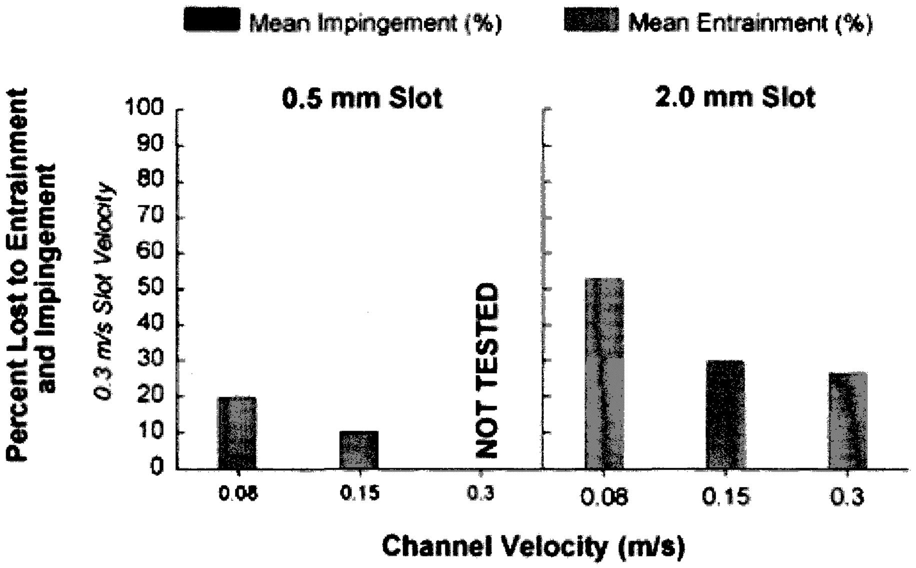
Figure 4-4 Unit 4 Wedge-wire Screen Design Layout Plan and Profile Views



Mean rates of impingement, entrainment (percent and per unit flow), and total lost (entrainment and impingement combined) for alewife eggs. Mean egg diameter = 0.7 (0.1). Entrainment rates are adjusted for collection efficiency.

Slot Size (mm)	Slot Velocity (m/s)	Channel Velocity (m/s)	Mean Percent Impingement (SD)	Mean Percent Entrainment (SD)	Mean Number Entrained per m³	Mean Percent Lost (SD)
0.5	0.30	0.08	0.0 (0.0)	19.7 (8.6)	0.72 (0.31)	19.7 (8.6)
		0.15	0.0 (0.0)	10.1 (15.2)	0.37 (0.55)	10.1 (15.2)
2.0	0.30	0.08	0.0 (0.0)	52.8 (31.6)	0.84 (0.50)	52.8 (31.6)
		0.15	0.0 (0.0)	29.5 (40.1)	0.47 (0.63)	29.5 (40.1)
		0.30	0.0 (0.0)	26.4 (11.3)	0.42 (0.18)	26.4 (11.3)

NOTE: Percent lost represents the proportion of exposed organisms that experienced either impingement or entrainment. it should not be interpreted as a mortality estimate.



Mean Percent of Alewife Eggs Lost to Impingement and Entrainment

Figure 4-5 EPRI (2003) Wedge-wire Screen Biological Evaluation Results for Alewife Eggs

The performance of wedgewire screens for reduction of impingement and entrainment will vary with the slot width of the screens. Although some organisms will be able to avoid the screens regardless of the slot width, physical exclusion increases as slot width decreases. Fish excluded by the screens are assumed to be able to escape rapidly due to their own swimming capabilities and aid of the lake currents to carry them out of the influence of the screens, thus impingement reduction is essentially 100% (Table 4-6, Figure 4-6).

Entrainment would not be reduced as much because the wedgewire screens would exclude only a portion of the entrainable fish. However these effectiveness estimates should be considered minimal values because the avoidance capability has not been factored into the reductions. For the 0.5 mm slot width, equivalent age 1 entrainment losses would have ranged from 590 to 1,518 (Table 4-6, Figure 4-7). The average percent reduction from baseline levels of entrainment range from 76% to 88%, with a 5-year average of 81%. The incremental increase in average entrainment reduction, beyond that achievable with current technology at Unit 4 is 34%.

For the 1 mm slot width screens, equivalent age 1 entrainment losses would have ranged from 843 to 1,848 with a 5-year average of 1,471 (Table 4-6, Figure 4-8). The average percent reduction from baseline levels of entrainment range from 69% to 83%, averaging 74%.

For the 2 mm slot width screens, equivalent age 1 entrainment losses would have ranged from 8,938 to 25,556 with a 5-year average of 21,832 (Table 4-6, Figure 4-9). The average percent reduction from baseline levels of entrainment range from 53% to 74%, averaging 61%.

For the 9 mm slot width, equivalent age 1 entrainment losses would increase to a range of 14,765 to 43,905. (Table 4-6, Figure 4-10). The average percent reduction from baseline levels of entrainment range from a 37% to 68% reduction, with a recent 5-year average of 47%.

Table 4-6 Estimated baseline equivalent age 1 losses from impingement and entrainment at AES Greenidge, and estimated losses if wedgewire screens with slot widths of 0.5, 1, 2, and 9 mm had been used from 2005-2009. Impingement values are the same for all slot widths.

	Wedgewire Screens			
	Baseline	Technology Performance		
	Equivalent Age 1 Loss		Equivalent Age 1 Loss	Average % Reduction
Impingement	11,753	Best year	-	100
		Worst year	-	100
		5-year mean	-	100
Entrainment 0.5 mm	66,045	Best year	590	88
		Worst year	1,518	76
		5-year mean	1,254	81
Entrainment 1 mm	66,045	Best year	843	83
		Worst year	1,848	69
		5-year mean	1,471	74
Entrainment 2 mm	66,045	Best year	8,938	74
		Worst year	25,566	53
		5-year mean	21,832	61
Entrainment 9 mm	66,045	Best year	14,765	68
		Worst year	43,905	37
		5-year mean	37,629	47

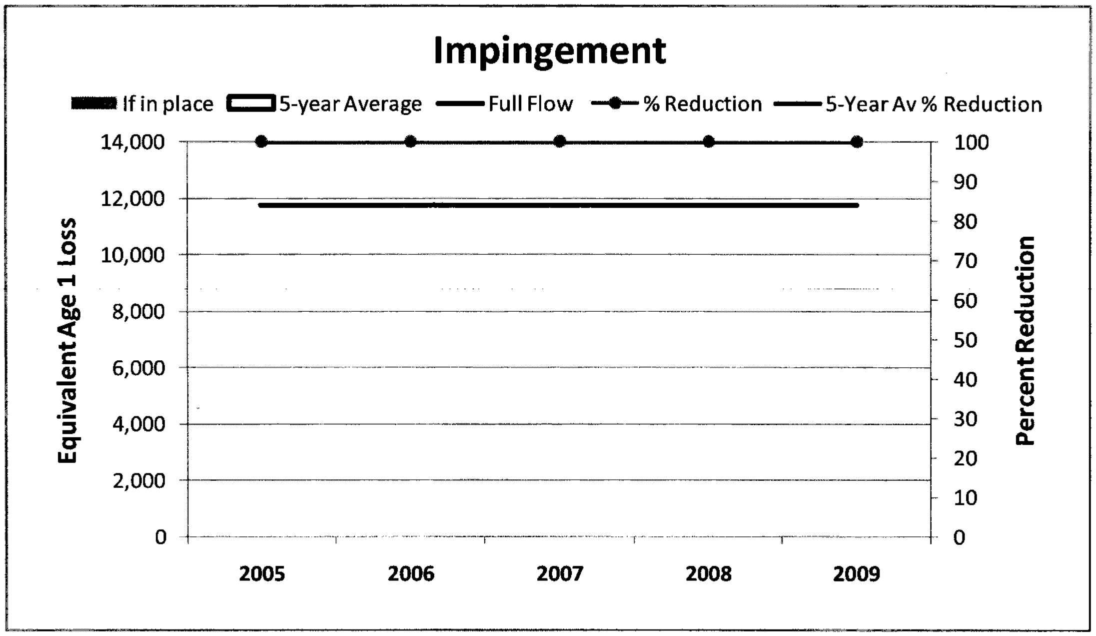


Figure 4-6 Estimated annual equivalent age 1 impingement loss from 2005-2009 at AES Greenidge if wedgewire screens had been used, and average percent reduction from baseline levels.

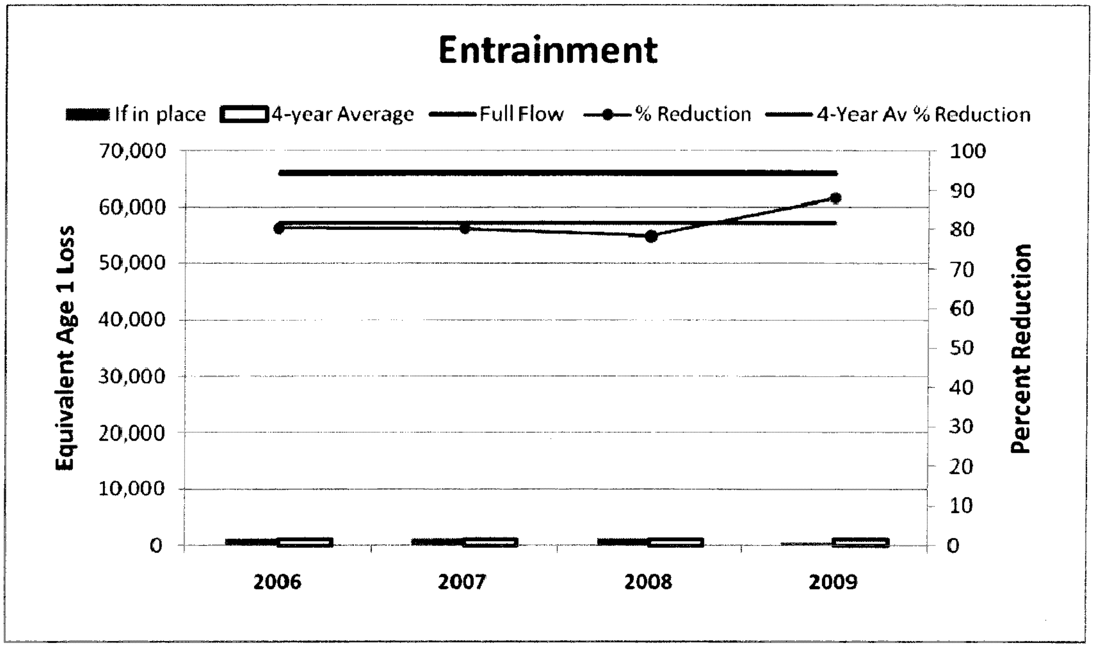


Figure 4-7 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge if 0.5 mm slot width wedgewire screens had been in place, and average percent reduction from baseline levels.

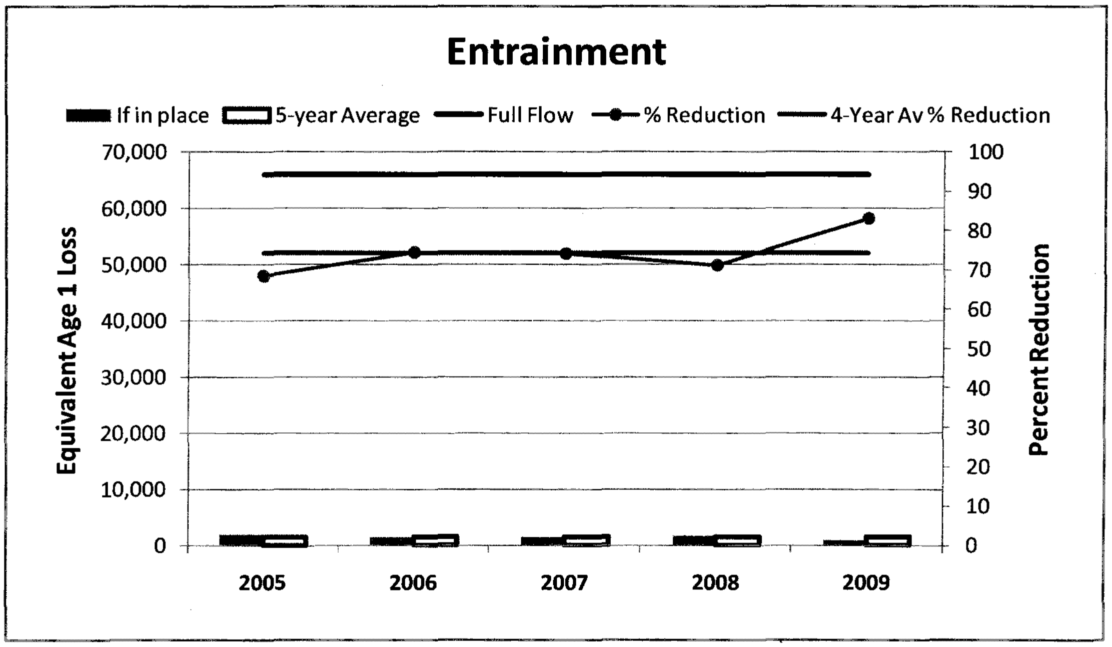


Figure 4-8 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge if 1 mm slot width wedgewire screens had been in place, and average percent reduction from baseline levels.

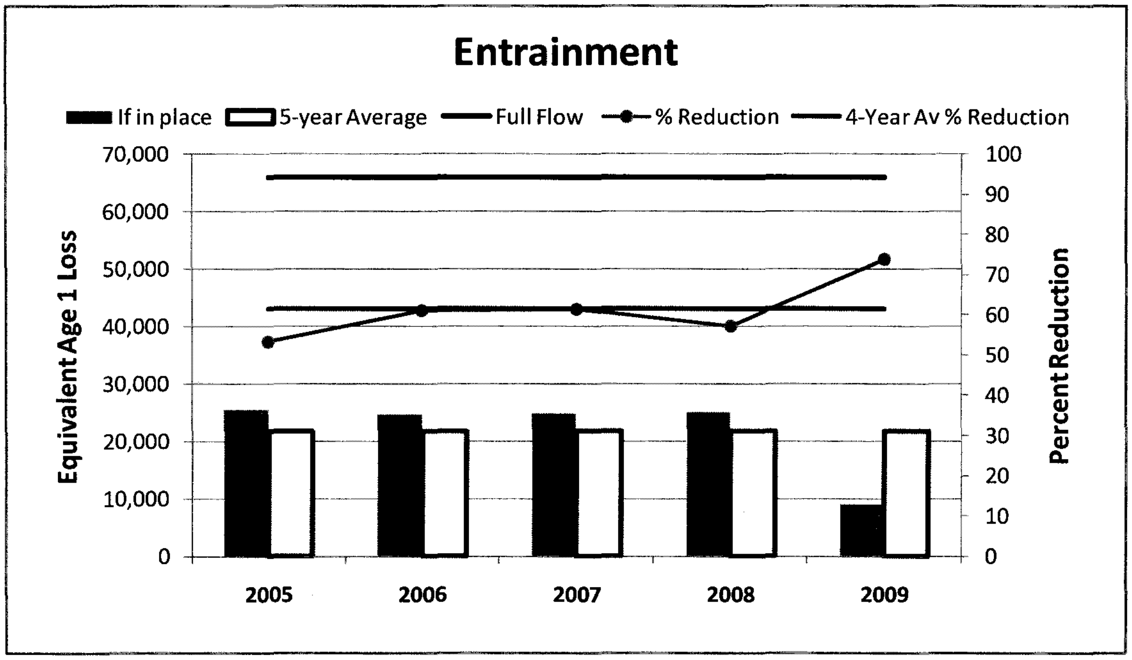


Figure 4-9 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge if 2 mm slot width wedgewire screens had been in place, and average percent reduction from baseline levels.

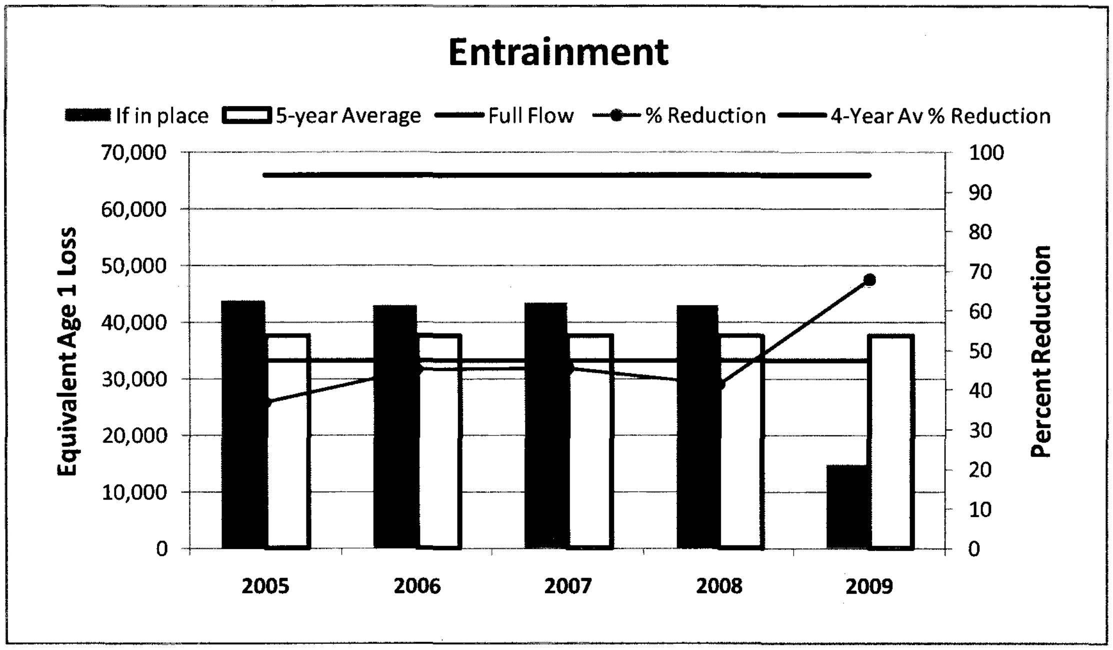


Figure 4-10 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge if 9 mm slot width wedgewire screens had been in place, and average percent reduction from baseline levels.

g. Brush-Cleaned Passive (Cylindrical) Screens with Wedge-wire Mesh

i. Description

Brush-cleaned wedge-wire screens are similar to the passive screens described in the preceding section but they are cleaned by brushes instead of an air burst system. Each screen would be mechanically cleaned by brushes inside and outside the screen cylinders and equipped with a series of water jets that would be mounted on the fixed external brush frame to sweep dislodged debris away from the screen. The screens would be attached to a stainless steel frame that would allow them to be raised out of the water for inspection, maintenance and repair and to be lowered on tracks with a winch for normal operation.

ii. Conceptual Design

As shown in Figure 4-11 and Figure 4-12, the conceptual design consists of brush-cleaned wedge-wire screens mounted onto one large box intake. For the smaller slot sizes of 0.5, 1.0, and 2.0, the screens would consist of a 6-foot diameter stainless steel cylinder that is 6.5 to 9.0 feet in length, the 9.0 mm screens would be 5-ft in diameter and 6-feet long. As discussed in more detail below, the screens would have sufficient surface area to insure that the through-slot velocity would be less than 0.5 fps. To ensure that there would be at least 2 feet of water depth above the top of the screens at all times, 10 feet, which is the lowest water column depth recorded in the last 50-years of U.S. Geological Survey observations of Seneca Lake levels, was used when configuring the screens. The general characteristics of the screen design are:

1) Two cylinders would be mounted to a single wide track. This would simplify the structure and allow a winch to lift two screens at a time.
2) The track would be a heavy wide flange. This will simplify the structure and reduce the number of areas where debris (e.g., SAV, ice) and mussels could enter and cause problems.
3) The screen rails would be mounted and supported from a new shell structure that would enclose the existing structure. The existing structure would be used to temporarily support the new shell structure. Corner piles would be driven to support the screen structure. Sealing plates would be welded to the new frames.
4) Polyethylene trash-racks would be used to protect the intake area when the screens are raised.
5) The screen would be designed to have minimal clearance to the track in order to reduce the potential for debris or fouling issues.

The screens would be attached to a stainless steel frame that can be raised or lowered on a vertical rail system. Each screen is mechanically cleaned by brushes inside and outside the screen cylinders. The exterior of the screen cylinder is cleaned by rotating its surface against a stationary brush bar. The interior of the cylinder is brush-cleaned with an internal brush bar that spins while the screen rotates. To assist with sweeping debris away from the screens during cleaning cycles, a series of water jets (mixing eductors) would be mounted on the fixed external brush frame. During cleaning cycles, the cylinders typically rotate at 4 RPM for one minute. A programmable, computerized controller runs the cleaning cycle and checks the system operation. The screen would run through the cleaning cycle based on a regular periodic schedule and when specified head differentials across the screens were detected. The screen unit would be capable of being retrieved for inspection and maintenance and would be lowered on tracks with a winch to resume normal operation.

During normal operation, the screen unit would be seated over the intake pipe opening and water would flow through the wedge-wire screen surface. The water would then flow into the rolling manifold area through the trash-rack and into the pump suction inlet. If the head differential across the screen reaches an undesired level during operations indicating that the screens are clogged, all the drums will be raised, allowing open flow to the suction pipe.

Heated water from plant discharge could be used to melt frazil ice. However, records of intake temperatures indicate that they are typically above freezing year round. If needed, a perforated pipe would be installed around all the screens (a circle around the entire end of pier/screens) and anchored to the lake floor. During times when frazil ice may occur, discharge water would be pumped out to this perforated manifold, the heated water would mix with cooler water far enough away from screens (10 feet, example) so that the heated water could mix and melt the frazil ice before coming into contact with the screens. The fail safe solution to frazil ice would be to retract the screens during the limited times when frazil ice may develop and allow unscreened flow as is the current situation. This would only occur during very limited emergency conditions.

The proposed screen system would be comprised of seven main components:

- Fish Screen Unit
- Retrieval Track
- Platform
- Hydraulic System
- Winching System
- Fish Screen Control Panel
- Water Jet Nozzles

Fish Screen Unit:

The proposed wedge-wire fish screen unit is an all 304-stainless steel assembly. The wedge-wire screens would be mounted to a welded internal suction and manifold that rolls down a track to cover the pump suction inlet. The screen unit needs to stay clean in order to function properly and to maintain needed flow rates, which is accomplished by operating a hydraulically activated cleaning system that allows the screen wedge-wire surface to be both internally and externally brushed. Two submersible hydraulic motors are located within each screen unit. The motors rotate the cylinder screens through gearboxes either clockwise or counter-clockwise. All of the screens rotate in the same direction and at the same speed.

Retrieval Track:

The track system would enable the screen to be raised and lowered for inspection, maintenance or during extended periods of non-operation. The track is bolted to the platform at the top and the docking inlet at the bottom. The screen unit rolls on the track using wheels mounted on the screen base. The wheels contact the top, side, and the underside of the top flange of the track. When the screen unit is lowered, it would roll down the track until the opening on the screen docking plate has been covered. The track has indentations at the bottom into which the screen unit wheels roll both to lock and seal against the docking inlet. The track also supports the hydraulic lines and limit-switch control wire on the side of each frame.

Platform:

The platform would be attached at the end of the existing pile supported intake pipe structure. The platform would support all of the retractable screens and the necessary controls.

Hydraulic System:

The hydraulic power unit (HPU) would include the hydraulic pump, directional control valves, oil reservoirs, pressure gauges and control switches. The hydraulic oil would be an environmentally safe type such as an approved vegetable oil based compound. All mechanical and control equipment would be located inside the panel enclosure. The enclosure would be easily accessible for inspection of oil levels and to perform routine maintenance. Hydraulic hoses would be plumbed from this HPU to the screen unit's two hydraulic motors through gearboxes that drive the screen cylinders about the brushes. An oil line runs between the two gearboxes to an auxiliary tank inside the panel. The hydraulic flow divider evenly distributes the oil to the motors so that the cylinders rotate at approximately the same speed. An electrical cable runs from both of the motor adaptor plates back to the control panel to monitor screen rotation.

Winching System:

A hydraulic powered winch system would be mounted at the top of the track and would raise and lower the screen unit. The winch cable attaches through a clevis to the screen. The power for the fish screen control panel must be on to operate the winch. The winch would be controlled using a pendant control switch located in the control panel. Magnetic limit switches at the upper and lower ends of the track limit the winch movement to prevent unnecessary cable stressing or cable loosening.

Fish Screen Control Panel:

The fish screen control panel (FSCP) would be used to set, control, and monitor the screens and the hydraulic system functions of the winch. There are several settings on the FSCP that control the duration and frequency of the brush cleaning cycles. While the manufacturer, Intake Screens, Inc., factory sets these values, the operator must adjust them based on observations and seasonal experience to keep the system running with minimal intake obstruction and head-loss. Alarms are used to notify the operator of malfunction and shut down the system when necessary. The control can also be preset for an emergency case such that when an undesired head differential is detected, all the drums will be raised, thus allowing open flow to the suction pipe.

Water Jets:

To assist with moving debris away from the screen during cleaning cycles, a series of water jets (mixing eductors) would be mounted on the fixed external brush frame at an angle to the drum screen. High pressure water would come from a water pump mounted inside the large box intake and would supply the manifold which would then distribute the water through each of the jets. The water pressure differential between inside and outside the screens would be continuously monitored. If the pressure differential exceeded a predetermined level, the water jets and brush system would be activated.

The 3-D renderings of the proposed brush-cleaned wedge-wire screen system design are provided in Figure 4-13 through Figure 4-19.

iii. Feasibility/Practicability Determination

As indicated by the preceding discussion, installation and operation of mechanically cleaned wedge-wire screens at the AES Greenidge offshore intake appears feasible from an engineering perspective. The ultimate design, however, would have to be workable in the relatively shallow water depths in this area of the lake, have a cleaning system for debris loads, and have a build height to accommodate potential seasonal ice flows.

It should also be noted that mechanically cleaned wedge-wire screens with a slot size of 0.5 mm have not been previously installed at a facility the size of AES Greenidge. Prior to committing to installation of screens with slot sizes less than 9.0 mm it would be necessary to conduct a pilot study that would determine how the screens would operate in the Seneca Lake environment. This study would need to be a year in duration in order to determine feasibility during the different seasonal conditions including debris loading from SAV and potential clogging of the screens with ice. The evaluation would focus primarily on estimating head loss at the screens that may result from debris and/or ice loads and possible biofouling. Results would be used to determine operational feasibility of the technology, potential cleaning frequencies, best cleaning practices, and potential for increases in head loss over time. The estimated cost of such a study is in the order of $300,000 to $400,000.

iv. Time required to implement

Implementation of wedge-wire screens at AES Greenidge would begin with finalizing the design and procurement of materials and contractors. Permitting needed to install the screens could require up to one year. The total time required for permitting, contracting, procurement of materials and construction is expected to be two to three years. The installation of the brush-cleaned wedgewire screen system would require shutdown or modification of normal plant operations. The estimated downtime based on the USEPA Technical Development Document is approximately 6 weeks.

v. Costs

The direct capital costs would include the screen retraction system, screens with wedgewire mesh and brush cleaning system, water jets to promote cleaning, installation, mobilization and housing/electrical/controls. The estimated annual O&M costs assume year-round operation and include added frequencies of brush cleaning, annual inspection and manual surface cleaning due to anticipated bio-fouling at the proposed location. The indirect costs associated with the implementation of a passive screen system would include permitting requirements for underwater construction, a two-year verification monitoring plan to monitor effectiveness of the installed intake technology, and a loss of revenue due to construction downtime. The effects on generation efficiency could be positive, negative, or neutral depending on how flows into the intake are modified by the screen system. No change in efficiency was assumed for costing purposes.

The total capital costs are estimated to range from $3.3 to $5.1 million for the 9.0 and 0.5 mm screens, respectively. Annual O&M costs are projected to range from $25,000 for the 1.0, 2.0 and 9.0-mm slot sizes and $34,000 for the 0.5-mm slot size. Indirect costs for permitting are estimated to be $45,000 while the two-year verification monitoring plan is estimated to cost $450,000. Down time of the facility during the screen installation would result in lost revenue on the order of $4.9 million. A pilot study to evaluate operational feasibility, particularly necessary for the smaller slot sizes (e.g., 0.5-mm), would cost approximately $350,000. Detailed estimated costs for 0.5, 1.0, 2.0 and 9.0 mm wedgewire screens are shown in Appendix C.

vi. Adverse environmental impacts

The brush-cleaned wedgewire screens would be located at the off-shore submerged location of the existing Unit 4 intake and the air supply compressor would be in an on-shore location such as the existing pump house or a small shed; therefore, there would be no visual (i.e., aesthetic) impacts. However, there would be potential interference with navigation of boats on the lake. Warning signs and buoys would be needed in order to prevent potential damage of the screens due to boat anchoring or boating hazards due to only 2 foot clearance above the top of screens under extreme low water conditions. There would also be aquatic habitat loss due to installation of the screen manifold on the lake bottom. The estimated bottom surface area needed for the installation of the screen manifold is about 200 sq. ft.

vii. Mitigative benefits

Intake designs incorporating wedge-wire screens have the potential to reduce both impingement and entrainment of fish relative to conventional 3/8-inch (9.25-mm) mesh traveling screens through incorporation of fine slot-size screens (e.g., 2-mm) and low through-slot velocities (e.g., < 0.5 fps). The anticipated reductions in entrainment and impingement for the brush cleaned wedge-wire screens are the same as those estimated for the passive wedgewire screens and discussed in detail Section F., vii. With regard to impingement mortality, fractional reductions relative to a hypothetical 3/8-inch traveling screens are estimated to be 1.0 (or 100%) across all species and life stages due to the 0.5 fps or less through-screen velocity design criterion used in the conceptual design of the passive wedgewire screens of all slot sizes. For entrainment, fractional reductions for 0.5, 1.0, and 2.0-mm slot size wedgewire screens are presented in Table 4-3 through Table 4-5 for each species and life stage documented in AES Greenidge entrainment sampling conducted during April through September 2006. The estimated reductions for these species and life stages were developed from consideration of screen selectivity (i.e., different slot sizes will exclude different sizes of fish; slot selectivity is species and life stage specific) as well as fish mobility and sweeping velocities present in the vicinity of the AES Greenidge intake. No reduction in entrainment is anticipated for the 9.0-mm slot size and therefore no table is provided.

Estimated baseline equivalent age 1 losses from impingement and entrainment are the same for brush-cleaned wedgewires as for similarly sized screens cleaned by other methods. (Table 4-6, Figure 4-8, Figure 4-9, Figure 4-10)

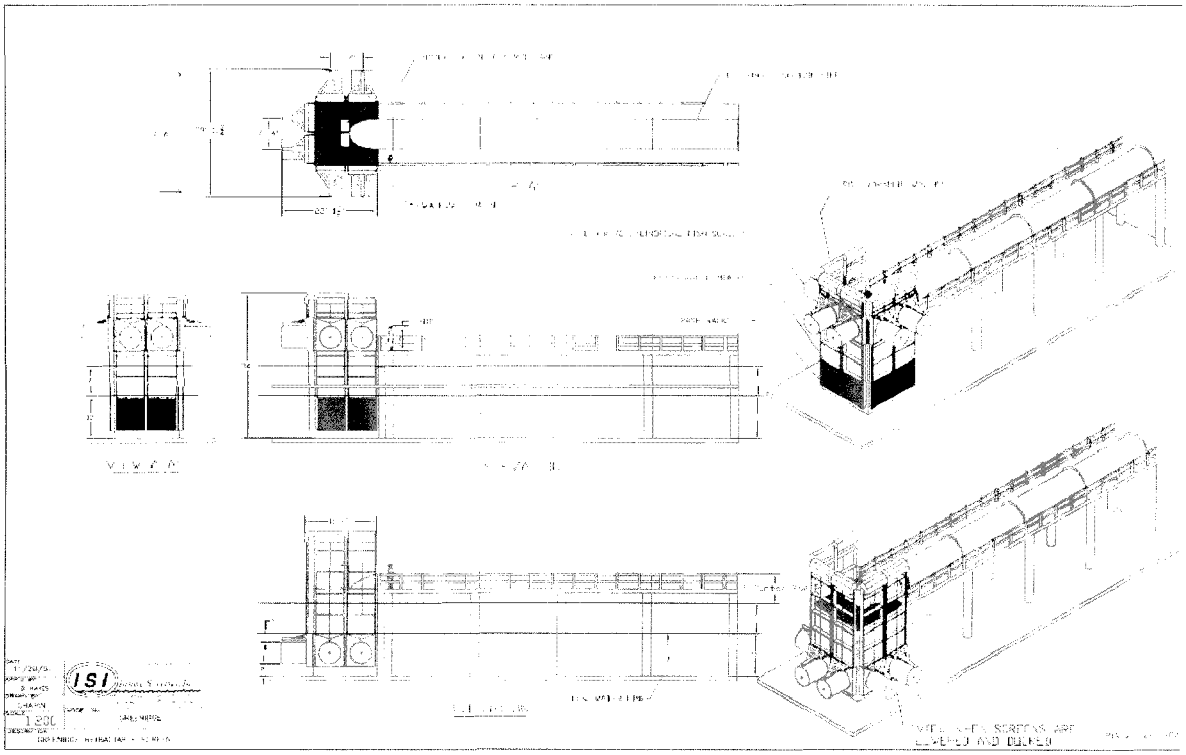


Figure 4-11 Proposed Design Layout of Brush-cleaned Wedge-wire Screen System for AES Greenidge Generating Station Unit 4

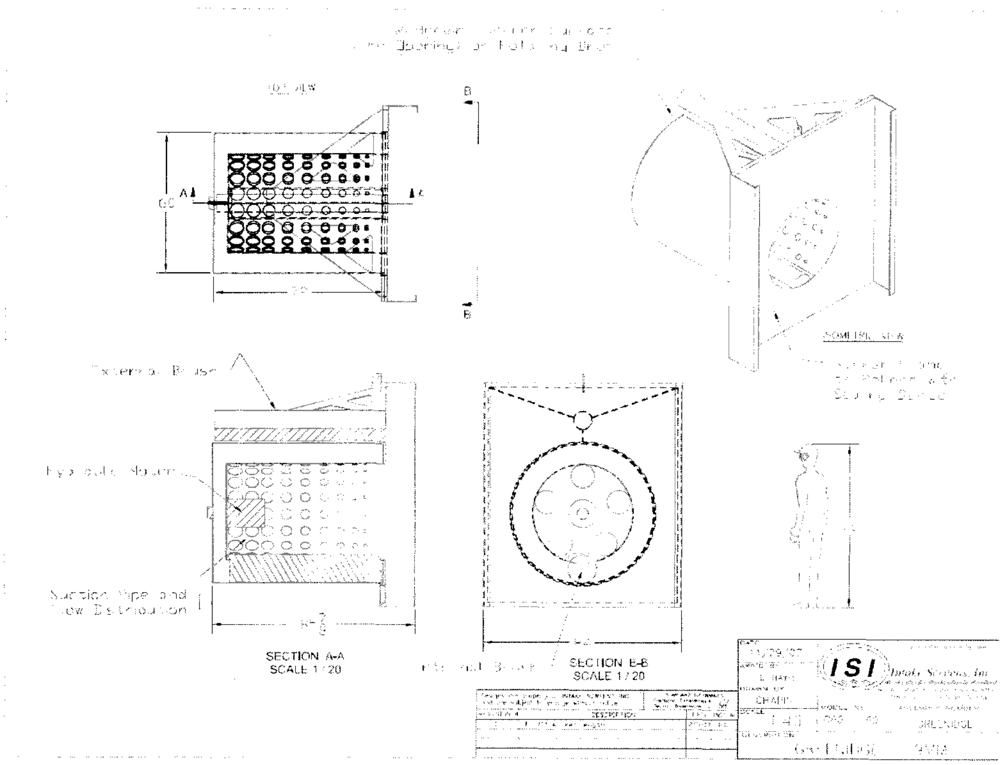
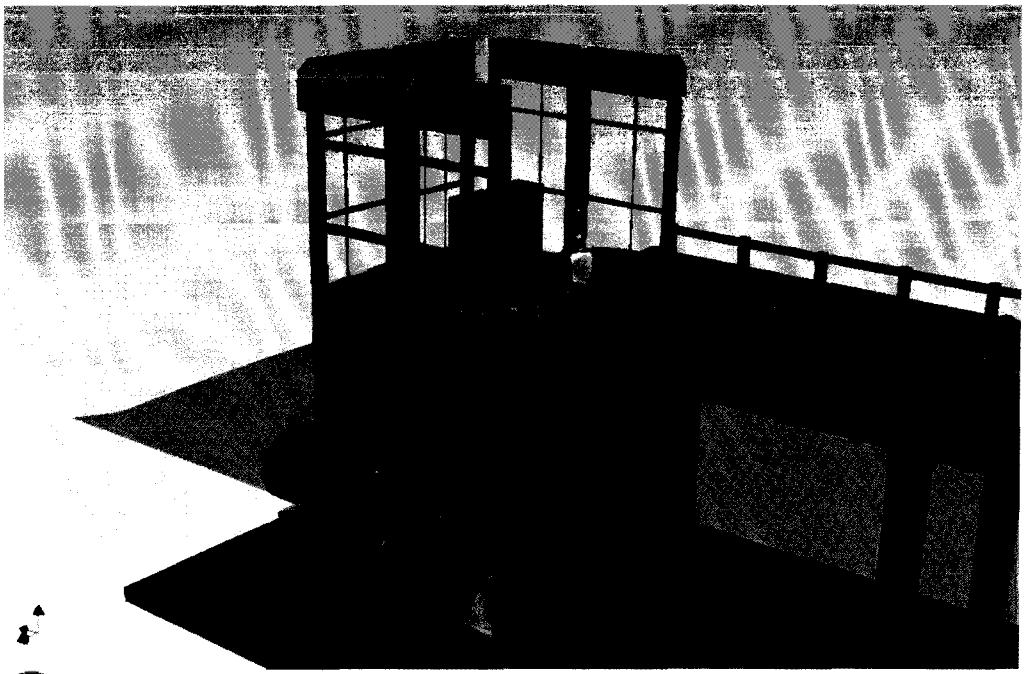


Figure 4-12 Proposed Design of Screen Unit for AES Greenidge Generating Station Unit 4

Intake Screens, Inc.

Figure 4-13 Profile View of Screens in Lowered Position



Intake Screens, Inc.

Figure 4-14 Profile View of Screens in Lowered Position from Oblique Angle

Figure 4-15 Top View of Platform and Screens in Lowered Position

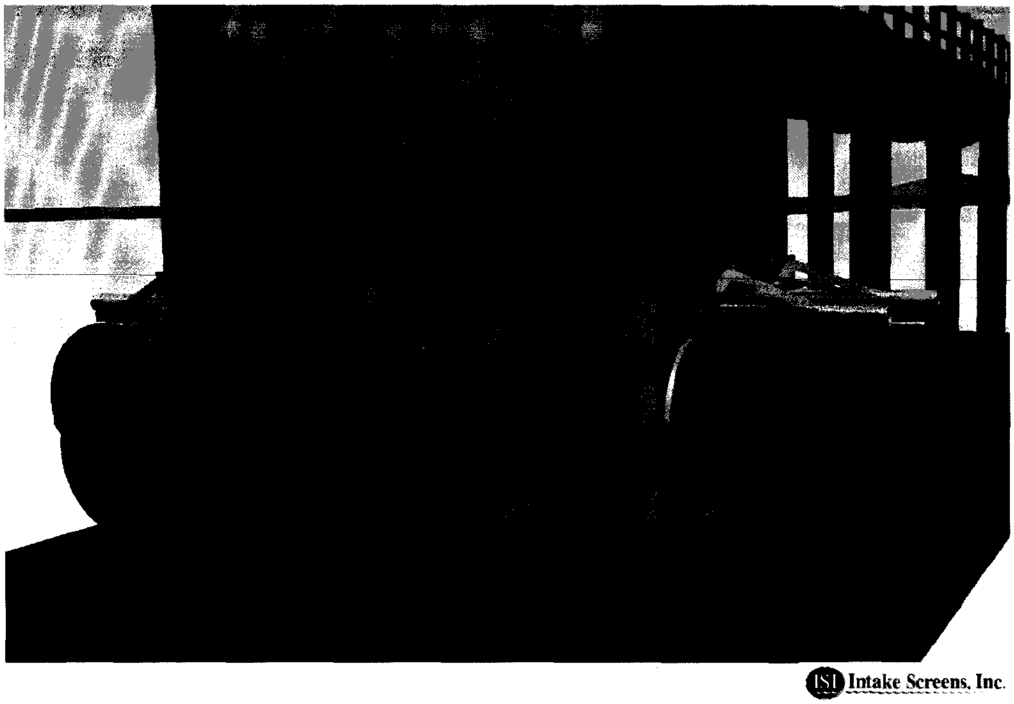


Figure 4-16 Detail View of External Screen Brushes and Internal Baffling Cylinder

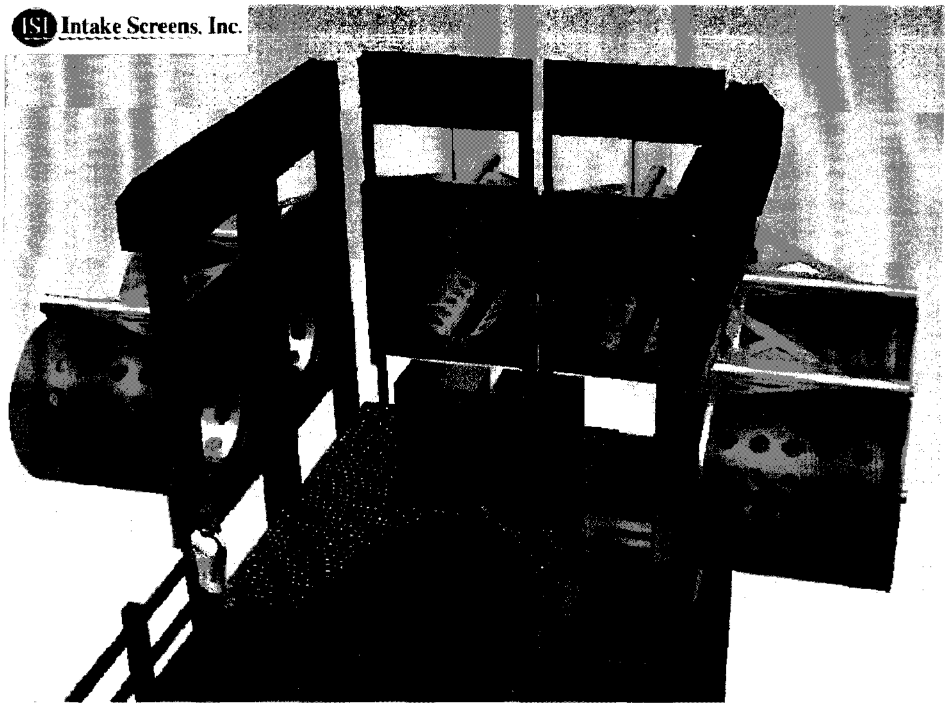


Figure 4-17 View of Screens in Raised Position

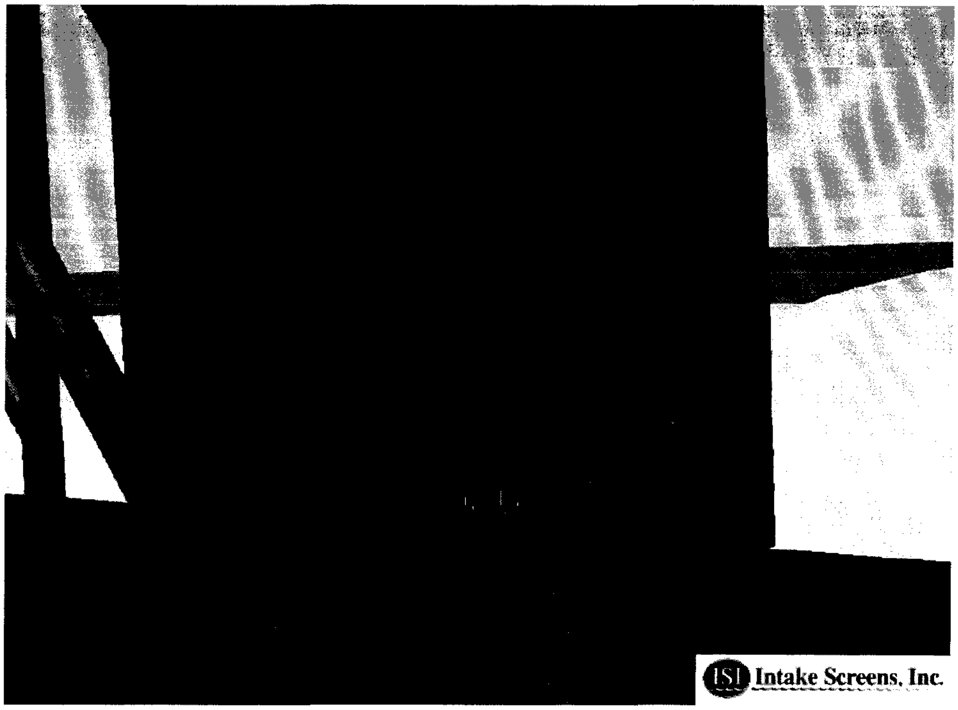


Figure 4-18 View of Intake Openings When Screens Are Raised

Figure 4-19 Profile View of System with Screens in Raised Position

2) Fish-handling systems

a. Fine mesh traveling screens with fish return

i. Description

Traveling screens have been used as barriers to debris loading and aquatic organism impingement at power generation facilities for decades. While these systems may be effective at preventing fish passage through cooling water intake systems, they have historically not been designed with fish protection in mind. Rather, they serve to prevent debris from damaging pumps and condensers. Conventional traveling screens offer no protection for non-motile, early life stages of aquatic organisms. Although there is no marked advantage between traveling and fixed screens in terms of impingement, a traveling screen may be used in concert with a fish return system to substantially increase survival of impinged organisms. By fitting travelling screens with fine mesh panels, organisms that would pass through the conventional travelling screen are impinged and thus can be excluded, washed off the screen and returned to the source water body. Studies have shown that the proportion of these organism that survive this process is species and site-specific.

ii. Conceptual Design

As discussed in Section 3, there are no travelling screens at Unit 4 and, because of the suction lift that must be maintained in the intake, it would not be practicable to install them. For this reason, a conceptual design has not been developed for travelling screens with or without fine mesh panels at AES Greenidge Unit 4.

iii. Feasibility/Practicability Determination

Traveling screens are not considered to be a potential alternative technology at AES Greenidge for several reasons. As discussed above, the primary reasons they are not practicable is because Unit 4 withdraws water via suction which must be maintained from the terminal end of the offshore intake to the pumps. Installation of a screen house and traveling screens at any point upstream of the pumps (between the pumps and lake) would break this suction and is therefore not feasible without a complete redesign of the cooling water intake system for this unit

If traveling screens could be installed at Unit 4, screens with 3/8-inch mesh would only reduce impingement mortality and not entrainment. In order to return the impinged fish to the lake at a depth similar to the one from which they were withdrawn the fish return pipe would need to be several hundred feet long. The return point would also need to be sufficiently distant from the intake to reduce the probability of re-impingement. To attempt to reduce entrainment of early life stage fish, the modified screens would need to be made of 0.5 to 2.0-mm fine mesh material. It is not known whether the percentage of eggs and larvae surviving impingement on fine mesh screens and passage through the return pipe would exceed current levels of survival of entrained organisms.

Installation of traveling screens at Unit 4, if found to be feasible, would be extremely costly. Major project components would include reconstruction of the Unit 4 cooling water intake system to replace the suction lift used to draw water into the intake, construction of the screen house and screens, and construction and operation of the fish return system.

Due to their expected high costs and the relatively low anticipated biological efficacy for the species involved, traveling screens are deemed impracticable at AES Greenidge and their conceptual design is not developed further in this technology assessment.

iv. Time required to implement

Not applicable.

v. Costs

Not applicable.

vi. Adverse environmental impacts

Not applicable.

vii. Mitigative benefits

Not applicable.

B. Flow Reduction Technologies

1) Closed Cycle Alternatives

Closed cycle cooling alternative technologies use re-circulated water rather than once-through water for condenser cooling. Variations include wet cooling towers, dry cooling towers, and cooling ponds. Closed cycle can be "full" or "partial" depending on the portion of cooling water provided by the closed cycle system. At AES Greenidge, cooling ponds are not considered to be potentially applicable due to their very large area requirements. Partial closed cycle alternatives are also not deemed practicable at AES Greenidge due to the duplicative expenses of building, maintaining, and operating two separate cooling water systems for the single unit. The closed cycle cooling technology considered for AES Greenidge is cooling towers. Burns Engineering Services, Inc. conducted an engineering and cost assessment of closed cycle alternatives for AES Greenidge. Burns' closed cycle retrofit analysis is included as Appendix D, with portions summarized in this section.

a. Cooling Towers

i. Description

Cooling towers dissipate heat to the atmosphere rather than to a water body. In closed cycle systems, cooling water flows through the condensers and cooling tower in a re-circulating loop. In dry closed cycle systems, cooling water conducts heat to a surface in contact with the air. Wet closed cycle systems use both conductive and evaporative cooling. Warm water from the condenser is cooled in a wet tower by ambient air, which is induced to flow either mechanically or by natural draft. Water withdrawals for make-up to the circulating water system for losses due to evaporation and blow-down are much lower than volumes required for once-through cooling water systems. The former Phase II rule estimated wet closed-cycle cooling can reduce cooling water requirements by approximately 93-98 percent from that required by once-through cooling technology.

Natural draft cooling towers induce airflow by convection; warm air rises through their large parabolic shape, typically over 400 feet tall. Mechanical draft cooling towers on the other hand use fans to move air through the towers, so they are not as large. Conventional wet mechanical draft towers produce a plume of supersaturated air that condenses into visible droplets. Mechanical draft towers can be plume abated to reduce plume appearance and drift. Cooling towers are a demonstrated technology for reducing impingement and entrainment impacts. Wet closed cycle cooling is identified as best technology available under the Phase I rule, for new facilities. Retrofitting closed cycle cooling to existing generating stations, however, is a costly endeavor that is not always feasible or practicable.

ii. Conceptual Design

Because AES Greenidge Unit 4 was designed and built with once-through cooling as a permanent and integral part of the generating station, designing a closed cycle retrofit is challenging. The original designers did not anticipate future cooling system modifications. The condenser and other components of the cooling water system were designed and fabricated to accommodate the relatively low hydraulic pressures of the original cooling water system and, could not withstand the higher pressures typically used to move water through a closed cycle system.

Natural draft towers, with their huge area requirements, large aesthetic impacts, and limited commercial availability are not considered feasible for this site. Dry cooling towers require more piping and land area than wet systems, so they are also readily eliminated from consideration. Plume visibility is the main difference between the remaining wet mechanical draft cooling tower systems. Based on technical expertise, past experiences, personal observations, photographs, engineering drawings and the design data provided by AES, Burns Engineering chose plume-abated mechanical draft cooling towers (Figure 4-20) for further evaluation at AES Greenidge. Selection of this design represents Burns Engineering's best engineering practice and judgment. A conceptual layout is shown in Figure 4-21.

Burns developed specifications for the cooling towers tailored to the conditions, and obtained a size and budget quote (Table 4-7) from SPX, a cooling tower manufacturer. To fulfill the cooling requirements, the cooling towers would consist of five cells, with a total footprint of 55 feet by 241 feet. The cooling tower would measure 75 feet high at the top of the fan stacks, and 61 feet to the top of the fan deck. A possible location was identified, as indicated in Figure 4-21

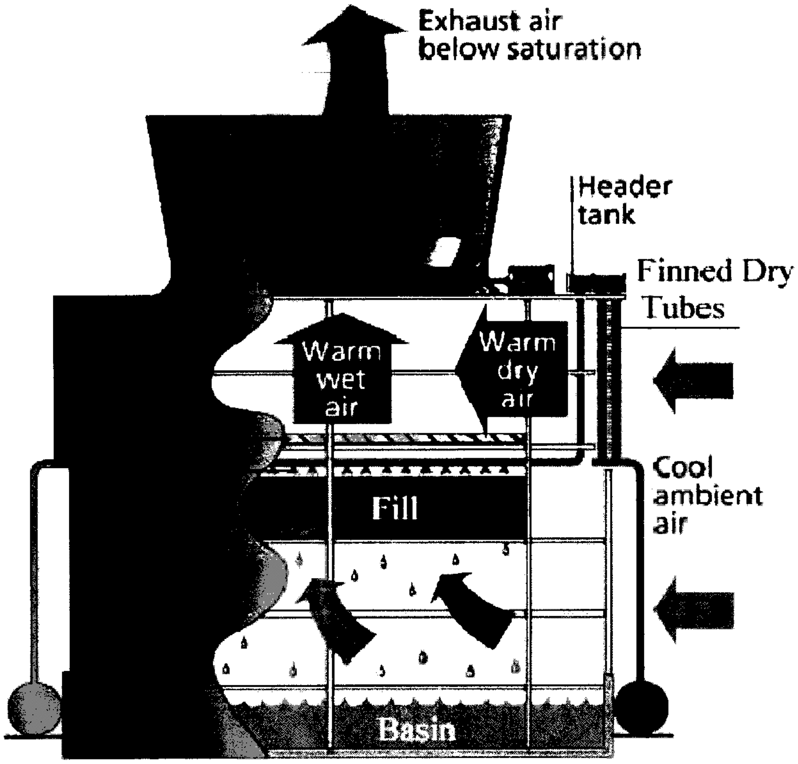
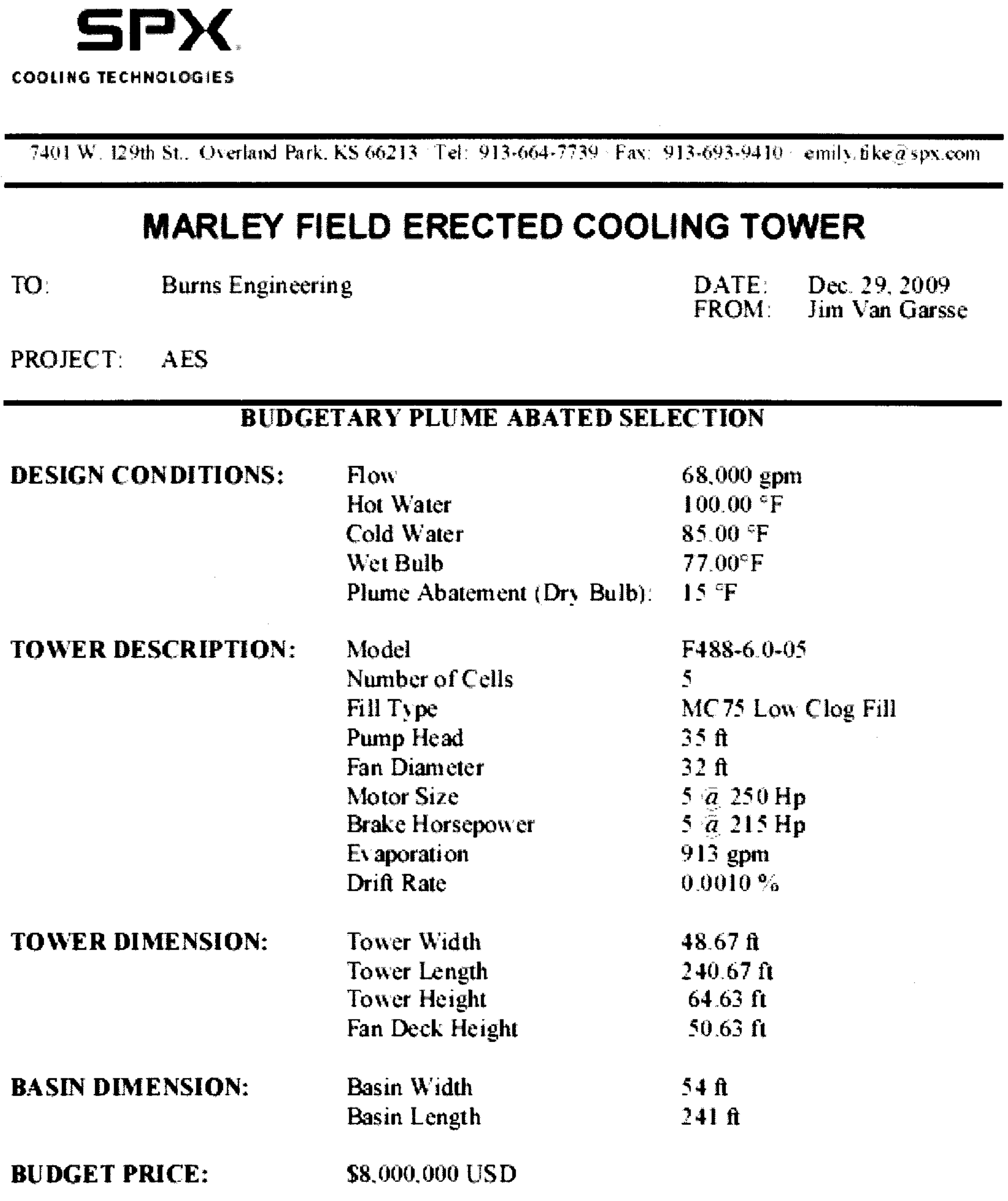


Figure 4-20 Conceptual AES Greenidge Cooling Tower Design

Table 4-7 Size and budget quote for cooling tower received from SPX based on design specification tailored to AES Greenidge



SPX
COOLING TECHNOLOGIES

7401 W. 129th St., Overland Park, KS 66213 · Tel: 913-664-7739 · Fax: 913-693-9410 · emily.fike@spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO: Burns Engineering

DATE: Dec. 29, 2009
FROM: Jim Van Garsse

PROJECT: AES

BUDGETARY PLUME ABATED SELECTION

DESIGN CONDITIONS:	Flow	68,000 gpm
	Hot Water	100.00 °F
	Cold Water	85.00 °F
	Wet Bulb	77.00°F
	Plume Abatement (Dry Bulb):	15 °F
TOWER DESCRIPTION:	Model	F488-6.0-05
	Number of Cells	5
	Fill Type	MC75 Low Clog Fill
	Pump Head	35 ft
	Fan Diameter	32 ft
	Motor Size	5 @ 250 Hp
	Brake Horsepower	5 @ 215 Hp
	Evaporation	913 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Width	48.67 ft
	Tower Length	240.67 ft
	Tower Height	64.63 ft
	Fan Deck Height	50.63 ft
BASIN DIMENSION:	Basin Width	54 ft
	Basin Length	241 ft
BUDGET PRICE:	$8,000,000 USD	

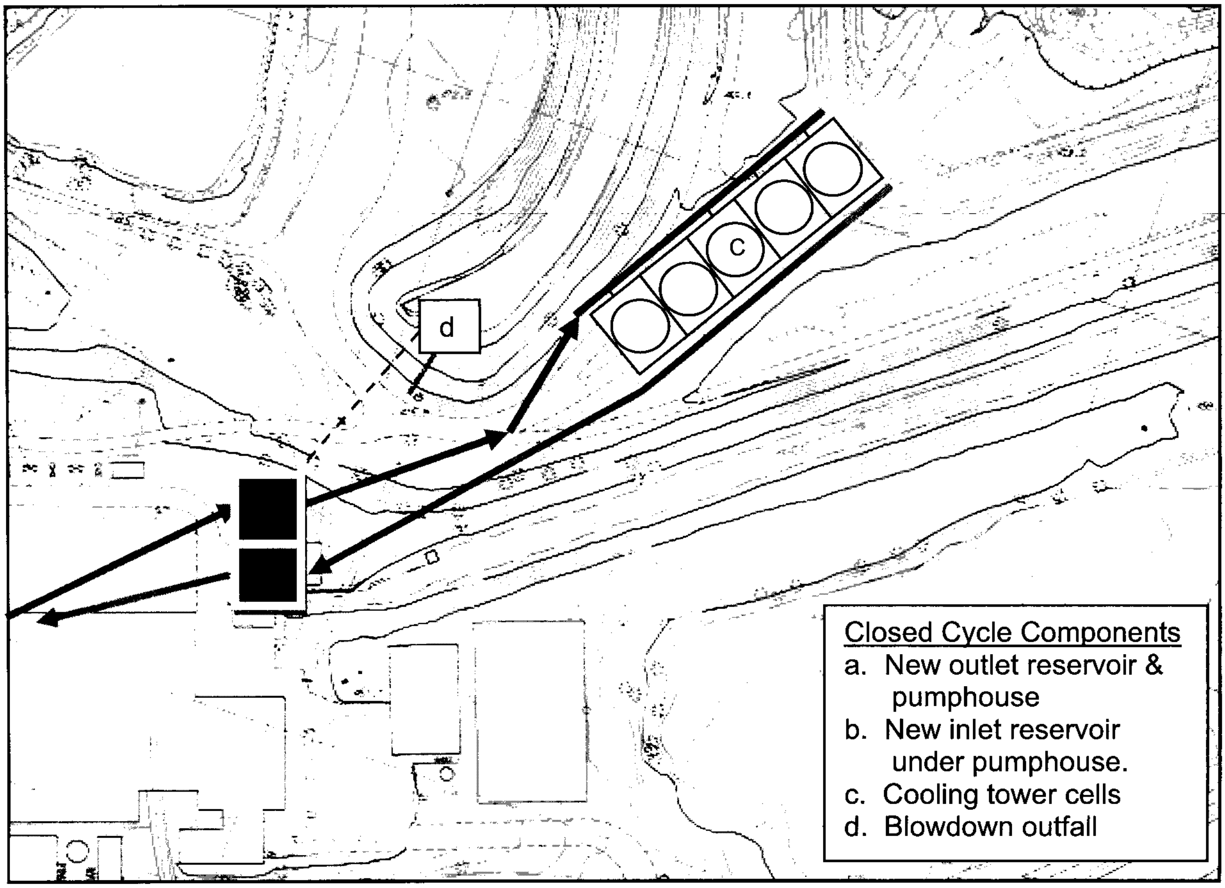


Figure 4-21 Potential closed cycle cooling location at AES Greenidge.

iii. Feasibility/Practicability Determination

The preliminary evaluation did not identify technical factors that would preclude building cooling towers at AES Greenidge, so the costs and biological benefits of plume abated mechanical draft cooling towers will be considered. This will provide closed cycle benchmarks for comparison with other alternative technologies, however it would be premature to conclude the technology is available for this facility.

iv. Time required to implement

Total time for the project from the initiation of the project planning to its completion is estimated to be at least 40 months (Table 4-8). Authorization to proceed would require local permits, environmental regulatory compliance triggered by the higher airborne emissions, and major modifications to the plant.

Table 4-8 Estimates of time required to implement closed cycle cooling at AES Greenidge

Project Task	Estimated Time Required
Permitting	12 months
Retrofit Planning & Design	12 months
Purchasing & Delivery	12 months
Cooling System Modifications	3 months
Cooling Tower Construction	3 months
Startup	1 Month
TOTAL:	**40 Months**

v. Costs

Costs associated with closed cycle cooling arise from capital expenditures, lost revenue during construction shutdown, increased auxiliary power consumption, decreased generating efficiency, and increased maintenance expenses. The capital cost of the closed-cycle retrofit is estimated to be $23,559,000 in January 2010 dollars (Table 4-9). The cost of a necessary 4-month shutdown, at $63/MWh assuming a 72% capacity factor, equates to $13,907,000 of lost revenue. Ongoing annual costs include an estimated $353,000 for the additional fuel due to negative heat rate effects (Table 4-10), $107,000 for added auxiliary power consumption, and

$150,000 for maintenance of the new equipment. Additional details of the closed cycle cooling costs are provided in Appendix D.

Table 4-9 Capital costs for closed cycle cooling at AES Greenidge.

CAPITAL COST OF CLOSED-CYCLE SYSTEM WITH WET PLUME-ABATED, COUNTERFLOW MECHANICAL DRAFT COOLING TOWER & REQUIRED SYSTEM COMPONENTS

ITEM	DESCRIPTION	BASIS	COST
1	One 5-cell Furnished & Erected Class F488-6.0-05 Plume-Abated Wet Cooling Tower Oriented in EW Direction, Noise attenuation	Dec. 2009 BES Ltr Spec & 12/29/2009 Budgetary Estimate from SPX	8,000,000
2	New CWS Piping Costs, including piping, elbows, valves, excavation, backfill, tie-ins, interferences	Means 2010 Q1	2,827,710
3	Cooling Tower Basin Cost, including site work, access road, backfill, and grade, piles, pile caps, Slab on Grade 6", Fdn walls	Means 2010 Q1	1,540,714
4	Wire CT fans MCC, switchgear, electricals, noise attenuation	Managing Waste Heat-Statistics	2,431,667
5	Inlet & Outlet Reservoir, pump house construction, Cooling Tower supply pumps, motors, and electricals	Means & pro-rate past pump estimates	2,586,375
6	Tower Acceptance Testing	Am Society Mech Engrs Test Code PTC 23-2003	65,000
7	**TOTAL DIRECT COSTS**		**$17,451,466**
8	Permit Cost Estimate	0.05	872,573
9	Construction Management	0.07	1,221,603
10	Engineering	0.08	1,396,117
11	Contingencies	0.15	2,617,720
12	**TOTAL ESTIMATED RETROFITTED PLUME ABATED CLOSED-CYCLE COOLING SYSTEM PROJECT CAPITAL COSTS (Jan 2010 COSTS)**		**$23,559,479**

Table 4-10 Additional fuel costs due to negative heat rate of closed cycle cooling at AES Greenidge

	Plant heat rate penalty,-B/kw-hr	Additional coal burned with once-through system, lb.	Seasonal extra fuel cost
Spring	250.2	3,183,961	$108,544
Summer Avg.	216.4	2,753,408	$93,866
Summer Max	436.5	5,554,557	$189,360
Fall	161.6	2,056,654	$70,113
Winter	184.7	2,350,246	$80,122
Annual Average Additional Cost			**$352,646**

vi. Adverse environmental impacts

Adverse environmental impacts could possibly occur due to increased air emissions, discharge of concentrated cooling water (blow down), cooling tower and plume visibility, drift deposition, icing, and noise emissions. Notably, an additional 5,000 tons of coal would need to be burned per year in order to make up for the plant inefficiency resulting from retrofitting a closed-cycle cooling system at AES Greenidge. Air pollutants such as carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, mercury, and particulates would increase. The increased generation may occur at AES Greenidge, or perhaps other less-controlled generating facilities.

Blowdown may require treatment prior to discharging, due to the fact that water quality contaminant concentrations will be higher in the discharge than currently. The concentration of minerals in this closed-cycle system increases over time due to a small portion of the recycled cooling water flow being evaporated by the tower. That results in a build-up of solids in the cooling water. This build-up in the circulating water at AES Greenidge is designed to be limited to a factor of five times that of current intake levels. Should treatment of blow down for contaminants prior to discharge be required, the facility would not have adequate or applicable existing water treatment facilities.

A major addition to the visual profile of the plant from the lake would occur. The structures of the 5 cell, plume abated cooling towers are about 241 ft long and will reach 65 ft to the top of the cooling tower fan stack. Based on the lake and ridge elevation, the top of the towers will stand more than 100 feet above the surface of the lake. Also, even with plume-abated towers, a visible plume would occur under certain atmospheric conditions.

Plume abated cooling towers also produce noise that would be audible on the lake and in areas surrounding the station.

vii. Mitigative benefits

Water consumption at Unit 4 would be reduced by 98% to 1,200 GPM. In combination with the retirement of Unit 3, reductions of both impingement and entrainment would be practically 100% (Table 4-11, Figure 4-22,and Figure 4-23)

Table 4-11 Estimated baseline equivalent age 1 losses from impingement and entrainment at AES Greenidge if closed cycle cooling had been used.

	Cooling Towers-full			
	Baseline	Technology Performance		
	Equivalent Age 1 Loss		Equivalent Age 1 Loss	Average % Reduction
Impingement	11,753	Best year	1	100
		Worst year	1	100
		5-year mean	1	100
Entrainment	66,045	Best year	26	100
		Worst year	26	100
		5-year mean	26	100

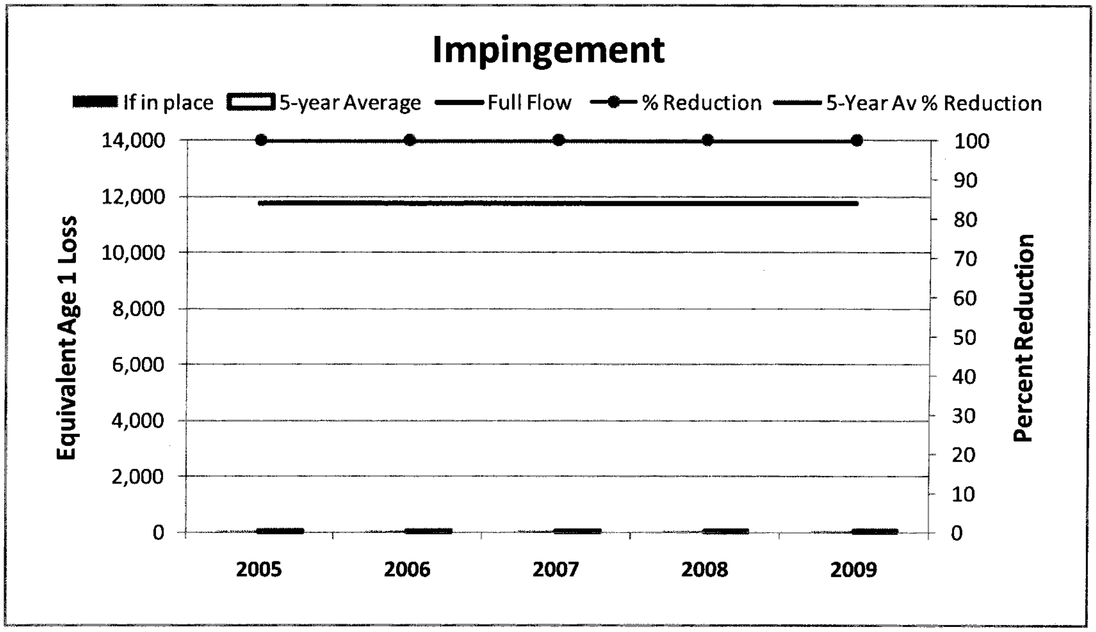


Figure 4-22 Estimated annual equivalent age 1 impingement loss from 2005-2009 at AES Greenidge if closed cycle cooling had occurred, and average percent reduction from baseline levels.

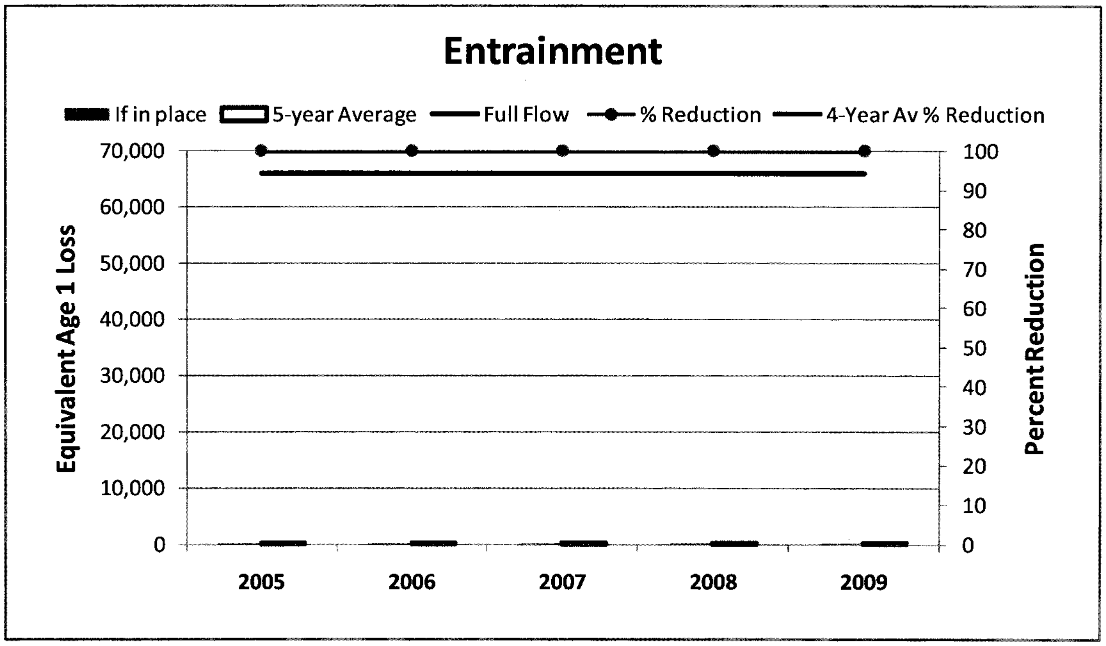


Figure 4-23 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge if closed cycle cooling had occurred, and average percent reduction from baseline levels.

b. Partial Closed Cycle

Partial closed cycle cooling refers to meeting part of a generating station's condenser cooling requirements with a closed cycle system. The partial closed cycle alternative is typically applied to wholly meet the cooling requirements of some individual units within a multiple-unit station, rather than having multiple systems partially meeting the requirements of each unit. At AES Greenidge, only a single unit will be operational. Retrofitting another separate closed cycle cooling system to Unit 4 for only part of the required condenser cooling is not considered to be a practicable alternative, and will not be evaluated further in this technology review.

2) Flow Management Alternatives

a. Variable Speed Pumps

i. Description

The premise for variable speed pumps alternatives is that at times the generating unit will have excess cooling capacity, either due to low intake water temperatures and/or low generating loads, thus the design cooling water flow provides excess cooling capacity. This excess cooling water flow can be reduced by using variable speed pumps.

ii. Conceptual Design

Modification of the existing pumps would require replacing the existing pump motors with new ones designed for variable speed operation. Variable frequency controls and new hardware connecting the power supply and pump drives will also be needed.

Conversion of all three CW pumps would be required for a variable speed operation to function properly at AES Greenidge. Retrofitting only one or two pumps would not be feasible, as the head from the stronger pumps would interfere with and overwhelm the flow from a variable speed pump on a lower setting.

It is assumed that the pumps themselves will not be replaced and that no resonant pump frequencies will occur that would cause any other major modifications to be implemented.

iii. Feasibility/Practicability Determination

The amount of water usage reduction attainable through the retrofitting of variable frequency drives at AES Greenidge is minimal. This is for two main reasons: (1) the plant is already operating with less than its three pumps for much of the year and (2) operational constraints, such as maintaining minimum flow velocity through the tubes and the SPDES intake-discharge temperature difference permit limitations, constrain the lowest permissible flow level.

Technical restrictions that apply to all options as to the lower limit of flow at which the plant can operate and produce full power are established by the water velocity through the condenser, condenser backpressure, and temperature rise and discharge temperature limits. For AES Greenidge Unit 4, the lowest level which can be considered for any season without exceeding one of these restrictions is 37,455 GPM, or 55% of total flow. Even this flow level can only be considered in spring and winter; otherwise, it will cause SPDES permit inlet-outlet temperature difference violations. As indicated by the outlined boxes in Table 4-12, the lowest possible flow that would not increase operating costs would be 67% of maximum in winter and spring months, 78% in the fall months, and 89% in the summer months.

Table 4-12 Analysis of seasonal AES Greenidge performance with flow reduction from variable speed pumping technology.

Period		Flow level (% of full flow)			
		89%	78%	67%	55%
Spring	Additional BTUs required	-6.83E+09	-4.00E+09	5.25E+06	6.14E+09
	Pump energy savings	-1.71E+09	-6.62E+08	1.75E+08	7.85E+08
	Net additional fuel BTUs required	-5.09E+09	-3.34E+09	-1.70E+08	5.36E+09
	Net added tons of coal burned	-178	-117	-6	187
	Performance Benefit+/Penalty- ($)	$13,326	$8,748	$445	($14,040)
Summer	Additional BTUs required	3.60E+08	7.64E+09	1.82E+10	3.47E+10
	Pump energy savings	4.13E+08	1.50E+09	2.33E+09	2.94E+09
	Net additional fuel BTUs required	-5.21E+07	6.15E+09	1.58E+10	3.17E+10
	Net added tons of coal burned	-2	215	553	1,110
	Performance Benefit+/Penalty- ($)	$137	($16,107)	($41,443)	($83,143)
Fall	Additional BTUs required	-4.95E+09	-2.96E+08	6.35E+09	1.67E+10
	Pump energy savings	-7.24E+09	3.39E+08	1.16E+09	1.76E+09
	Net additional fuel BTUs required	-4.23E+09	-6.35E+08	5.19E+09	1.49E+10
	Net added tons of coal burned	-148	-22	182	521
	Performance Benefit+/Penalty- ($)	$11,073	$1,664	($13,604)	($39,066)
Winter	Additional BTUs required	-7.28E+09	-4.27E+09	4.49E+06	6.59E+09
	Pump energy savings	-1.77E+09	3.39E+08	1.78E+08	7.99E+08
	Net additional fuel BTUs required	-5.51E+09	-4.61E+09	-1.73E+08	5.79E+09
	Net added tons of coal burned	-193	-161	-6	202
	Performance Benefit+/Penalty- ($)	$14,428	$12,081	$454	($15,164)

iv. Time required to implement

Variable speed pumping could be implemented about a year after all approvals were obtained. A plant shut-down of approximately one week would be required to install the new pump drives; presumably this work could be included during a scheduled outage.

v. Costs

The capital cost of implementing the VFD Option, including engineering, purchasing, specification, and installation, is estimated at $684,000 (Table 4-13). Costs resulting from decreased generating efficiency are partially offset some of the time by reduced power consumption by the variable speed pumps.

The net performance benefit/penalties are included in Table 4-12. The cost of the yearly penalty at the combined maximum seasonal flow reduction points is $58,915, with an additional 786 tons of coal burned to maintain output. Other values based on different combinations of seasonal flow operating levels can be determined from Table 4-12.

Table 4-13 Direct capital costs estimates for variable speed pumps at AES Greenidge.

Variable Speed Pump Conversion	**Direct Costs**
Control Hardware (each)	$63,485
Motors (each)	$88,502
Engineering, Purchasing, Specification, Installation per pump	$75,994
Total Cost Per Pump	$227,981
Total cost for 3 Pumps	**$683,943**

vi. Adverse environmental impacts

There would be an increase in air emissions for the same amount of generation output, associated with the lower efficiency of operation. This reduced efficiency would require up to 786 additional tons of coal annually. Discharge water temperatures would be increased, although approximately the same amount of heat would be discharged to Seneca Lake in the reduced flow volume.

vii. Mitigative benefits

The total maximum level of reduction in water usage possible with VFD option from typical 2007- 2009 levels is about 11.4% of total annual flow, or an average reduction of 7,600 GPM.

Analysis of the steam cycle for AES Greenidge indicates that flow reductions below the design flow could be implemented, particularly outside the summer months, without resulting in operating penalties. For purposes of this evaluation, the lowest flow that would not increase operating costs were used to examine the potential benefits of VFD technology. It was assumed that flow would be limited to 67% of full flow in winter and spring (which essentially mirrors current operating practice), 78% of full flow in the fall, and 89% of full flow in the summer months.

If this operating mode had been in effect since 2005 at Unit 4, the estimated equivalent age 1 impingement losses at the station would have ranged from 4,275 to 5,896, with an average over the last five years of 5,215 (Table 4-14, Figure 4-24). The percentage reduction from baseline losses would range from 49% to 64% with a mean of 55%. The incremental increase in average impingement reduction, beyond that achievable with current technology is 6%.

Entrainment would be similarly reduced by the proportional flow reduction. Equivalent age 1 entrainment losses would have ranged from 14,765 to 38,775 (Table 4-14, Figure 4-25). The average percent reduction from baseline levels of entrainment range from 43% to 68%, with a recent 5-year average of 51%. The incremental increase in average entrainment reduction, beyond that achievable with current technology is 4%.

Table 4-14 Estimated baseline equivalent age 1 losses from impingement and entrainment at AES Greenidge, and estimated 2005-2009 losses with variable speed pumps operated limited to 67% of full flow in winter and spring, 78% of full flow in the fall, and 89% of full flow in the summer.

	Variable Speed Pumps			
	Baseline	Technology Performance		
	Equivalent Age 1 Loss		Equivalent Age 1 Loss	Average % Reduction
Impingement	11,753	Best year	4,275	64
		Worst year	5,896	49
		5-year mean	5,215	55
Entrainment	66,045	Best year	14,765	68
		Worst year	38,775	43
		5-year mean	33,888	51

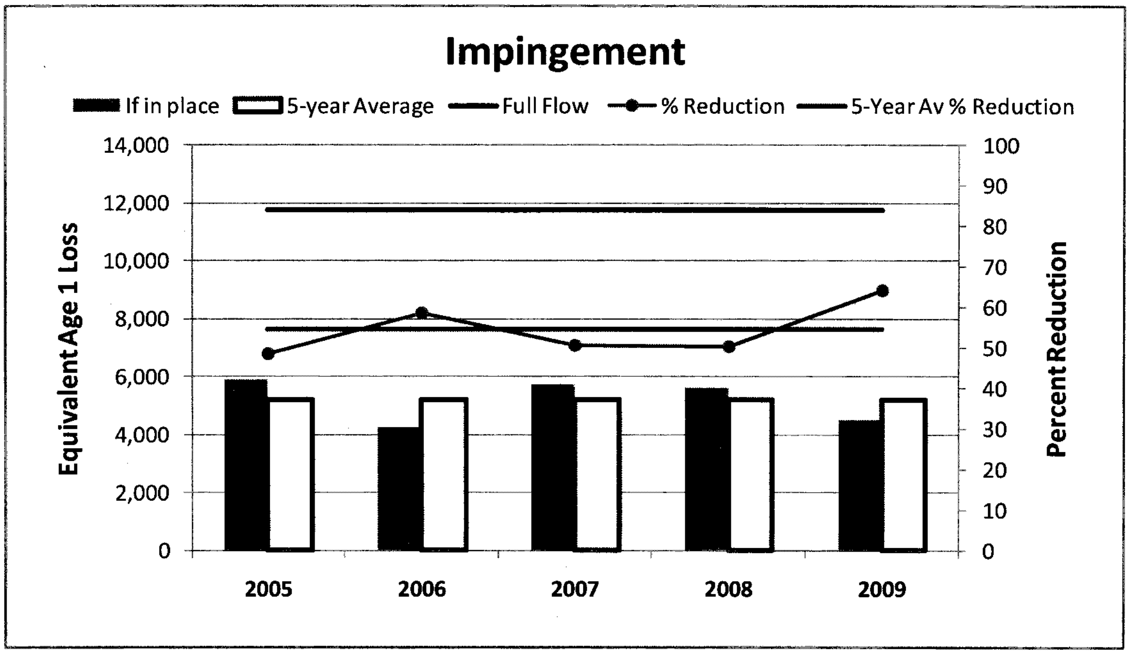


Figure 4-24 Estimated annual equivalent age 1 impingement loss from 2005-2009 at AES Greenidge based on actual operation and with variable speed pumps operating at 67% to 89% of design flow, and average percent reduction from baseline levels.

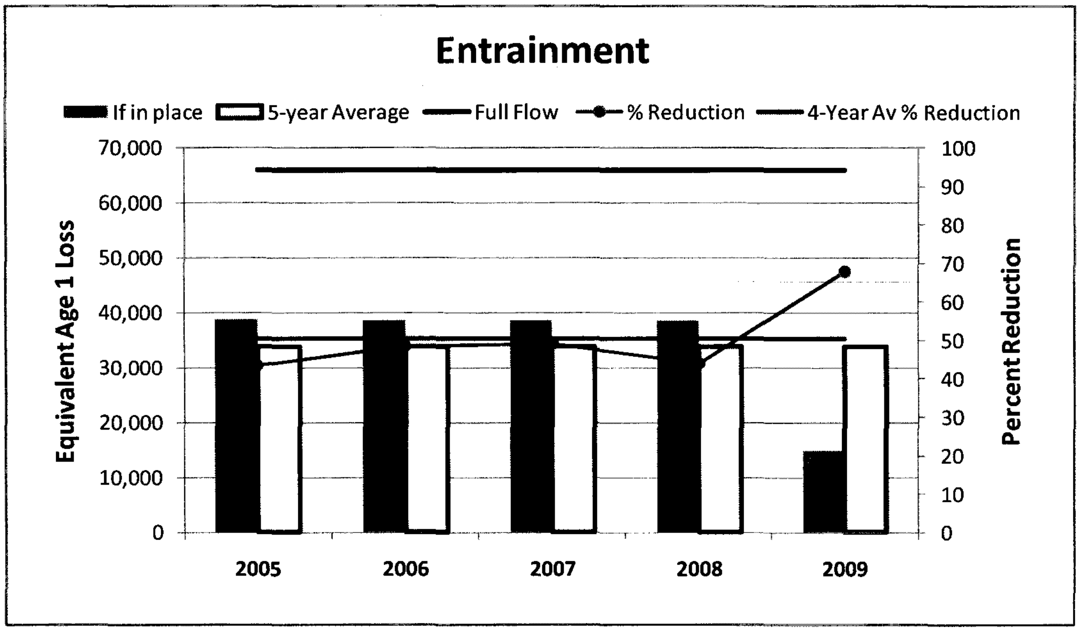


Figure 4-25 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge based on actual operation and with variable speed pumps operating at 67% to 89% of design flow, and average percent reduction from baseline levels.

b. Outages

i. Description

Targeted outages reduce impingement and entrainment during periods when a power station does not operate, or when it uses fewer cooling water pumps to service only those units that are generating. Outages as mitigation measures are most effective when entrainment and/or impingement is concentrated in a few months rather than spread evenly over the entire year. If normal maintenance outages can be scheduled within a period of high involvement then the mitigation can be both effective and inexpensive. However, if outages must be taken solely for the purpose of reducing entrainment and impingement, then they can be extremely expensive due to the lost opportunity for generation.

Specified outages were part of the mitigation package that led to the 1981 Settlement Agreement for the Hudson River power stations (Englert et al. 1988). In that agreement, the Roseton, Indian Point, and Bowline Point stations were required to take outages during the primary striped bass entrainment season of May-August. Roseton and Bowline Point had 30 unit-days of outage between May 15 and June 30 each year. Bowline Point additionally committed to 31 unit-days of outage during July. The Indian Point units were required to average 42 unit-days of outage annually between May 10 and August 10. A degree of flexibility was built into the agreement to allow trading of outage requirements among the stations, and to allow the stations to operate if their output was necessary in periods of high demand. At the Danskammer Point facility, the current SPDES permit requires a level of entrainment reduction that can only be met through significant unit outages, although outages are not explicitly specified. The facility operator can choose when to operate the units so that the overall mitigation targets, which are expressed as multi-year averages, are met.

At AES Greenidge, as well as at AES Westover, the outage alternative has already been implemented through permanent outages for one unit at each station, thus reducing the actual cooling water use from the permitted levels.

ii. Conceptual Design

For purposes of evaluating this alternative, outages in the spring and fall were considered, since these are the seasons when peak electrical demand has historically been lower. The first outage pattern considered was two one-month outages, in April and October, and the second pattern was one-month outages in May and September. The second pattern is closer to the peaks in entrainment and impingement, but is also closer to peak demand periods.

iii. Feasibility/Practicability Determination

As with the Hudson River Settlement Agreement, to be feasible, mitigative outages must have sufficient flexibility to allow a station to operate when needed to maintain electrical system reliability. This could be accomplished through permit conditions that allow a station to forgo the outages under specified conditions, include provisions for averaging over a period of years to accommodate fluctuations in dispatching, or through trading agreements with other facilities. Months-long outages are not feasible without some flexibility to allow a facility to take advantage of generating opportunities should they occur.

iv. Time required to implement

Since no equipment would need to be installed, implementation could occur as soon as a suitable set of permit conditions could be negotiated.

v. Costs

Costs of outages are difficult to predict. If the April and October schedule had been in effect in 2005-2009, the lost opportunity to generate at AES Greenidge Unit 4 would have been substantial. The mean annual revenue loss for2005-2009 with April and October outages would have been $4,973,944, and $5,013,484 for May and September outages (Table 4-15). The lost revenue would be partially offset by reduced fuel expenditures while the plant is offline. However, scheduled outages in these months would have likely reduced any planned maintenance outages taken in other months, possibly increasing both the generation output and fish impingement and entrainment. It is important that any plan for mitigation outages have sufficient flexibility to allow generating opportunities to be maximized.

Table 4-15 Estimated lost generation if AES Greenidge had implemented a mitigative outage program during 2005-2009.

Month	Mean MWhr	Mean outage cost
April	42,087	$2,651,494
May	39,924	$2,515,191
September	39,655	$2,498,293
October	36,864	$2,322,449
Apr & Oct	78,951	$4,973,944
May & Sep	79,579	$5,013,484

vi. Adverse environmental impacts

To the extent that AES Greenidge could meet its entrainment and impingement mitigation requirements through outage scheduling, any adverse environmental impacts would depend on the generating source used to replace the energy that AES Greenidge would have provided.

vii. Mitigative benefits

Using an assumption that generation in the non-outage months would not have changed due to the scheduled mitigation outages, the effects of mitigation outages can be estimated. If an April and October outage had been in place from 2005-2009, estimated equivalent age 1 impingement losses at the station would have ranged from 3,909 to 6,256, with an average over the last five years of 4,820 (Table 4-16, Figure 4-26). Average percent reduction in impingement losses would have ranged from 43% to 68% with an average of 55%, which is a 6% incremental increase over the current technology.

Entrainment losses would have ranged from 14,530 to 43,204 and averaged 37,129 (Table 4-16, Figure 4-27). Percent reduction from baseline values would range from 44% to 70% with a mean of 53%, which is a 6% increase over current technology.

Table 4-16 Estimated baseline equivalent age 1 losses from impingement and entrainment at AES Greenidge, and estimated 2005-2009 losses with current technology scheduled mitigative outages during the months of April and October.

	Scheduled Outages (A,O)			
	Baseline	Technology Performance		
	Equivalent Age 1 Loss		Equivalent Age 1 Loss	Average % Reduction
Impingement	11,753	Best year	3,909	68
		Worst year	6,256	43
		5-year mean	4,820	55
Entrainment	66,045	Best year	14,530	70
		Worst year	43,204	44
		5-year mean	37,129	53

Scheduled outages in May and September would have been slightly more effective. If a May and September outage had been in place from 2005-2009, estimated equivalent age 1 impingement losses at the station would have ranged from 4,158 to 7,706 with an average over the last five years of 5,551 (Table 4-17, Figure 4-28). Average % reduction in impingement losses would have ranged from 46% to 69% with an average of 60%, which is an 11% incremental increase over the current technology.

Entrainment losses would have ranged from 13,284 to 39,003 and averaged 33,550. Percent reduction from baseline entrainment would range from 46% to 71%, and averaged 55%, which is 8% above current technology (Table 4-17, Figure 4-29).

Table 4-17 Estimated baseline equivalent age 1 losses from impingement and entrainment at AES Greenidge, and estimated 2005-2009 losses with current technology and scheduled mitigative outages during the months of May and September.

	Scheduled Outages (M,S)			
	Baseline	Technology Performance		
	Equivalent Age 1 Loss		Equivalent Age 1 Loss	Average % Reduction
Impingement	11,753	Best year	4,158	69
		Worst year	7,706	46
		5-year mean	5,551	60
Entrainment	66,045	Best year	13,284	71
		Worst year	39,003	46
		5-year mean	33,550	55

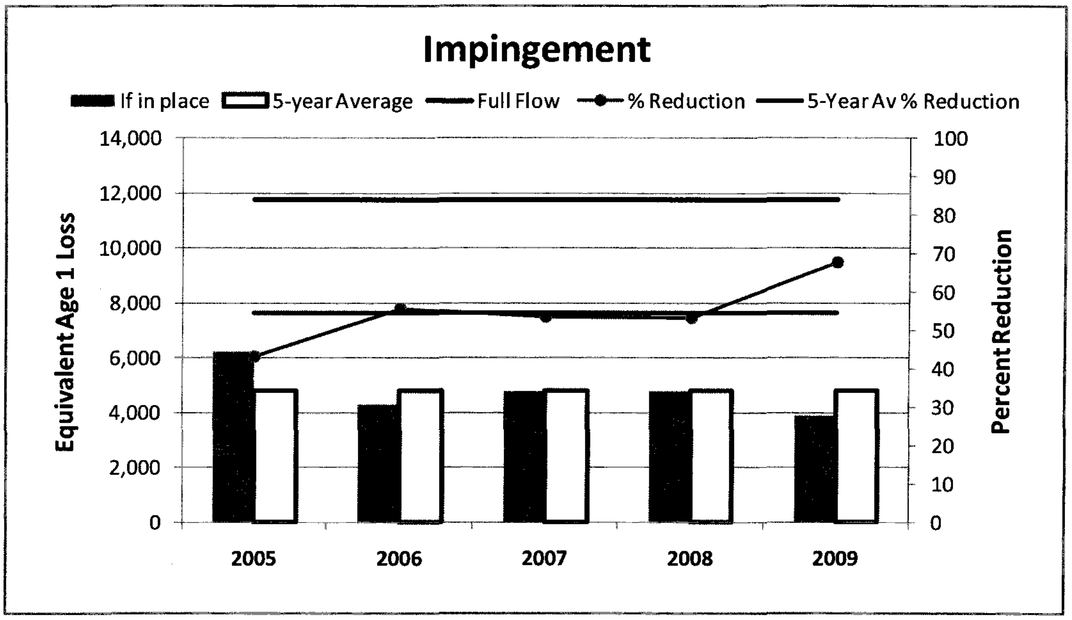


Figure 4-26 Estimated annual equivalent age 1 impingement loss from 2005-2009 at AES Greenidge based on actual operation and mitigative outages during April and October, and average percent reduction from baseline levels.

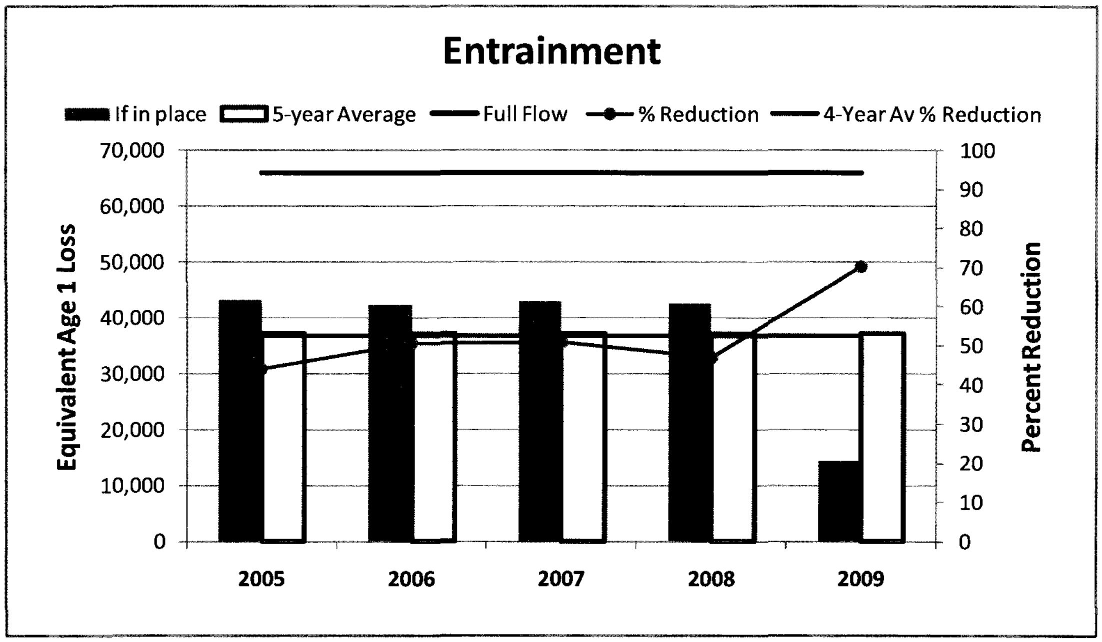


Figure 4-27 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge based on actual operation and mitigative outages during April and October, and average percent reduction from baseline levels.

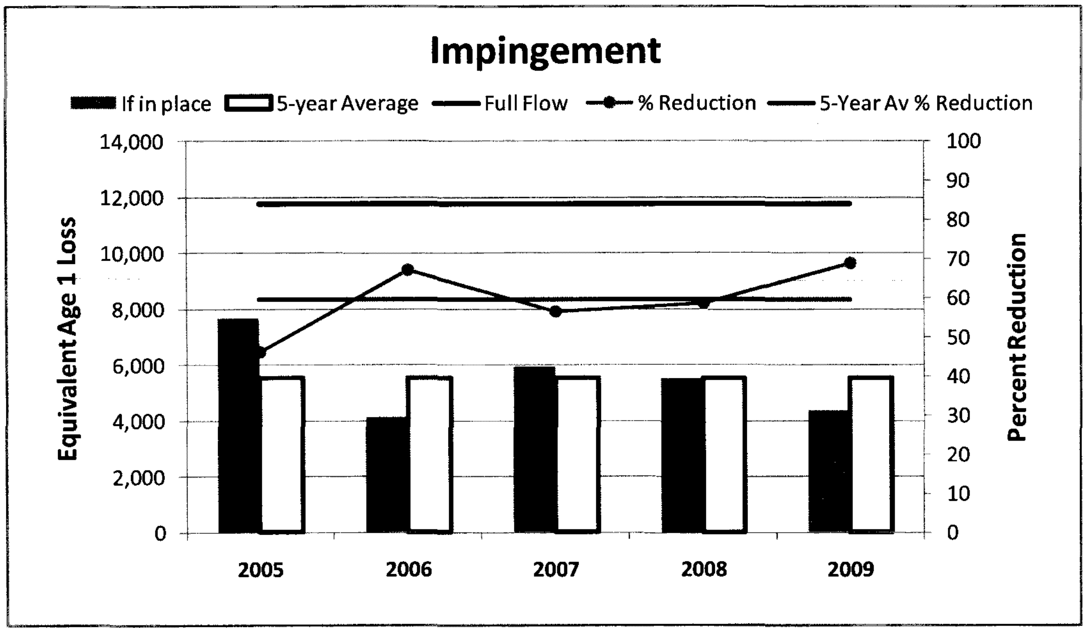


Figure 4-28 Estimated annual equivalent age 1 impingement loss from 2005-2009 at AES Greenidge based on actual operation and mitigative outages during May and September, and average percent reduction from baseline levels.

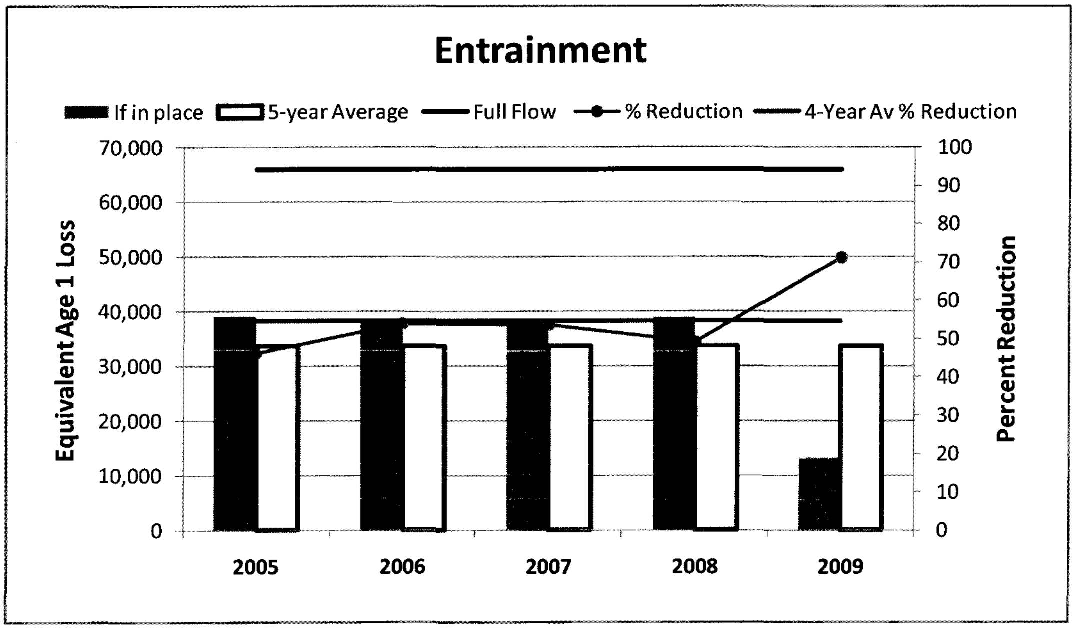


Figure 4-29 Estimated annual equivalent age 1 entrainment loss from 2005-2009 at AES Greenidge based on actual operation and mitigative outages during May and September, and average percent reduction from baseline levels.

5. Summary

The intent of the Design & Construction Technology Report is to evaluate alternative technologies for the cooling water intake with respect both to their feasibility/practicability of being implemented at the facility and to their effectiveness (i.e., how much reduction in impingement and entrainment mortality could be achieved) relative to the existing technology. The analysis in Section 4 first screens the candidate technologies for feasibility/practicability. Technologies that could not be installed or that would have only minimal effectiveness for the species involved at AES Greenidge were deemed infeasible or impracticable, and these technologies were not evaluated further. The options that could be implemented and that would appear to have more than minimal effectiveness were taken to a conceptual design stage, which consisted of estimating potential costs and effectiveness (to the extent that can be done with current data).

The estimates of biological effectiveness in Section 4 are based not on totals of individual organisms entrained or impinged[1], but instead on the equivalent age 1 fish loss. Conversion of total organisms to this, or a similar metric, provides a better index of the potential gains to the local fish population than the simple counts of organisms affected. This approach to calculating effectiveness was recommended by the Department in comments to the USEPA on the proposed Phase II §316(b) rule.[2]

An important consideration in evaluating the effectiveness of potential technologies is how long each technology may take to be implemented and become operational, and thus how long it will ultimately be used. A technology that can be implemented immediately may be more effective than a technology that would take five years or more to install, even if the annual gains are smaller for the immediately applicable technology.

In order to provide the "time-line perspective" on the candidate AES Greenidge technologies, a cumulative effectiveness analysis was performed. For each alternative, the current cooling water intake technology is assumed to remain in place until the estimated year of

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[1] Estimated actual numbers entrained and impinged are presented in Appendix A.

[2] Comments by NYSDEC commissioner D. Sheehan to USEPA.

implementation. Each technology is then assumed to operate through 2028, the year when AES' lease on the facility expires (Table 5-1).

The annual installed performance of the technology alternatives in Table 5-1 are at least 45 percent relative to baseline levels. The current technology provides this level of reduction through its current practice of seasonal use of reduced flow at Unit 4, lower than 100% capacity factor, and retirement of Unit 3. The wedgewire screen options achieve cumulative reductions in equivalent age 1 losses ranging from 51% (9 mm) to 99% (0.5 and 1 mm). Reductions for variable speed pump drives and scheduled outages in the spring and fall achieve reductions only slightly above those of the current technology and practice. Cooling towers, when installed and operating, would achieve essentially a 100% reduction, but with estimated implementation in 2018 the reduction achieved would only be 78%. The slight difference between wedgewire screens and closed cycle cooling is magnified in the cumulative performance through 2028 due to the earlier implementation for the wedgewire screens. Through 2028, the small mesh wedgewire screens would produce an 83% reduction in cumulative equivalent age 1 losses, while cooling towers would be expected to produce only a 78% reduction. Installation of 2 mm wedgewire screens by 2016 would produce a reduction of 64%, but other technologies produce only a marginal increase in overall percent reduction

In making its recommendation for proposed technologies for the AES Greenidge cooling water intake, AES will consider the expected annual performance of each technology, but AES will also consider the implications of the timing of construction and years of subsequent operation. In addition, the costs of each technology will also be considered, along with other relevant factors such as SEQRA-related issues, air emission increases, construction impacts, permitting and easement issues, and long-term plans for the facility, among others.

Table 5-1 Annual installed performance and cumulative performance through 2028 for feasible/practicable alternative intake technologies for AES Greenidge. Equivalent age 1 losses are for entrainment and impingement combined. Note percent reductions are calculated for illustration of the differences between annual and cumulative reductions. They are not intended for comparison to the performance standards in the SPDES permit.

Alternative	Year Installed	Annual (when installed)		Cumulative through 2028	
		Equivalent Age 1 Loss	% Reduction	Equivalent Age 1 Loss	% Reduction
Full Flow Baseline		78,000	0%	1,400,000	0%
Unit 4 - Current Tech		43,000	45%	781,000	44%
Wedgewire Screens 0.5 mm	2016	1,000	99%	233,000	83%
Wedgewire Screens 1 mm	2016	1,000	99%	236,000	83%
Wedgewire Screens 2 mm	2016	22,000	72%	501,000	64%
Wedgewire Screens 9 mm	2016	38,000	51%	706,000	50%
Cooling Towers-full	2018	-	100%	304,000	78%
Variable Speed Pumps	2013	39,000	50%	712,000	49%
Scheduled Outages (A,O)	2011	42,000	46%	755,000	46%
Scheduled Outages (M,S)	2011	39,000	50%	704,000	50%

6. Literature Cited

Brown, R. 2000. The potential of strobe lighting as a cost-effective means for reducing impingement and entrainment. Environmental Science and Policy 3(2000):405-416.

Callinan, C.W. 2001. Water Quality Study of the Finger Lakes. New York State Department of Environmental Conservation. July 2001. Report accessed 7/6/2010 online at http://www.dec.ny.gov/lands/25576.html.

CHG&E. 1999. Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permit for Bowline Point 1 & 2, Indian Point 2 & 3, and Roseton 1 & 2 Steam Electric Generating Stations. Prepared by Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, New York Power Authority, and Southern Energy of New York.

Drbal, L. F., P. G. Bost, and K. L. Westra. 1996. Power Plant Engineering. Black and Veatch.

Dunning, D.J., Q.E. Ross, P.G. Geoghegan, J.J. Reichle, J. K. Menezes, and J.K. Watson. 1992. Alewives Avoid High-Frequency Sound. North American Journal of Fisheries Management, 12:407-416.

Enercon. 2010. Evaluation of Alternative Intake Technologies at Indian Point Units 2 & 3. Report prepared for Entergy Nuclear. 134 pg.

Englert, T.E., Boreman, and H.Y. Chen. 1988. Plant Flow Reductions and Outages as Mitigation Measures. American Fisheries Society Monograph 4: 274-279, 1988.

EPRI. 1989. Field Testing of Behavioral Barriers for Fish Exclusion at Cooling-Water Intake Systems, Ontario Hydro Pickering Nuclear Generating Station. EPRI GS-6246.

EPRI. 1992. Evaluation of Strobe Lights for Fish Diversion at the York Haven Hydroelectric Project. Report Prepared by Stone & Webster Environmental Services.

EPRI. 1994. Research Update on Fish Protection Technologies for Water Intakes. Electric Power Research Institute, Palo Alto, CA.

EPRI. 1998. Review of Downstream Fish Passage and Protection Technology Evaluations and Effectiveness. TR-111517. Final Report. November 1998.

EPRI. 1999. Fish Protection at Cooling Water Intakes. Electric Power Research Institute, Palo Alto, CA.

EPRI. 2003. Laboratory Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intakes. Technical Report. Final Report. May, 2003.

Halfman, J.D., and K.A. O'Neill. 2009. Water quality of the Finger Lakes, New York: 2005 – 2008. Finger Lakes. Institute, Hobart and William Smith Colleges. 33 pg.

Halfman, J.D., and K. F. Bush. 2006. A preliminary water quality study of selected Finger Lakes, New York. Finger Lakes Institute, Hobart and William Smith Colleges. 15 pg.

Haymes, G.T., and P.H. Patrick. 1986. Exclusion of adult alewife, Alosa pseudoharengus, using low-frequency sound for application at water intakes. Can. J. Fish. Aquat. Sci. 43:855-862.

Henningson, Durham & Richardson Architecture and Engineering, P.C. In Association with HDR Engineering, Inc. (HDR). 2010a. AES Greenidge Generating Station 2006 Ichthyoplankton and Entrainment Studies. Prepared for AES Greenidge. April 29, 2010.

Henningson, Durham & Richardson Architecture and Engineering, P.C. In Association with HDR Engineering, Inc. (HDR). 2010b. AES Greenidge Generating Station 2006-2007 Impingement Study. Prepared for AES Greenidge. April 29, 2010.

Henningson, Durham & Richardson Architecture and Engineering, P.C. In Association with HDR Engineering, Inc. (HDR). 2010c. AES Greenidge Generating Station 2006-2007 Finfish Community and Waterbody Studies. Prepared for AES Greenidge. April 29, 2010.

Henningson, Durham & Richardson Architecture and Engineering, P.C. In Association with HDR Engineering, Inc. (HDR). 2010d. AES Greenidge Generating Station Impingement and Entrainment Characterization Study. Prepared for AES Greenidge. April 29, 2010.

Henningson, Durham & Richardson Architecture and Engineering, P.C., In Association with HDR Engineering, Inc. (HDR). 2006. Proposal for Information Collection in Compliance with Section 316 (b) Phase II-Requirements of the Clean Water Act for Greenidge Generating Station. Revision 2. February 6, 2006.

Hutchison, J.B., and J.A Matousek. 1988. Evaluation of a Barrier Net Used to Mitigate Fish Impingement at a Hudson River Power Plant Intake. In: L.W. Barnthouse, R.J. Klauda, D.S.

Vaughan and R.L. Kendal, (Eds.), Science, Law and Hudson River Power Plants. American Fisheries Society Monograph 4. American Fisheries Society, Bethesda, MD.

Ichthyological Associates, Inc. 1994. An Evaluation of the Effectiveness of the Strobe Light Deterrent System at Milliken Station on Cayuga Lake, Tompkins County, New York, December 1993 and April through August 1994. Prepared for New York State Electric and Gas Corporation.

Ichthyological Associates, Inc. 1997. An Evaluation of the Effectiveness of the Strobe Light Deterrent System at Milliken Station on Cayuga Lake, Tompkins County, New York, December 1995 through November 1996. Prepared for New York State Electric and Gas Corporation.

Jinks, S., N. Decker, W. Dey, J. Young, and D. Dixon. 2003. A review of impingement survival studies at steam-electric power stations. Presentation given May 7, 2003 at EPA Symposium on Technologies for Protecting Aquatic Organisms from Cooling Water.

Johnson, G.L. Thomas, R.E. Thorne, and W.C. Acker. 1980. A field examination of the effectiveness of a velocity cap in minimizing entrapment. University of Washington College of Fisheries, Fisheries Research Institute Report FRI-UW-8003. prepared for Southern California Edison.

Karlsen, H.E. 1992a. Infrasound Sensitivity in the Plaice (*Pleuronectes platessa*). Journal of Experimental Biology, 171: 173-187.

Karlsen, H.E. 1992b. The Inner Ear is Responsible for Detection of Infrasound in the Perch (*Perca fluviatilis*). Journal of Experimental Biology, 171: 163-172.

Knudsen, F. R., P. S. Enger, and O. Sand. 1994. Avoidance Responses to Low Frequency Sound in Downstream Migrating Atlantic Salmon, *Salmo salar* L. Journal of Fish Biology, 45:227-233

Knudsen, F.R., C.B. Schreck, S.M. Knapp, P.S. Enger, and O. Sand. 1997. Infrasound Produces Flight and Avoidance Responses in Pacific Juvenile Salmonids. Journal of Fish Biology, 51 : 824-829.

Langford, T. E. 1983. Electricity Generation and the Ecology of Natural Waters. Liverpool University Press.

LMS (Lawler Matusky and Skelly Engineers LLP). 1986. Brayton Point Station Unit 4 Impingement Survival Study. Prepared for NEPCO.

LMS Engineers. 1997. Lovett Generating Station Gunderboom System Evaluation Program 1996. Prepared for Orange and Rockland Utilities, Inc. by Lawler, Matusky and Skelly Engineers, Pearl River, NY.

Loeffelman, P.H., J.H. Van Hassel, and D.A. Klinect. 1991. Using Sound to Divert Fish from Turbine Intakes. Hydro Review, 10:30-37.

Nestler, J.M., G.R. Ploskey and J. Pickens. 1992. Responses of Blueback Herring to High-Frequency Sound and Implications for Reducing Entrainment at Hydropower Dams. North American Journal of Fisheries Management, 12:667-683.

NYSEG. 1977. Greenidge Station 316(a) demonstration.

Ross, Q.E. 1999. Studies of the Feasibility of Using High-Frequency Sound in Conjunction with By-passes Located Outside of the Sound Field to Provide Protection for Young-of-the-Year and Adult Blueback Herring at the Cresent and Vischer Ferry Hydroelectric Projects. New York Power Authority, White Plains, NY.

Ross, Q.E., D.J. Dunning, J.K. Menezes, M.J. Kenna, Jr., and G. Tiller 1996. Reducing Impingement of Alewives with High-Frequency Sound at a Power Plant Intake on Lake Ontario. North American Journal of Fisheries Management, 16:548-559.

Sager, D.R., Hocutt, C.H. and Stauffer, J.R., Jr. 2000. Avoidance behavior of *Morone americana, Leiostomus xanthurus* and *Brevoortia tyrannus* to strobe light as a method of impingement mitigation. Environmental Science and Policy 3(2000): 393-403.

Seneca Lake Area Partners in Five Counties. 1999. Setting a Course for Seneca Lake. Watershed planning report accessed 5/8/2008 from Genesee/Finger Lakes Regional Planning Council website at http://www.gflrpc.org/Publications/SenecaLakeWMP.htm.

Smith, C.L. 1985. The Inland Fishes of New York State. New York State Department of Environmental Conservation.

Stark, L. (2005). 4 January 2005 letter to Mr. Benjamin H. Grumbles of the U.S. EPA.

Steiner, L. 2000. Pennsylvania Fishes. Pennsylvania Fish and Boat Commission. 170 p.

Tenera Environmental. 2006. Additional information on HBGS intake velocity cap studies. Memo to AES Huntington Beach. Tenera Environmental, San Luis Obispo, CA.

Thomas, G.L., R.E. Thorne, W.C. Acker, and T.B. Stables. 1980. The effectiveness of a velocity cap and decreased flow in reducing fish entrapment. University of Washington College of Fisheries Research Institute Report FRI-UW-8027. Prepared for Southern California Edison.

Turnpenny, A.W.H. 1981. An analysis of mesh sizes required for screening fishes at water intakes. Estuaries, 4(4):363-368.

Turnpenny, A.W.H. 1988. The behavioral basis of fish exclusion from coastal power station cooling water intakes. RD/L/3301/R88.

USEPA. 2004. National Pollutant Discharge Elimination System: Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities. U.S. Environmental Protection Agency Report # 2040-AD62.

Weight, R. R. 1958. Ocean cooling water systems for 800 MW power station. J. Power Div., Proc. Am. Soc. Civil Engr. Paper 1888, 22 p.

APPENDIX A

Loss Estimate Data

Table A- 1 Annual impingement estimates for Full Flow Baseline

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	594	594	594	594	594	594	594	594
Banded Killifish	1,864	1,864	1,864	1,864	1,864	1,864	1,864	1,864
Bluegill	1,422	1,422	1,422	1,430	1,422	1,422	1,430	1,424
Bluntnose Minnov	168	168	168	168	168	168	168	168
Brown Bullhead	1,841	1,841	1,841	1,876	1,841	1,841	1,876	1,848
Catfish sp	63	63	63	63	63	63	63	63
Crayfish	1,522	1,522	1,522	1,522	1,522	1,522	1,522	1,522
Lamprey sp	35	35	35	35	35	35	35	35
Largemouth Bass	335	335	335	335	335	335	335	335
Pumpkinseed	1,111	1,111	1,111	1,128	1,111	1,111	1,128	1,114
Rock Bass	61	61	61	61	61	61	61	61
Smallmouth Bass	118	118	118	118	118	118	118	118
Spottail Shiner	68	68	68	68	68	68	68	68
Sunfish sp	6,992	6,992	6,992	6,997	6,992	6,992	6,997	6,993
Unidentified	19	19	19	19	19	19	19	19
Yellow Perch	52	52	52	52	52	52	52	52
_Total	16,265	16,265	16,265	16,330	16,265	16,265	16,330	16,278

Table A- 2		Annual impingement estimates for			Actual Current Tech			
Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	499	541	365	447	164	164	541	403
Banded Killifish	1,762	1,087	994	965	807	807	1,762	1,123
Bluegill	1,318	987	763	784	653	653	1,318	901
Bluntnose Minnov	149	107	111	93	54	54	149	103
Brown Bullhead	1,681	1,188	1,222	941	798	798	1,681	1,166
Catfish sp	59	36	22	26	20	20	59	33
Crayfish	1,361	1,166	837	945	507	507	1,361	963
Lamprey sp	28	29	22	20	6	6	29	21
Largemouth Bass	303	252	195	203	155	155	303	222
Pumpkinseed	1,018	631	707	550	426	426	1,018	666
Rock Bass	52	34	39	31	13	13	52	34
Smallmouth Bass	109	88	60	66	57	57	109	76
Spottail Shiner	62	56	37	46	25	25	62	45
Sunfish sp	6,511	3,823	3,952	3,644	2,901	2,901	6,511	4,166
Unidentified	15	19	17	15	10	10	19	15
Yellow Perch	45	30	34	32	13	13	45	31

Table A- 3 Annual impingement estimates for Unit 4 - Current Tech

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	390	362	363	378	164	164	390	331
Banded Killifish	1,352	552	930	845	777	552	1,352	891
Bluegill	901	592	649	641	630	592	901	683
Bluntnose Minnov	123	69	104	89	54	54	123	88
Brown Bullhead	1,226	705	947	898	796	705	1,226	914
Catfish sp	38	28	22	26	20	20	38	27
Crayfish	989	763	819	861	507	507	989	788
Lamprey sp	22	23	22	20	6	6	23	19
Largemouth Bass	211	152	168	163	144	144	211	168
Pumpkinseed	780	349	593	530	426	349	780	536
Rock Bass	43	23	39	31	13	13	43	30
Smallmouth Bass	71	53	53	53	53	53	71	57
Spottail Shiner	43	37	37	43	25	25	43	37
Sunfish sp	4,896	2,040	3,663	3,159	2,769	2,040	4,896	3,305
Unidentified	13	13	13	13	10	10	13	12
Yellow Perch	38	17	34	28	13	13	38	26
_Total	11,136	5,778	8,456	7,778	6,407	5,778	11,136	7,911

Table A- 4 Annual impingement estimates for Wedgewire Screens 0.5

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	-	-	-	-	-	-	-	-
Banded Killifish	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-
Bluntnose Minnov	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	-	-	-	-	-	-
Catfish sp	-	-	-	-	-	-	-	-
Crayfish	-	-	-	-	-	-	-	-
Lamprey sp	-	-	-	-	-	-	-	-
Largemouth Bass	-	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-	-
Rock Bass	-	-	-	-	-	-	-	-
Smallmouth Bass	-	-	-	-	-	-	-	-
Spottail Shiner	-	-	-	-	-	-	-	-
Sunfish sp	-	-	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	-	-
Yellow Perch	-	-	-	-	-	-	-	-
_Total	-	-	-	-	-	-	-	-

Table A- 5 Annual impingement estimates for Wedgewire Screens 1

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	-	-	-	-	-	-	-	-
Banded Killifish	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-
Bluntnose Minnov	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	-	-	-	-	-	-
Catfish sp	-	-	-	-	-	-	-	-
Crayfish	-	-	-	-	-	-	-	-
Lamprey sp	-	-	-	-	-	-	-	-
Largemouth Bass	-	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-	-
Rock Bass	-	-	-	-	-	-	-	-
Smallmouth Bass	-	-	-	-	-	-	-	-
Spottail Shiner	-	-	-	-	-	-	-	-
Sunfish sp	-	-	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	-	-
Yellow Perch	-	-	-	-	-	-	-	-
_Total	-	-	-	-	-	-	-	-

Table A- 6 Annual impingement estimates for Wedgewire Screens 2

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	-	-	-	-	-	-	-	-
Banded Killifish	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-
Bluntnose Minnov	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	-	-	-	-	-	-
Catfish sp	-	-	-	-	-	-	-	-
Crayfish	-	-	-	-	-	-	-	-
Lamprey sp	-	-	-	-	-	-	-	-
Largemouth Bass	-	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-	-
Rock Bass	-	-	-	-	-	-	-	-
Smallmouth Bass	-	-	-	-	-	-	-	-
Spottail Shiner	-	-	-	-	-	-	-	-
Sunfish sp	-	-	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	-	-
Yellow Perch	-	-	-	-	-	-	-	-
_Total	-	-	-	-	-	-	-	-

Table A- 7 Annual impingement estimates for Wedgewire Screens 9

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	-	-	-	-	-	-	-	-
Banded Killifish	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-
Bluntnose Minnov	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	-	-	-	-	-	-
Catfish sp	-	-	-	-	-	-	-	-
Crayfish	-	-	-	-	-	-	-	-
Lamprey sp	-	-	-	-	-	-	-	-
Largemouth Bass	-	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-	-
Rock Bass	-	-	-	-	-	-	-	-
Smallmouth Bass	-	-	-	-	-	-	-	-
Spottail Shiner	-	-	-	-	-	-	-	-
Sunfish sp	-	-	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	-	-
Yellow Perch	-	-	-	-	-	-	-	-
_Total	-	-	-	-	-	-	-	-

Table A- 8 Annual impingement estimates for Cooling Towers-full

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	-	-	-	-	-	-	-	-
Banded Killifish	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-
Bluntnose Minnov	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	-	-	-	-	-	-
Catfish sp	-	-	-	-	-	-	-	-
Crayfish	-	-	-	-	-	-	-	-
Lamprey sp	-	-	-	-	-	-	-	-
Largemouth Bass	-	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-	-
Rock Bass	-	-	-	-	-	-	-	-
Smallmouth Bass	-	-	-	-	-	-	-	-
Spottail Shiner	-	-	-	-	-	-	-	-
Sunfish sp	2	2	2	2	2	2	2	2
Unidentified	-	-	-	-	-	-	-	-
Yellow Perch	-	-	-	-	-	-	-	-
_Total	2	2	2	2	2	2	2	2

Table A- 9 Annual impingement estimates for Variable Speed Pumps

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	350	335	331	346	164	164	350	305
Banded Killifish	905	548	901	841	777	548	905	794
Bluegill	645	592	642	641	630	592	645	630
Bluntnose Minnov	89	57	89	84	54	54	89	75
Brown Bullhead	906	682	896	882	796	682	906	832
Catfish sp	29	28	22	26	20	20	29	25
Crayfish	848	721	764	824	507	507	848	733
Lamprey sp	18	18	18	18	6	6	18	16
Largemouth Bass	163	148	161	159	144	144	163	155
Pumpkinseed	548	338	546	522	426	338	548	476
Rock Bass	31	18	31	29	13	13	31	24
Smallmouth Bass	53	53	53	53	53	53	53	53
Spottail Shiner	41	35	35	41	25	25	41	35
Sunfish sp	3,370	2,022	3,346	3,152	2,769	2,022	3,370	2,932
Unidentified	11	11	11	11	10	10	11	11
Yellow Perch	28	15	28	26	13	13	28	22
_Total	8,035	5,621	7,874	7,655	6,407	5,621	8,035	7,118

Table A- 10 Annual impingement estimates for Scheduled Outages (A,O)

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	390	362	363	378	164	164	390	331
Banded Killifish	1,144	500	768	720	706	500	1,144	768
Bluegill	858	592	615	618	615	592	858	660
Bluntnose Minnov	102	69	87	78	47	47	102	77
Brown Bullhead	1,062	704	815	810	739	704	1,062	826
Catfish sp	38	28	22	26	20	20	38	27
Crayfish	847	702	710	769	459	459	847	697
Lamprey sp	22	23	22	20	6	6	23	19
Largemouth Bass	191	152	152	152	137	137	191	157
Pumpkinseed	547	327	407	400	346	327	547	405
Rock Bass	22	23	22	20	6	6	23	19
Smallmouth Bass	71	53	53	53	53	53	71	57
Spottail Shiner	43	37	37	43	25	25	43	37
Sunfish sp	3,180	2,021	2,285	2,237	2,174	2,021	3,180	2,379
Unidentified	13	13	13	13	10	10	13	12
Yellow Perch	17	17	17	17	6	6	17	15
_Total	8,547	5,623	6,388	6,354	5,513	5,513	8,547	6,485

Table A- 11 Annual impingement estimates for Scheduled Outages (M,S)

Species	2005	2006	2007	2008	2009	Minimum	Maximum	Mean
Alewife	364	343	348	360	150	150	364	313
Banded Killifish	1,352	552	930	845	777	552	1,352	891
Bluegill	901	592	649	641	630	592	901	683
Bluntnose Minnov	80	23	59	50	43	23	80	51
Brown Bullhead	1,183	659	902	859	785	659	1,183	878
Catfish sp	-	-	-	-	-	-	-	-
Crayfish	810	609	685	723	430	430	810	651
Lamprey sp	-	-	-	-	-	-	-	-
Largemouth Bass	211	152	168	163	144	144	211	168
Pumpkinseed	763	330	575	514	421	330	763	521
Rock Bass	21	-	17	11	7	-	21	11
Smallmouth Bass	71	53	53	53	53	53	71	57
Spottail Shiner	43	37	37	43	25	25	43	37
Sunfish sp	4,763	1,918	3,552	3,051	2,718	1,918	4,763	3,200
Unidentified	13	13	13	13	10	10	13	12
Yellow Perch	38	17	34	28	13	13	38	26
_Total	10,613	5,298	8,022	7,354	6,206	5,298	10,613	7,499

Table A- 12 Annual entrainment estimates for Full Flow Baseline

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	184,965	184,965	184,965	184,965	184,965	184,965	184,965	184,965
Banded Killifish	Lar	25,598	25,598	25,598	25,598	25,598	25,598	25,598	25,598
Banded Killifish	Juv	83,619	83,619	83,619	83,619	83,619	83,619	83,619	83,619
Brook Silverside	Egg	8,257	8,257	8,257	8,257	8,257	8,257	8,257	8,257
Bullhead sp	Juv	16,515	16,515	16,515	16,515	16,515	16,515	16,515	16,515
Carp	Juv	17,065	17,065	17,065	17,065	17,065	17,065	17,065	17,065
Carps and Minnows	Egg	8,257	8,257	8,257	8,257	8,257	8,257	8,257	8,257
Carps and Minnows	Lar	25,322	25,322	25,322	25,322	25,322	25,322	25,322	25,322
Darters	Lar	16,515	16,515	16,515	16,515	16,515	16,515	16,515	16,515
Suckers	Lar	33,029	33,029	33,029	33,029	33,029	33,029	33,029	33,029
Unidentified	Egg	57,746	57,746	57,746	57,746	57,746	57,746	57,746	57,746
Unidentified	Lar	34,130	34,130	34,130	34,130	34,130	34,130	34,130	34,130
White Sucker	Lar	140,046	140,046	140,046	140,046	140,046	140,046	140,046	140,046
Yellow Perch	Lar	8,257	8,257	8,257	8,257	8,257	8,257	8,257	8,257
_Total		659,321	659,321	659,321	659,321	659,321	659,321	659,321	659,321

Table A- 13		Annual entrainment estimates for				Actual Current Tech			
Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	82,959	174,330	139,865	87,867	115,657	82,959	174,330	120,136
Banded Killifish	Lar	5,773	20,611	25,272	17,359	20,970	5,773	25,272	17,997
Banded Killifish	Juv	18,858	67,329	82,554	56,705	68,502	18,858	82,554	58,790
Brook Silverside	Egg	3,704	7,783	6,244	3,923	5,163	3,704	7,783	5,363
Bullhead sp	Juv	2,654	13,566	13,622	10,712	9,371	2,654	13,622	9,985
Carp	Juv	3,848	13,741	16,848	11,572	13,980	3,848	16,848	11,998
Carps and Minnows	Egg	3,704	7,783	6,244	3,923	5,163	3,704	7,783	5,363
Carps and Minnows	Lar	7,552	21,524	23,092	15,495	19,143	7,552	23,092	17,361
Darters	Lar	7,407	15,565	12,488	7,845	10,327	7,407	15,565	10,726
Suckers	Lar	6,677	30,740	25,637	14,824	14,814	6,677	30,740	18,538
Unidentified	Egg	14,865	47,631	55,102	37,483	45,705	14,865	55,102	40,157
Unidentified	Lar	13,344	27,770	33,898	27,269	27,903	13,344	33,898	26,037
White Sucker	Lar	39,061	130,338	89,052	54,134	60,093	39,061	130,338	74,536
Yellow Perch	Lar	3,704	7,783	6,244	3,923	5,163	3,704	7,783	5,363
_Total		214,110	586,494	536,162	353,034	421,954	214,110	586,494	422,351

Table A- 14 Annual entrainment estimates for Unit 4 - Current Tech

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	82,959	113,530	87,867	87,867	108,480	82,959	113,530	96,141
Banded Killifish	Lar	5,773	17,234	16,907	17,234	17,226	5,773	17,234	14,875
Banded Killifish	Juv	18,858	56,298	55,228	56,298	56,273	18,858	56,298	48,591
Brook Silverside	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Bullhead sp	Juv	2,654	10,290	10,989	10,712	9,371	2,654	10,989	8,803
Carp	Juv	3,848	11,489	11,271	11,489	11,484	3,848	11,489	9,916
Carps and Minnows	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Carps and Minnows	Lar	7,552	16,557	15,194	15,412	16,327	7,552	16,557	14,208
Darters	Lar	7,407	10,137	7,845	7,845	9,686	7,407	10,137	8,584
Suckers	Lar	6,677	19,883	14,814	14,824	14,814	6,677	19,883	14,202
Unidentified	Egg	14,865	38,387	36,609	37,242	38,147	14,865	38,387	33,050
Unidentified	Lar	13,344	22,978	22,729	22,978	22,912	13,344	22,978	20,988
White Sucker	Lar	39,061	84,303	62,813	54,134	60,093	39,061	84,303	60,081
Yellow Perch	Lar	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
_Total		214,110	416,290	354,035	347,804	379,342	214,110	416,290	342,316

Table A- 15 Annual entrainment estimates for Wedgewire Screens 0.5

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	33,184	45,412	35,147	35,147	43,392	33,184	45,412	38,456
Banded Killifish	Lar	5,773	17,234	16,907	17,234	17,226	5,773	17,234	14,875
Banded Killifish	Juv	-	-	-	-	-	-	-	-
Brook Silverside	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Bullhead sp	Juv	-	-	-	-	-	-	-	-
Carp	Juv	-	-	-	-	-	-	-	-
Carps and Minnows	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Carps and Minnows	Lar	7,552	16,557	15,194	15,412	16,327	7,552	16,557	14,208
Darters	Lar	-	-	-	-	-	-	-	-
Suckers	Lar	6,677	19,883	14,814	14,824	14,814	6,677	19,883	14,202
Unidentified	Egg	14,865	38,387	36,609	37,242	38,147	14,865	38,387	33,050
Unidentified	Lar	3,848	11,489	11,271	11,489	11,484	3,848	11,489	9,916
White Sucker	Lar	2,720	5,136	3,827	3,022	3,575	2,720	5,136	3,656
Yellow Perch	Lar	-	-	-	-	-	-	-	-
_Total		82,027	164,234	141,615	142,216	154,651	82,027	164,234	136,949

Table A- 16 Annual entrainment estimates for Wedgewire Screens 1

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	39,821	54,494	42,176	42,176	52,070	39,821	54,494	46,147
Banded Killifish	Lar	1,847	5,515	5,410	5,515	5,512	1,847	5,515	4,760
Banded Killifish	Juv	-	-	-	-	-	-	-	-
Brook Silverside	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Bullhead sp	Juv	-	-	-	-	-	-	-	-
Carp	Juv	-	-	-	-	-	-	-	-
Carps and Minnows	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Carps and Minnows	Lar	7,552	16,557	15,194	15,412	16,327	7,552	16,557	14,208
Darters	Lar	7,407	10,137	7,845	7,845	9,686	7,407	10,137	8,584
Suckers	Lar	6,677	19,883	14,814	14,824	14,814	6,677	19,883	14,202
Unidentified	Egg	14,865	38,387	36,609	37,242	38,147	14,865	38,387	33,050
Unidentified	Lar	3,848	11,489	11,271	11,489	11,484	3,848	11,489	9,916
White Sucker	Lar	12,402	33,966	25,308	24,518	25,056	12,402	33,966	24,250
Yellow Perch	Lar	-	-	-	-	-	-	-	-
_Total		101,827	200,564	166,473	166,867	182,782	101,827	200,564	163,703

Table A- 17 Annual entrainment estimates for Wedgewire Screens 2

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	41,480	56,765	43,934	43,934	54,240	41,480	56,765	48,071
Banded Killifish	Lar	5,773	17,234	16,907	17,234	17,226	5,773	17,234	14,875
Banded Killifish	Juv	13,200	39,409	38,660	39,409	39,391	13,200	39,409	34,014
Brook Silverside	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Bullhead sp	Juv	-	-	-	-	-	-	-	-
Carp	Juv	-	-	-	-	-	-	-	-
Carps and Minnows	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Carps and Minnows	Lar	7,552	16,557	15,194	15,412	16,327	7,552	16,557	14,208
Darters	Lar	7,407	10,137	7,845	7,845	9,686	7,407	10,137	8,584
Suckers	Lar	6,677	19,883	14,814	14,824	14,814	6,677	19,883	14,202
Unidentified	Egg	14,865	38,387	36,609	37,242	38,147	14,865	38,387	33,050
Unidentified	Lar	13,344	22,978	22,729	22,978	22,912	13,344	22,978	20,988
White Sucker	Lar	39,061	84,303	62,813	54,134	60,093	39,061	84,303	60,081
Yellow Perch	Lar	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
_Total		160,471	320,857	271,274	264,781	287,365	160,471	320,857	260,950

Table A- 18 Annual entrainment estimates for Wedgewire Screens 9

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	82,959	113,530	87,867	87,867	108,480	82,959	113,530	96,141
Banded Killifish	Lar	5,773	17,234	16,907	17,234	17,226	5,773	17,234	14,875
Banded Killifish	Juv	18,858	56,298	55,228	56,298	56,273	18,858	56,298	48,591
Brook Silverside	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Bullhead sp	Juv	2,654	10,290	10,989	10,712	9,371	2,654	10,989	8,803
Carp	Juv	3,848	11,489	11,271	11,489	11,484	3,848	11,489	9,916
Carps and Minnows	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Carps and Minnows	Lar	7,552	16,557	15,194	15,412	16,327	7,552	16,557	14,208
Darters	Lar	7,407	10,137	7,845	7,845	9,686	7,407	10,137	8,584
Suckers	Lar	6,677	19,883	14,814	14,824	14,814	6,677	19,883	14,202
Unidentified	Egg	14,865	38,387	36,609	37,242	38,147	14,865	38,387	33,050
Unidentified	Lar	13,344	22,978	22,729	22,978	22,912	13,344	22,978	20,988
White Sucker	Lar	39,061	84,303	62,813	54,134	60,093	39,061	84,303	60,081
Yellow Perch	Lar	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
_Total		214,110	416,290	354,035	347,804	379,342	214,110	416,290	342,316

Table A- 19 Annual entrainment estimates for Cooling Towers-full

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	73	73	73	73	73	73	73	73
Banded Killifish	Lar	10	10	10	10	10	10	10	10
Banded Killifish	Juv	32	32	32	32	32	32	32	32
Brook Silverside	Egg	3	3	3	3	3	3	3	3
Bullhead sp	Juv	7	7	7	7	7	7	7	7
Carp	Juv	7	7	7	7	7	7	7	7
Carps and Minnows	Egg	3	3	3	3	3	3	3	3
Carps and Minnows	Lar	10	10	10	10	10	10	10	10
Darters	Lar	7	7	7	7	7	7	7	7
Suckers	Lar	13	13	13	13	13	13	13	13
Unidentified	Egg	22	22	22	22	22	22	22	22
Unidentified	Lar	14	14	14	14	14	14	14	14
White Sucker	Lar	54	54	54	54	54	54	54	54
Yellow Perch	Lar	3	3	3	3	3	3	3	3
_Total		258	258	258	258	258	258	258	258

Table A- 20 Annual entrainment estimates for Variable Speed Pumps

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	82,959	110,995	87,867	87,867	108,480	82,959	110,995	95,634
Banded Killifish	Lar	5,773	15,361	15,361	15,361	15,361	5,773	15,361	13,443
Banded Killifish	Juv	18,858	50,179	50,179	50,179	50,179	18,858	50,179	43,915
Brook Silverside	Egg	3,704	4,955	3,923	3,923	4,843	3,704	4,955	4,270
Bullhead sp	Juv	2,654	8,685	8,685	8,685	8,685	2,654	8,685	7,479
Carp	Juv	3,848	10,241	10,241	10,241	10,241	3,848	10,241	8,962
Carps and Minnows	Egg	3,704	4,955	3,923	3,923	4,843	3,704	4,955	4,270
Carps and Minnows	Lar	7,552	15,196	14,164	14,164	15,084	7,552	15,196	13,232
Darters	Lar	7,407	9,910	7,845	7,845	9,686	7,407	9,910	8,539
Suckers	Lar	6,677	14,921	14,814	14,824	14,814	6,677	14,921	13,210
Unidentified	Egg	14,865	34,653	33,621	33,621	34,541	14,865	34,653	30,260
Unidentified	Lar	13,344	20,482	20,482	20,482	20,482	13,344	20,482	19,054
White Sucker	Lar	39,061	63,267	62,813	54,134	60,093	39,061	63,267	55,874
Yellow Perch	Lar	3,704	4,955	3,923	3,923	4,843	3,704	4,955	4,270
_Total		214,110	368,755	337,841	329,172	362,175	214,110	368,755	322,411

Table A- 21 Annual entrainment estimates for Scheduled Outages (A,O)

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	82,959	113,530	87,867	87,867	108,480	82,959	113,530	96,141
Banded Killifish	Lar	5,773	17,234	16,907	17,234	17,226	5,773	17,234	14,875
Banded Killifish	Juv	18,858	56,298	55,228	56,298	56,273	18,858	56,298	48,591
Brook Silverside	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Bullhead sp	Juv	2,654	10,290	10,989	10,712	9,371	2,654	10,989	8,803
Carp	Juv	3,848	11,489	11,271	11,489	11,484	3,848	11,489	9,916
Carps and Minnows	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Carps and Minnows	Lar	7,552	16,557	15,194	15,412	16,327	7,552	16,557	14,208
Darters	Lar	7,407	10,137	7,845	7,845	9,686	7,407	10,137	8,584
Suckers	Lar	-	-	-	-	-	-	-	-
Unidentified	Egg	14,865	38,387	36,609	37,242	38,147	14,865	38,387	33,050
Unidentified	Lar	13,344	22,978	22,729	22,978	22,912	13,344	22,978	20,988
White Sucker	Lar	29,379	55,473	41,332	32,638	38,612	29,379	55,473	39,487
Yellow Perch	Lar	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
_Total		197,751	367,577	317,740	311,484	343,047	197,751	367,577	307,520

Table A- 22 Annual entrainment estimates for Scheduled Outages (M,S)

Species	Stage	2005	2006	2007	2008	2009	Minimum	Maximum	5-yr Mean
Alewife	Egg	82,959	113,530	87,867	87,867	108,480	82,959	113,530	96,141
Banded Killifish	Lar	5,773	17,234	16,907	17,234	17,226	5,773	17,234	14,875
Banded Killifish	Juv	18,858	56,298	55,228	56,298	56,273	18,858	56,298	48,591
Brook Silverside	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Bullhead sp	Juv	-	-	-	-	-	-	-	-
Carp	Juv	3,848	11,489	11,271	11,489	11,484	3,848	11,489	9,916
Carps and Minnows	Egg	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
Carps and Minnows	Lar	7,552	16,557	15,194	15,412	16,327	7,552	16,557	14,208
Darters	Lar	7,407	10,137	7,845	7,845	9,686	7,407	10,137	8,584
Suckers	Lar	6,677	19,883	14,814	14,824	14,814	6,677	19,883	14,202
Unidentified	Egg	14,865	38,387	36,609	37,242	38,147	14,865	38,387	33,050
Unidentified	Lar	13,344	22,978	22,729	22,978	22,912	13,344	22,978	20,988
White Sucker	Lar	9,682	28,830	21,481	21,496	21,481	9,682	28,830	20,594
Yellow Perch	Lar	3,704	5,068	3,923	3,923	4,843	3,704	5,068	4,292
_Total		182,077	350,527	301,714	304,454	331,359	182,077	350,527	294,026

APPENDIX B

Methodology for Calculating Mitigative Benefits

Methodology for Analysis of Alternatives

The various alternatives for AES Greenidge were compared by estimating annual fish losses for each alternative according to the following methodology.

I&E Reduction Calculations

The analysis of AES Greenidge impingement and entrainment was conducted using calculation methodologies that are commonly used for §316(b) and NYCRR 704.5 compliance demonstrations. Conceptually, the analysis is very simple:

$$IL = \sum_{sm} ID_{sm} F_m (1 - IS_{sm}) \qquad (1)$$

Annual impingement loss (*IL*) is the monthly impingement density of species *s* (ID_{sm}) multiplied by the monthly flow (F_m) and the complement of the impingement survival rate for species *s* in month *m* (IS_{sm}), summed over all species and 12 months. Entrainment loss (*EL*) is calculated similarly using mean monthly entrainment density (ED_{sm}), and entrainment survival (ES_{sm}). For Greenidge, both IS_{sm} and ES_{sm} are assumed to be 0 for the baseline and for existing technology.

Although AES Greenidge has one non-baseline feature (the intake is located offshore at a depth of approximately 15 ft), there are no data available to estimate the effect of this feature on impingement or entrainment densities. Therefore, the current intake configuration, except for the actual flows employed, will be considered to reflect baseline conditions for the purpose of this analysis:

$$IL_{Baseline} = \sum_{sm} ID_{sm} F_{mBaseline} \qquad (2)$$

where

$F_{mBaseline}$ = baseline flow in month *m* (constant 101,000 gpm)

For the calculation baseline, IS_{sm} is set to 0 because design and or operation of most cooling water intakes would not permit significant survival of impinged fish, absent measures taken to comply with §316(b) or NYCRR 704.5.

When estimating the impingement loss for alternative technologies, it must be determined whether the alternative would increase impingement survival, or decrease the impingement density, or both. For example, the effect of addition of a deterrent system technology to the existing intake would be calculated as:

$$IL_{Alt} = \sum_{sm} ID_{sm} F_m (1 - IS_{Alt\_sm})(1 - e_{Alt\_sm}) \qquad (3)$$

where

IS_{Alt_sm} = impingement survival using alternative technology for species *s* in month *m*

e_{Alt_sm} = efficacy of alternative technology for species *s* in month *m*

For entrainment, ES_{Alt_sm} was assumed to be 0 for all alternatives:

$$EL_{Alt} = \sum_{sm} ED_{sm} F_m (1 - e_{Alt\_sm}) \qquad (4)$$

IL and *EL* can both be calculated for total numbers of organisms as described above by first summing the monthly densities across all life stages. However, more ecologically relevant loss estimates can be derived by converting the various life stages affected to a single common life stage. In this way, numerical losses of eggs are not added directly to numerical losses of juveniles which would produce a total loss estimate that is difficult to interpret. The equivalent age for conversion was defined as of Age 1 (12 months of age):

$$IL_{sm1} = \sum_{a} IL_{sm} f_{sam} S_{ato1\_sm} \qquad (5a)$$

where

IL_{sm1} = impingement loss of species *s* in month *m* expressed as equivalent age 1 fish

IL_{sm} = impingement loss of species *s* in month *m*

f_{sam} = fraction of species *s* that is age *a* in month *m*

S_{ato1_sm} = survival of species *s* from age *a* to age 1 (adjusted to median age of impingement within age)

The monthly age compositions were estimated from the monthly length frequency distributions of impinged fish.

For entrainment:

$$EL_{sm1} = \sum_k EL_{ksm} S_{kto1\_sm} \tag{5b}$$

where

ED_{ksm} = entrainment density of stage *k* of species *s* in month *m*

S_{kto1_sm} = survival of stage *k* of species *s* in month *m* to age 1 (adjusted to median age of entrainment within month)

The effectiveness of the various alternative technologies can be measured by both the reduction in losses from the baseline level (IR_{Alt} and ER_{Alt}), or by the percent reduction from the baseline level ($I\%R_{Alt}$ and $E\%R_{Alt}$). The mean percent reduction was calculated as the average percent reduction over all of the species impinged or entrained:

$$IR_{Alt} = IL_{Baseline} - IL_{Alt} \tag{6a}$$
$$ER_{Alt} = EL_{Baseline} - EL_{Alt} \tag{6b}$$

$$I\%R_{Alt} = \frac{100}{n_{sI}} \sum_s \frac{IL_{Baseline\_s} - IL_{Alt\_s}}{IL_{Baseline\_s}} \tag{7a}$$
$$E\%R_{Alt} = \frac{100}{n_{sE}} \sum_s \frac{EL_{Baseline\_s} - EL_{Alt\_s}}{EL_{Baseline\_s}} \tag{7b}$$

where

n_{sI} = number of species impinged

n_{sE} = number of species entrained

Life cycle performance for each alternative was estimated over a period from 2011 to 2028. For each alternative, it was assumed that current technology would continue each year (*y*) until the year in which an alternative could be installed and operated (*yinst*). The alternative would then be in place for the remainder of the evaluation period. Future losses were discounted at discount rates (*d*) of 0% and 3%:

$$LCIL_{Alt} = \sum_{y=2011}^{yinst-1} IL_{Current}(1-d)^{y-2011} + \sum_{y=yinst}^{2030} IL_{Alt}(1-d)^{y-2011} \quad (8a)$$

$$LCEL_{Alt} = \sum_{y=2011}^{yinst-1} EL_{Current}(1-d)^{y-2011} + \sum_{y=yinst}^{2030} EL_{Alt}(1-d)^{y-2011} \quad (8b)$$

$$LCI\%R_{Alt} = \sum_{y=2011}^{yinst-1} I\%R_{Current}(1-d)^{y-2011} + \sum_{y=yinst}^{2030} I\%R_{Alt}(1-d)^{y-2011} \quad (9a)$$

$$LCE\%R_{Alt} = \sum_{y=2011}^{yinst-1} E\%R_{Current}(1-d)^{y-2011} + \sum_{y=yinst}^{2030} E\%R_{Alt}(1-d)^{y-2011} \quad (9b)$$

Impingement and Entrainment Density – ID_{sm} & ED_{sm}

The only monthly impingement and entrainment densities available were from the 2006 sampling program conducted by HDR and described in the IMECS (HDR 2009d). See Tables 3-2 and 3-5.

Monthly Flow - F_m

Plant operation data were available for 2005-2009. These years reflect the range of recent operation of AES Greenidge. For baseline calculations, flows were considered to be the full flow for Units 3 and 4. Estimates of actual historical impingement and entrainment used the actual monthly flows in 2005-2009. Annual estimates and mean annual estimates for the most recent five years (2005-2009) were calculated.

For evaluating alternatives for future operation, the actual historical flows for Unit 4 were used. Impingement and entrainment for each alternative were calculated for each year, adjusted as appropriate for the alternative, and the maximum annual loss, minimum annual loss, and average loss over the most recent five years was used as the best estimate of projected future performance.

Table B-1 Cooling water flows used for alternatives evaluation at AES Greenidge.

Condition or Alternative	Monthly Flow
Baseline	Constant flow of 101,000 gpm
Current Technology	Historical Unit 4 flows: 2005-2009
Variable Speed Pumps	Seasonally adjusted % of historical flows 2005-2009
Scheduled Outages	Historical Unit 4 flows, but with prescribed outages
Cooling Towers	1,200 gpm
Others	Historical 2005-2009 Unit 4 flows

Impingement and Entrainment Survival –$IS_{s\,m}$ and $ES_{s\,m}$

Because AES Greenidge has no fish return system, and there have been no entrainment survival studies conducted at the station, both impingement and entrainment survival are assumed to be zero. None of the alternatives that were passed through the feasibility/practicability affect either impingement or entrainment survival.

Light deterrent - e_{ldm}

Not practicable.

Sound deterrent - e_{sdm}

Not Practicable

Wedgewire screens - e_{wsm}

HDR developed estimates of the fraction of common species that would be retained (excluded) by wedgewire screens of 0.5, 1, 2, and 9 mm slot widths. In addition, the fraction of each life stage that would be capable of swimming off the screen if retained, or swept off the screen by water currents was estimated to present an estimate of the efficacy of wedgewire screens. The values of e_{wsm} are provided in Tables 4-3 through 4-5 of the document.

APPENDIX C

Additional Cost Estimate Details for Alternatives

Detailed Cost Estimate for Wedgewire Screen with Airburst Cleaning System at AES Greenidge Unit 4

Capital Costs of Wedge-wire Screen Equipment and Installation (in year 2010 dollars)

Screen Mesh Size (mm)	Screen Size[1]	Number of Screens[1] (#)	Screen Cost[1] ($)	Screen Installation[2] ($)	Mobilization[2] ($)	Steel Fittings[2] ($)	Total Cost ($)
0.5	T-66HC*	8	687,200	268,240	61,586	92,515	1,109,540
1.0	T-60HC	6	433,800	201,180	41,057	85,337	761,374
2.0	T-54HCE	6	409,800	201,180	41,057	85,337	737,374
9.0	T-48HCE	4	227,600	134,120	41,057	78,159	480,936

Note:

1. Source - Johnson Screens [Memo from Mark Watson on 7/7/2010]
2. Source - Table 1-5 of Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004

Capital Cost of Airburst Air Supply Equipment[1] (in year 2010 dollars)

Screen Mesh Size (mm)	Screen Size	Number of Screens (#)	Vendor Supplied Equipment Cost ($)	Estimated Housing Area (sq. Ft)	Housing Cost ($)	Electrical[2] ($)	Controls[3] ($)	Total Airburst minus Air Piping to Screens ($)
0.5	T-66HC*	8	72,000	8x8	12,438	7,200	3,600	95,238
1.0	T-60HC	6	62,000	8x8	12,438	6,200	3,100	83,738
2.0	T-54HCE	6	54,000	8x8	12,438	5,400	2,700	74,538
9.0	T-48HCE	4	48,000	6x6	6,996	4,800	2,400	62,196

Note:

1. Source - Table 1-8 of Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004
2. Electrical costs = 10% of air supply equipment (BPJ) [Source: Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004]
3. Controls costs = 5% of air supply equipment (BPJ) [Source: Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004]

Capital Cost of Installed Air Supply Pipes (in year 2010 dollars)

Screen Mesh Size (mm)	Screen Size	Number of Screens (#)	Air Burst Pipe Size (inch.)	Freshwater Airburst Distribution Installed Pipe Costs ($)
0.5	T-60HC*	8	12	$1,377,004
1.0	T-66HC	6	10	$1,377,004
2.0	T-54HCE	6	8	$918,002
9.0	T-42HCE	4	8	$918,002

Note:

Source of Cost Estimate - Table 1-9 of Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004

Total Calculated Capital Costs (in year 2010 dollars)

Screen Mesh Size (mm)	Screen Size	Number of Screens (#)	Direct Capital Costs ($)	Engineering Cost[1] ($)	Contractor Overhead and profit Cost[2] ($)	Sitework Cost[3] ($)	Contingency[4] ($)	Total Capital Cost ($)
0.5	T-60HC*	8	2,581,782	258,178	387,267	258,178	258,178	3,743,583
1.0	T-66HC	6	2,222,115	222,211	333,317	222,211	222,211	3,222,067
2.0	T-54HCE	6	1,729,913	172,991	259,487	172,991	172,991	2,508,374
9.0	T-42HCE	4	1,461,134	146,113	219,170	146,113	146,113	2,118,644

Note:

Source of Cost Estimate - Page 1-10 of Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004

1. 10% of direct capital costs
2. 15% of direct capital costs
3. 10% of direct capital costs
4. 10% of direct capital costs

Costs of Operation and Maintenance of Wedge-wire Screen System (in year 2010 dollars)

		Operating Costs for Air Burst Air Supply System[1]			Annual Inspection		Cleaning by Diver Team[1]	
Screen Mesh Size (mm)	Screen Size	Backwash Frequency events/day	Annual Power required (kw hour)	Annual Power Cost 9.3 cents/kw hour[2] ($)	Labor Required for inspection[1] (hr/year)	Labor Cost for inspection[3] ($/year)	Diver Team Costs ($)	Total O&M Cost ($)
0.5	T-60HC*	9	34,036	3,165	564	38,065	26,933	68,164
1.0	T-66HC	9	34,036	3,165	564	38,065	26,933	68,164
2.0	T-54HCE	4	15,127	1,407	376	25,377	13,467	40,250
9.0	T-42HCE	4	15,127	1,407	376	25,377	13,467	40,250

Note:

1. Assumed values for low debris in Table A-1 and A-2 of Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004
2. Average retail price of electricity in New York State, Industrial, 2010 - http://www.eia.doe.gov/electricity/epm/table5_6_b.html
3. O&M labor rate per hour is $60.0/hr. [Note: The source document recommend $41.1/hr (in 2002 dollars) and it was adjusted to 2010 dollars and geographical consideration (20% upward adjustment).]

Indirect Costs (in 2010 dollars)

Permit Requirements ($)	Verification Monitoring Plan ($)	Revenue Loss due to Downtime[1] ($)	Total Indirect Cost ($)
45,000	454,272	4,892,000	5,391,272

Note:

1. Estimated assuming $63/MWh and an 72% capacity factor and do not account for the variable costs to produce energy.

Detailed Cost Estimate for Wedgewire Screen with Mechanical Brush Cleaning System at AES Greenidge Unit 4

Direct Capital Costs of Wedge-wire Screen Equipment and Installation (in 2010 dollars)

Screen Mesh Size (mm)	Screen Size	Number of Screens	Mobilization / demobilization	Sitework and Pile Installation	Tee screen and Mechanical Components	Electrical/hydraulic Systems	Screen Installation	Total Direct Capital Cost
0.5	6 ft dia. x 8.3 ft long	10	227,619	554,200	$1,930,000	420,000	367,500	3,499,319
1.0	6 ft dia. x 9 ft long	6	154,161	382,300	$1,177,000	420,000	235,000	2,368,461
2.0	6 ft dia. x 6.5 ft long	6	154,161	382,300	$1,177,000	420,000	235,000	2,368,461
9.0	5 ft dia. x 6 ft long	6	147,021	382,300	$1,075,000	420,000	235,000	2,259,321

Total Calculated Capital Costs (in 2010 dollars)

Screen Mesh Size (mm)	Screen Size	Number of Screens (#)	Direct Capital Costs ($)	Engineering Cost[1] ($)	Contractor Overhead and profit Cost[2] ($)	Sitework Cost[3] ($)	Contingency[4] ($)	Total Capital Cost ($)
0.5	6 ft dia. x 8.3 ft long	10	3,499,319	349,932	524,898	349,932	349,932	5,074,013
1.0	6 ft dia. x 9 ft long	6	2,368,461	236,846	355,269	236,846	236,846	3,434,268
2.0	6 ft dia. x 6.5 ft long	6	2,368,461	236,846	355,269	236,846	236,846	3,434,268
9.0	5 ft dia. x 6 ft long	6	2,259,321	225,932	338,898	225,932	225,932	3,276,015

Note:

Source of Cost Estimate - Page 1-10 of Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004

1. 10% of direct capital costs
2. 15% of direct capital costs
3. 10% of direct capital costs
4. 10% of direct capital costs

Costs of Operation and Maintenance of Wedge-wire Screen System (in 2010 dollars)

		Operating Costs for Mechanical Cleaning System			Annual Inspection		
Screen Mesh Size (mm)	Replacement Parts	Cleaning Frequency events/day	Annual Power required (kw hour)	Annual Power Cost 9.3 cents/kw hour[1] ($)	Labor Required for inspection (hr/year)	Labor Cost for inspection[2] ($/year)	Total O&M Cost ($)
0.5	2,000	4	9,200	856	520	31,200	34,056
1,2,9	1,000	4	5,500	512	390	23,400	24,912

Note:

1. Average retail price of electricity in New York State, Industrial, 2010 - http://www.eia.doe.gov/electricity/epm/table5_6_b.html
2. O&M labor rate per hour is $60.0/hr. [Note: The EPA documents recommend $41.1/hr (in 2002 dollars) and it was adjusted to 2007 dollars and geographical consideration (20% upward adjustment).]

Indirect Costs (in 2010 dollars)

Permit Requirements ($)	Verification Monitoring Plan ($)	Revenue Loss due to Downtime[1] ($)	Total Indirect Cost ($)
45,000	454,272	4,892,000	5,391,272

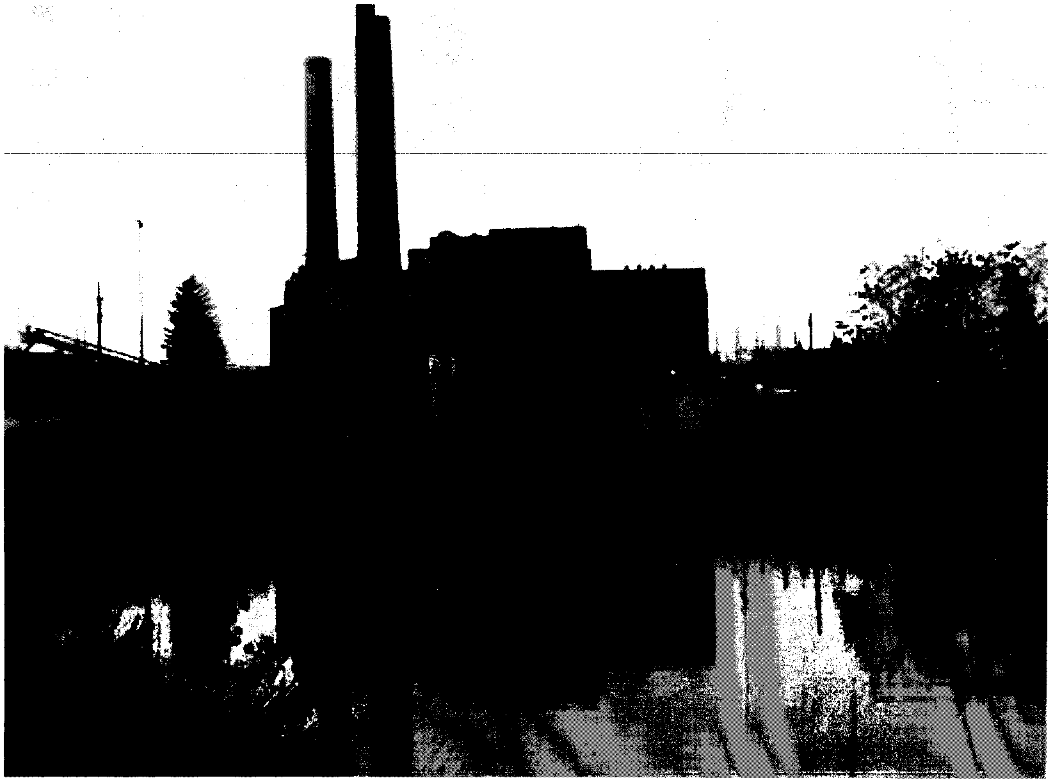
Note:

1. Estimated assuming $63/MWh and an 72% capacity factor and do not account for the variable costs to produce energy.

APPENDIX D

Closed Cycle Cooling and Variable Speed Pump Analysis

ENGINEERING & COST ASSESSMENT OF RETROFITTING A CLOSED-CYCLE COOLING SYSTEM AT AES GREENIDGE GENERATING STATION



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1. AES Greenidge Closed-Cycle Cooling System Retrofit Analysis

The purpose of this report is to assess the engineering feasibility and impact of retrofitting a closed-cycle cooling system for AES Greenidge's Unit 4. Costs in terms of fuel penalties and megawatt penalties for forced load reductions, as well as the direct construction costs of the retrofitted components themselves are developed below. Conversion of the presently open-cycle AES Greenidge to a closed-cycle cooling system with cooling towers would minimize its water usage and any related adverse environmental intake effects. The aquatic impacts of the station would, however, be replaced by airborne impacts and this switch would also reduce the power producing efficiency of the station. These costs can then be weighed against the potential environmental benefits.

1.1 Summary/ Conclusion of Evaluation of Retrofitting the Closed-cycle Cooling System

The effects and cost of retrofitting a closed-cycle cooling system at Greenidge are as follows:

- Water consumption would be reduced by 98% to 1,200 GPM. An additional 5,000 tons of coal would need to be burned per year in order to make up for the plant inefficiency resulting from retrofitting a closed-cycle cooling system.. This will result in higher airborne emissions and the corresponding required environmental reviews.
- A plant shutdown of 4 months would be necessary to modify the existing circulating water water (CW) system and to conduct component testing and the start-up trials. At $63/MWh and a 72% capacity factor, the nominal loss of revenue during that shutdown period was estimated at $13,907,000.
- The total capital cost of the closed-cycle retrofit will be $23,559,000 in January 2010 dollars. The entire project would take approximately 40 months to complete from initiation of design to completion.
- One-time costs for construction of the closed-cycle retrofit and the lost revenue due to lost generation during the outage will be $37.4 million.
- The plant will incur additional costs of more than $610,000 per year due to maintenance, increased auxiliary power requirements, and higher coal consumption of the station. It was estimated the increased plant net heat rates from the closed-cycle system would

require additional fuel costs of $353,000 per year. Total plant costs also include the additional auxiliary power of 1.9 MW.

- A major addition to the visual profile of the plant from the lake will occur. The structures of the 5 cell, plume abated cooling towers are about 241 ft long and will reach 65 ft to the top of the cooling tower fan stack. Based on the lake and ridge elevation, the top of the towers will stand more than 100 feet above the surface of the lake.
- Negative impacts to plant operations such as increased emissions of criteria air pollutants would have permitting implications under New Source Review, Prevention of Significant Deterioration, and New Source Performance Standards programs.
- Opposition from local residents and recreational users of Seneca Lake to aesthetic impacts in the Town of Torrey and Village of Dresden would likely pose a significant challenge to AES.
- Adverse environmental impacts such as discharge of concentrated cooling water (blow down), plume visibility, drift deposition, icing, and noise would also occur.
- Authorization to proceed will require local permits, environmental regulatory compliance triggered by the higher airborne emissions and major modifications to the plant.

1.2 AES Greenidge Station Description

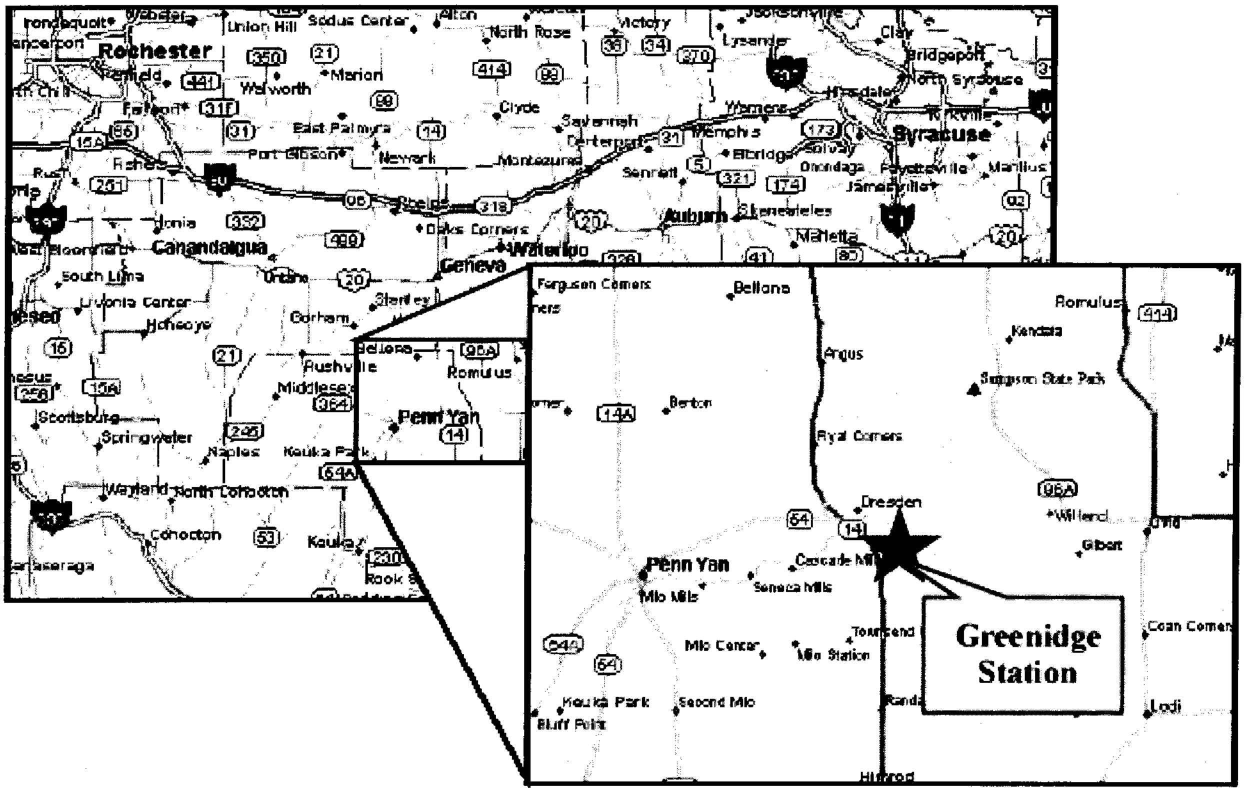


Figure 1- AES Greenidge Location

AES Greenidge is located in Yates County, New York, on the western shoreline of Seneca Lake (Figure 5). AES acquired the Greenidge Generating Station facilities from NYSEG in 1999. Unit 3 began operation in 1950 and Unit 4 in 1953.

The station's only operating unit (Unit 4) is primarily coal-fired, though it can burn other materials, such as wood. The unit generates a nominal maximum output of 105 megawatts. Unit generation for the most recent years available is shown in

Table 1. Due to lower capacity factors then normal in 2009 , calculations in this report will use an average of the 2007 and 2008 capacity factors (72%).

Table 1- Greenidge Unit 4 Generation: 2007- 2009

GREENIDGE UNIT #4 GENERATION: 2007-2009					
	Annual Generation (MW)		Avg. Hourly Generation (MW)		
YEAR	Gross	Net	Gross	Net	Capacity Factor
2007	712,867	655,413	81.4	74.8	71.3%
2008	731,054	670,384	83.6	76.7	72.9%
2009	477,716	434,976	54.5	49.7	47.3%

As Unit 3 was retired from service in December 31, 2009, this report will focus on developing a closed-cycle cooling system retrofit for Unit 4 only. However, because elements of the Unit 3 cooling water system will be reused to construct the Unit 4 closed-cycle retrofit, its components and layout will be described and referenced in this report.

1.3 AES Greenidge Closed-Cycle Cooling Water System Design Overview

AES Greenidge was designed and constructed with a once-through cooling system. The plant designers did not consider or anticipate a conversion to a closed-cycle system when developing the cooling water system and all other piping, electrical, gas, and water lines, and other plant structures and systems. In addition, the condenser and component cooling water heat exchanger were designed and fabricated to accommodate the relatively low hydraulic pressures of the original CW system. Constructed in the early 1950's, the AES Greendige station is permitted to withdraw a maximum of 190 million gallons per day of cooling water from offshore intake structures located within Seneca Lake. The intake pipe for the now retired Unit No. 3 splits to two capped intake structures located approximately 550 and 710 feet offshore. Unit 4 has an above ground intake pipe, terminating in an intake structure surrounded by louvers approximately 650 feet offshore.

Figure 2- AES Greenidge Unit 4 Intake

Cooling water is discharged through a canal into the Keuka Lake outlet. The station's SPDES permit requires a Summer intake-discharge temperature difference (also known as delta T) of no more than 26 degrees F, and maximum discharge temperature of 108 degrees F. During the SPDES-defined Winter period, the permit limits the delta T to 31 degrees F, and the maximum discharge temperature to 86 degrees F. Winter periods is defined by the SPDES as those periods in which the average daily water temperatures remain at or below 52°F for five or more consecutive days. All other times are classified as summer periods.

Unit 4 has three pumps capable of generating up to 68,100 gallons per minute of flow through the condenser. There are no variable flow controls on the cooling water system or pumps. Plant operating data shows that, in 2009, the unit operated with two pumps 73% of the time. Three pumps were in service 27% of the year, typically during the summer months.. One pump operation or a full shutoff occurred less than 1% of the year.

The effects of retrofitting a closed-cycle cooling system to Greenidge would require extensive modifications to the CW system and have a large negative impact on the plant. The design and construction of such a project would result in unfavorable effects to facility operations, cause adverse airborne environmental impacts (including increased emissions), and would be both costly and lengthy to install. The required additional auxiliary power and the impact on net heat rate and extra fuel costs would also impact the generation and profitability of the station.

Although retrofitting closed cycle cooling is theoretically possible, in reality it is not considered very practical at AES Greenidge. Nonetheless, the sections below consider the development and the sighting of the towers and piping most feasible and appropriate for the site.

1.4 AES Greenidge Retrofit Cooling Tower Type Selection

Although there are many types of cooling towers, most have at least one major environmental or technical disadvantage that immediately renders them inappropriate to application at Greenidge. A dry cooling tower system, with its enormous footprint and massive piping requirements, would be excessively difficult to retrofit at Greenidge and would not be well-suited for the application. Natural draft cooling towers rely upon their enormous height to generate the draft needed for proper cooling, and are accordingly used at plants much larger than Greenidge. Therefore, both of these tower types are ruled out as retrofit options.

The two remaining commercially viable closed-cycle cooling systems considered in this evaluation were ones that would utilize either a wet mechanical draft or a plume-abated cooling tower. Certainly, both the wet and plume-abated cooling tower designs would increase the station's heat rate, net power consumption, fuel costs and air emissions of NOx, SO_2, PM10, PM2.5 (limits on particulate matter discharge of a given size in μm), CO and CO_2. A mechanical draft tower will always create a plume unless the relative humidity is low and the weather is warm. The safety risk presented by the plume requires that only a plume-abated tower be considered for retrofit at Greenidge. Even a plume-abated tower cannot fully mitigate this danger at all times.

Thus, based on technical expertise, observations, and engineering , the design that was considered for evaluation was a plume-abated mechanical draft cooling tower. Though many detailed variations are possible, the consideration of this conceptual design for further evaluation represents best engineering practice and judgment.

1.5 Description of a Plume-Abated Cooling Tower

In every wet closed-cycle cooling system, heat from the warmed water of the condensers is dissipated mainly by evaporative cooling. This cooling occurs by evaporating a small percentage of the heated discharge water in the cooling tower. A plume-abated closed-cycle cooling system, however, combines convective and evaporative cooling to also reduce the formation of a visible vapor plume.

Similar to a wet tower, a plume-abated cooling tower consists of a basin that collects the cooled water, the fill section where the wet cooling effect takes place, a dry cooling section where the convective heat transfer occurs, an enclosed structure to support the fill and the dry section, and a means of producing a cooling air flow. A plume-abated cooling tower has a lower wet cooling section (called the fill section) and an upper dry, finned-tube section. The wet section supplies the major cooling effect, which occurs mostly by the evaporation of a small percentage of the heated discharge water as it contacts the cooling air. The fill section has an anti-fouling, non-clogging, counter-flow, plastic PVC fill, while the finned tube surface of the dry section would use an ASTM-304 stainless steel core tube material that has a high corrosion resistance to the slightly concentrated lake water chemistry.

Warm water from the condenser is cooled in the tower by ambient air which is induced to flow through both the upper and lower sections of the plume-abated tower by large fans as illustrated in Figure 3.

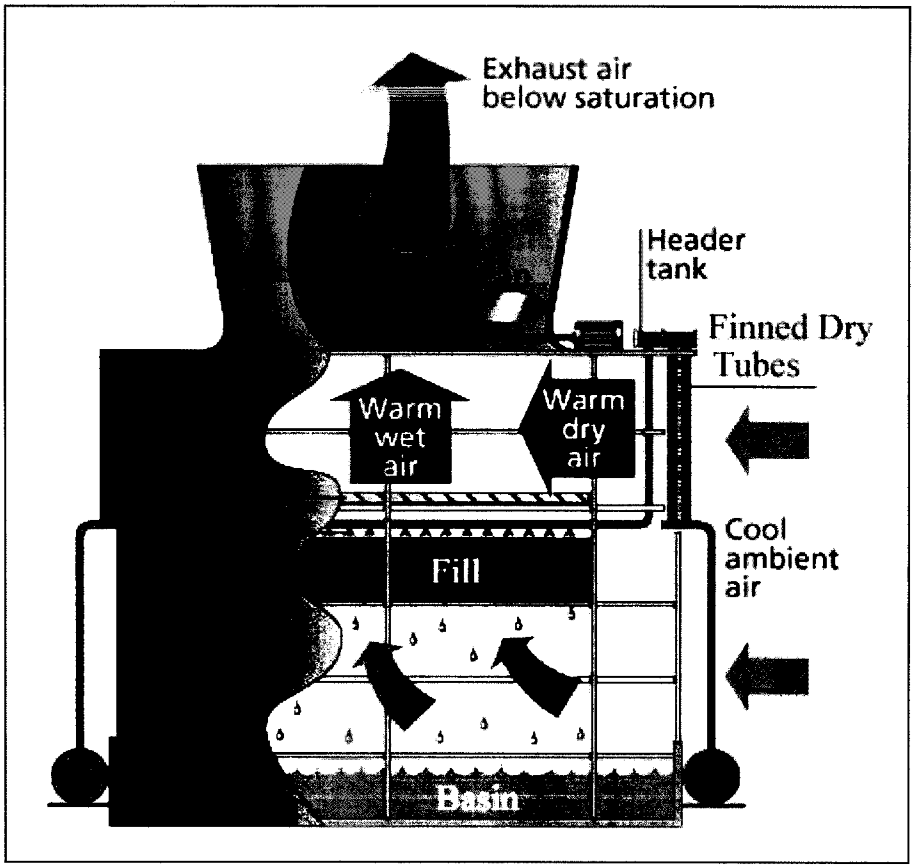


Figure 3- Plume-Abated Cooling Tower

The warm water flowing through the upper dry section however heats, but does not humidify, its incoming air flows. The dry air flow is in parallel to the incoming lower wet section air flow. The dry air first becomes heated and then humidified by mixing with the air from the lower, wet section. Meanwhile, slightly cooled, the dry section water mixes with the water flow in the wet section of the tower. Once the proportion of the total water flow to the dry and wet sections is established in each cell, a siphon action maintains the water flow to the dry section aided by a vacuum pump. Motor driven shutters located at the periphery of the dry sections allow control of the air flow to that section. In the wet section, the warm discharge water from the condenser is dispersed by spray nozzles at the top of the wet section into small droplets and thin sheets that fall by gravity through the fill into the basin.

The cooling tower would be manufactured out of fiberglass reinforced polymer to prevent leachate releases, minimize maintenance, and provide a life expectancy of at least 20 years. Freeze protection would also be included in the design to allow for winter operation. The plume-abated tower evenly distributes the warm water to be cooled to both the wet and dry portions, and has a feature to minimize the carryover or "drift."

Rather than having a single, large structure to provide the necessary rate of heat transfer for the total plant flow, the flow to be cooled is passed through several smaller, self-contained individual cells. Using several small cells reduces the engineering, manufacturing, operation, and maintenance requirements for the closed-cycle system and results in better performance. Each of the cells contains all of the design elements described above.

In typical wet mechanical draft cooling towers, the small vapor droplets contained in a saturated or supersaturated exit plume are noticeable to the eye. But the parallel streams of air that flow across the dry sections and through the fill sections in a plume-abated tower mix together as they move through the tower and fan. The mixing of the saturated and low humidity air streams reduces the proportionate level of moisture in the overall air mixture. The total mix then exits the fan cylinder at a sub-saturated moisture condition, i.e., at a relative humidity of less than 100%. This unsaturated exit air plume then cools to ambient conditions and, with the exception of extreme cases, avoids supersaturation resulting in plume visibility. This type of cooling tower design significantly reduces the persistence of the plume, making it much less noticeable.

1.6 Closed-Cycle Retrofit Intake and Discharge Flow Impacts

Greenidge withdraws fresh water for cooling purposes from Seneca Lake. Its make-up to supply the closed-cycle plume abated towers would amount to about 2% of the current once-through circulating water flow when Unit 4 is operating on closed-cycle. When Unit 4 is retrofitted with closed-cycle cooling, the station would require a maximum of 1,200 gpm for make-up. Approximately 300 gpm would be returned to Seneca Lake as blowdown.

The concentration of minerals in this closed-cycle system increases over time due to a small portion of the recycled CW flow being evaporated by the tower. That results in a build-up of solids in the cooling water. This build-up in the circulating water of the Greenidge closed-cycle retrofit system is designed to be limited to a factor of five times that of current intake levels and is maintained by injecting make-up water to balance the water losses from evaporation and blow down. Should treatment of blow down for contaminants prior to discharge be required, the facility would most likely not have adequate or applicable existing water treatment facilities, and an additional waste treatment facility upgrade would need to be constructed, adding to the project's costs.

1.1 Plume-Abated Cooling Tower Size and Placement

To fulfill the cooling requirements of Greenidge's Unit 4 condenser, the cooling tower would be comprised of five cells, with a total footprint of 55 feet by 241 feet. The cooling tower would measure 75 feet high at the top of the fan stacks, and 61 feet to the top of the fan deck.

Proper thermal performance of a cooling tower depends on a steady stream of fresh cooling air entering the tower, and upon minimizing the moisture-laden fan exhaust from being drawn back into the air intake (i.e., recirculation). In order to minimize recirculation effects, the tower needs to be oriented parallel to the prevailing winds at the site. AES Greenidge does not have a meteorological station which records wind data at the site. Therefore, data from the nearest weather station (Penn Yan airport) was used to determine the predominant wind direction in the area. From the windrose plot for the Penn Yan airport for a one year period from June 1,2009 - June 1, 2010, the wind generally comes out of a westerly and southwesterly direction. This information served as a basis for the cooling tower orientation at Greenidge. The wind direction and speed is an indication of the severity, persistence, area of effect, and likelihood of potential hazards of plume and drift should they occur.

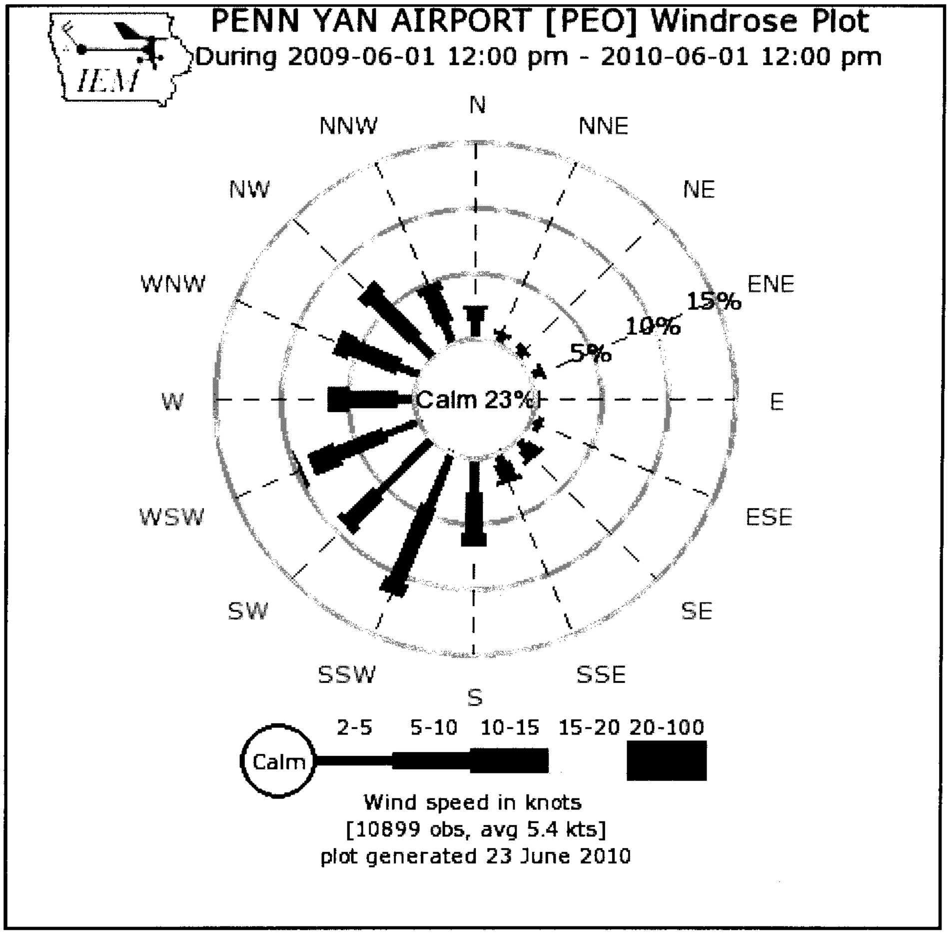


Figure 4- Local Wind-Rose Plot

1.2 Site Description

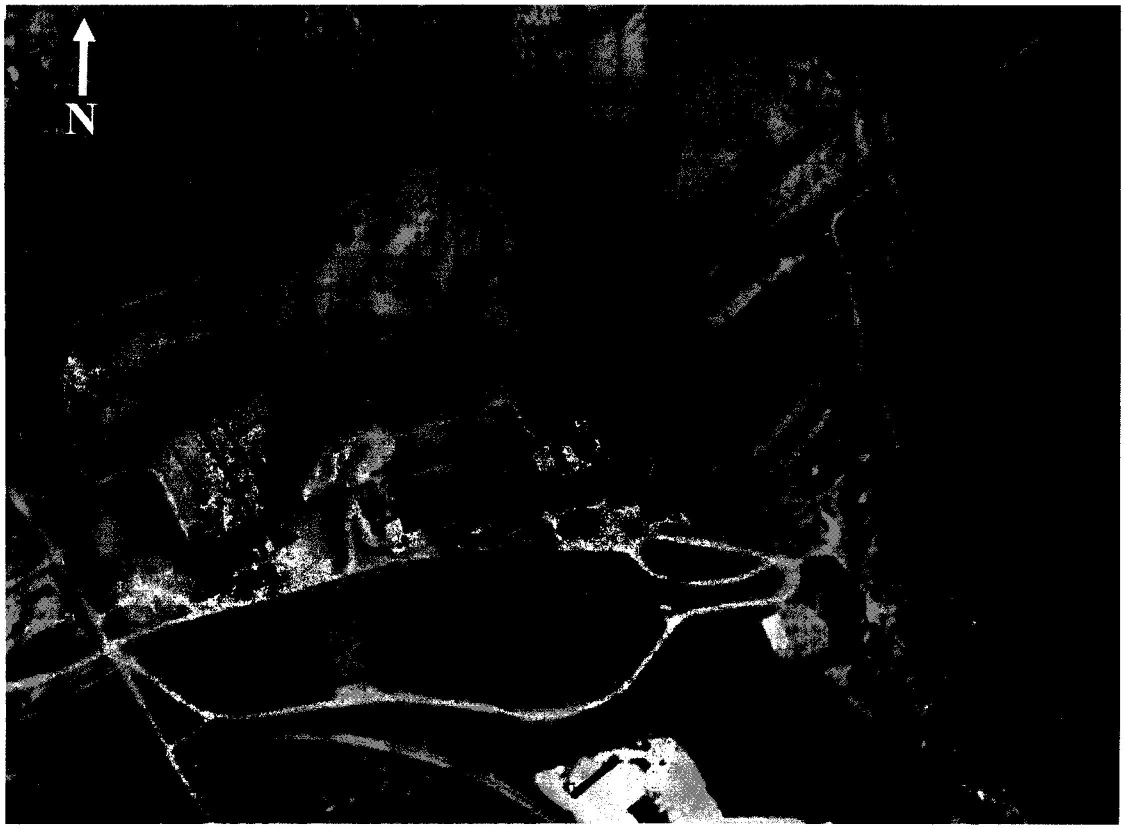


Figure 5- AES Greenidge Site Location

The land upon which AES Greenidge is built is bordered on the north along a property line running northeast, averaging about 500 feet north of the Keuka Lake Outlet. The western property line is curved and runs parallel to the railroad line. To the south, the parcel is delineated along a property line running East-northeast roughly 200 feet from the coal pile. To the east of the property is Seneca Lake. Forested buffer zones exist on strips of land along the north and south parcel boundary. Figure 5 depicts an aerial view of the site, showing existing structures. Figure 6 is a schematic of the same area, labeling features and showing property delineations.

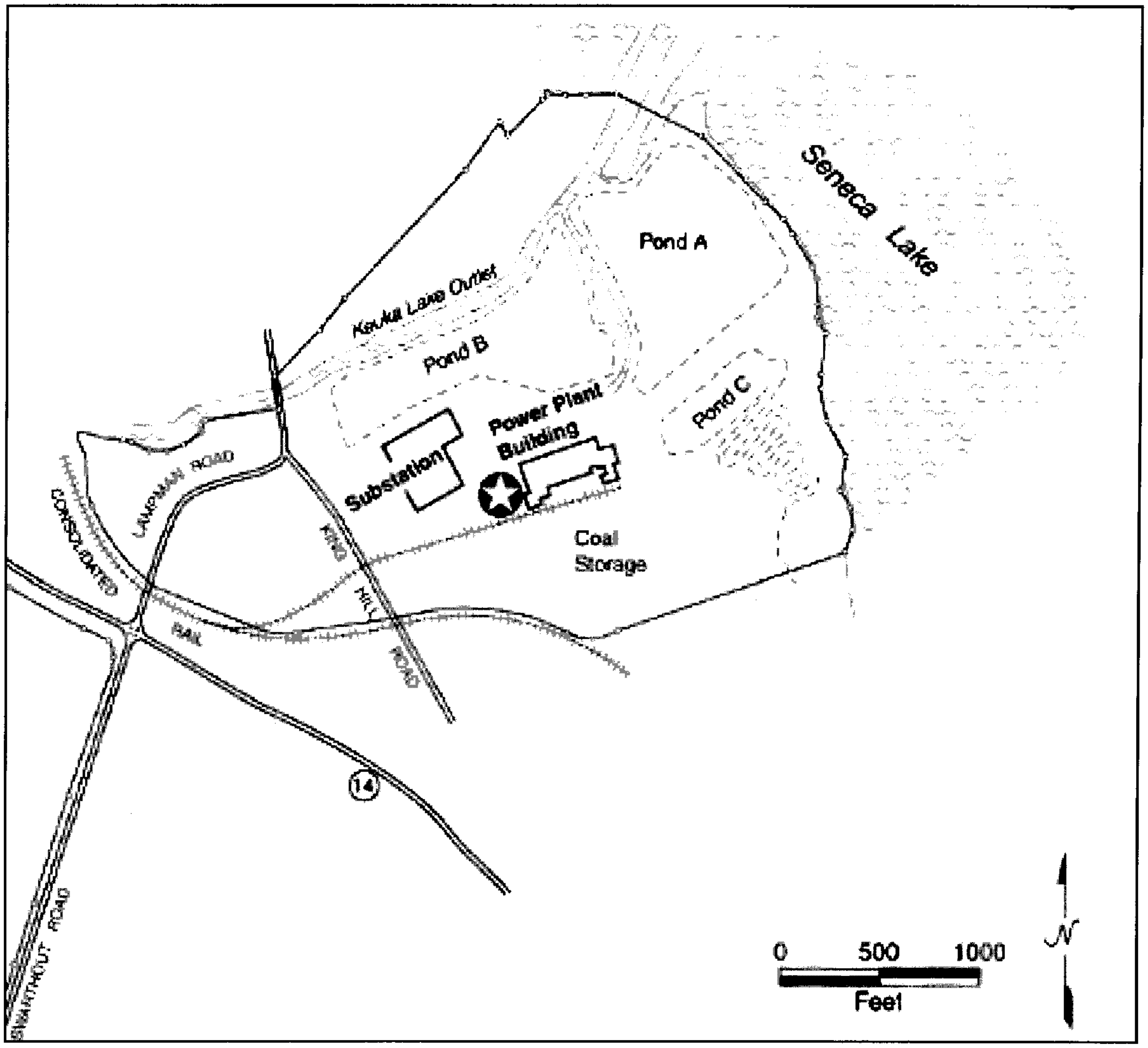


Figure 6- Plant Parcel Boundaries and Features

Though the aerial view provides a good sense of the parcel size, location, and current use, it does not clearly show the significant variations in elevation across the parcel. The topography of the site is vastly uneven, and contains a series of small ridges and valleys, which make buildable areas of a size needed for the cooling tower both difficult to locate and expensive to prepare for construction. A large portion of the site was constructed on fill, and thus will require added pile supports for foundation construction.

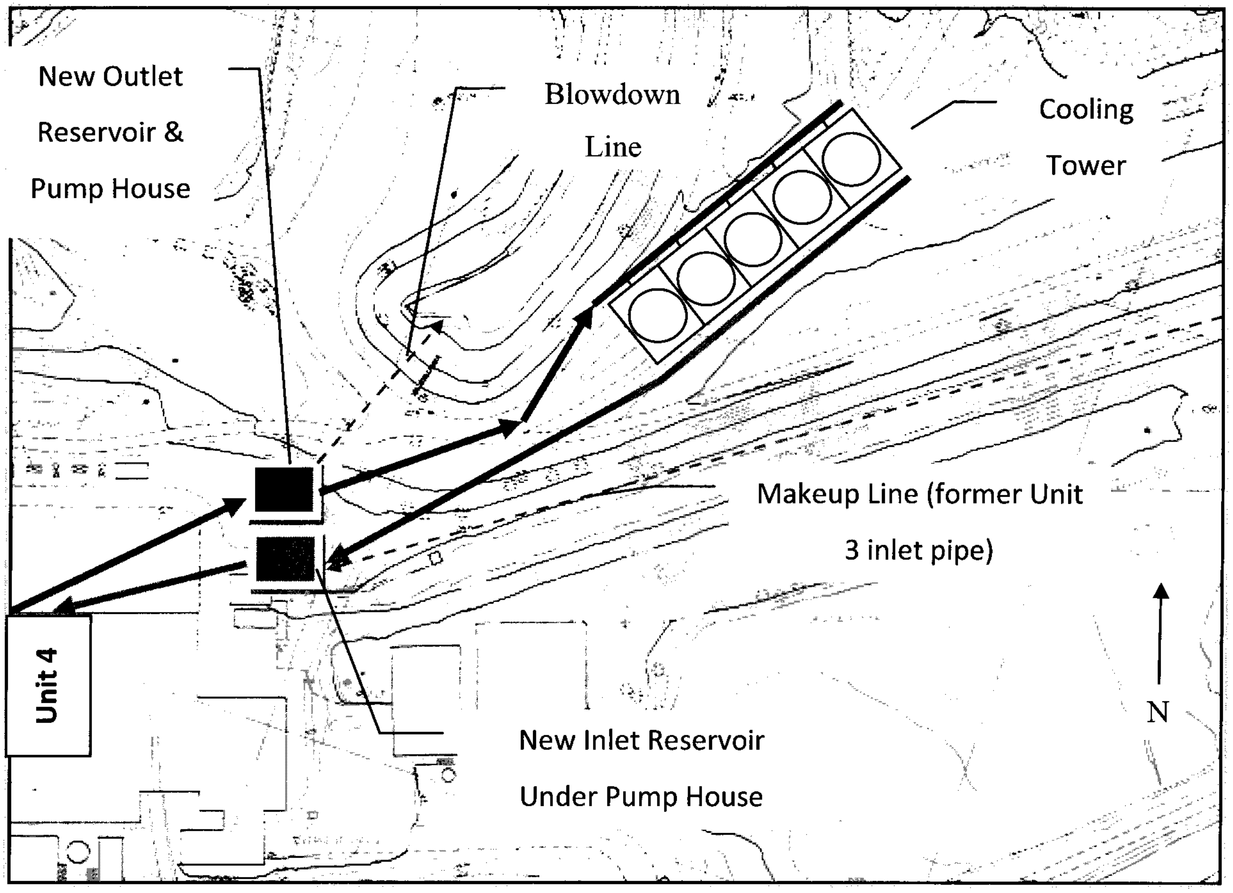


Figure 7- Topographic Detail of Site with Conceptual Closed-Cycle CW System Retrofit

The site chosen for placement of the cooling tower sits on a ridge to the east of the discharge canal. The site is relatively level, and large enough to accommodate the cooling tower footprint. It also is situated to allow for relatively short tie-ins to the newly designed closed-cycle cooling water system pipes. Furthermore, the site will not interfere with the large number of transmission lines that exist to the south and west of the cooling tower site. Access to the tower construction site will need to be developed, as discussed below.

1.3 Closed-Cycle Cooling System Conceptual Design Considerations

The overall objective of this closed-cycle design is to maintain the components of the existing cooling system to the maximum extent practicable while minimizing detrimental effects on station operation, generation, safety, and aesthetics.

In designing the Greenidge closed-cycle retrofit cooling system, several constraints arising from the existing site and equipment need to be taken into account. First, the existing condenser related hydraulic piping is likely designed for relatively low pressures. In addition, the condensers are comprised of cast iron waterboxes and were built as a low hydraulic pressure condenser design. To reuse the same piping and condensers, and prevent excessive stresses on the waterboxes or tube pullout, the retrofit hydraulic pressures must be similar to the existing pressures. To accomplish this, the hydraulic circuit and cooling towers must be situated such that the design produces a low hydraulic pressure in the condensers.

A review of the condensers, plant layout and the CW design data recommends the closed-cycle design require a separate cooling tower circuit loop. This separate loop would be comprised of a modified inlet pump bay, a new condenser discharge reservoir basin and pump house, and piping from the discharge reservoir to the cooling tower and from the cooling tower to the new inlet bay. The existing piping system between the inlet bay, the condenser, and the discharge would remain unchanged. The CW inlet pump bay and new discharge reservoir would be designed to ensure a stable hydraulic operation, to accommodate piping to and from the cooling tower, and to accept the makeup quantities and discharge blow down as needed. Flow by gravity from the towers would return the cooled water to the inlet bay. Utilizing this approach avoids the high hydraulic pressure head of the closed-cycle pumps from acting on the existing condensers and system components, which were not designed for the higher pressures of a closed cycle system.

The current access to the cooling tower site is unsuitable for large-scale building equipment, and will need to be upgraded. The dirt road currently leading around the perimeter of "B"Pond is the only suitable road for this purpose, and will need to be paved. The dirt road leading directly from the plant to the top of the ridge, though shorter, is too narrow and too steep for this purpose.

The towers should be oriented roughly parallel to the prevailing winds to minimize warm air exit plume recirculation effects. The cooling tower site chosen takes this optimal orientation into consideration.

Using the existing Unit 4 raised intake line for makeup water would require significant pump power to draw water through the large diameter Unit 4 intake pipe (see Figure 2), with a large new pump dedicated for this purpose. As the makeup water volumes are small, this would be inefficient. As an alternate solution, a portion of the Unit 3 intake will be reused to deliver makeup water to the CW system. The Unit 3 piping is buried and, although its elevation was not directly evident, it provides water to the vicinity of the Unit 4 intake area by gravity feed. Additionally, it has a smaller diameter than the unit 4 intake line more suited to the small amount of flow needed for make-up water requirements. Thus, it can supply makeup water with minimal pumping, saving the capital, maintenance, and operational cost of a new pump. The existing Unit 3 intake line will be redirected into the newly constructed Unit 4 inlet reservoir, and makeup introduction will be controlled by motor-operated valve adjustment. The existing discharge line would be tied into the outlet reservoir for blowdown.

The high elevation of the cooling tower relative to the inlet reservoir will result in very high water velocities at the bottom of the return line. This will necessitate the installation of extra baffling to prevent erosion of the inlet reservoir.

The engineering assessments for this conceptual closed-cycle cooling system were based on reasonable assumptions about the performance of Greenidge Unit 4 and its condenser. These were derived from historical data, design information, and best professional judgments for the design and location of the cooling tower.

Minimization of the plume and placement of the tower to mitigate these effects have been considered in the choosing of the site. Based on the design conditions selected, the proposed plume-abated closed-cycle cooling system at Greenidge would not be expected to have a visible plume until local air temperature falls below 15 °F. The tower location and prevailing wind direction minimizes the hazard created should extreme weather conditions allow the formation of a plume. Surrounding properties should not be affected, and the prevailing winds (Figure 4) should keep any plume and drift away from the plant building, substation and transmission lines most of the time.

The tower will be a high enough structure to be seen from the lake. Therefore, local opposition to this plume abated tower alternative would pose a significant challenge to overcome before any construction activities could begin.

Any effect of the noise, plume, size, and /or drift of the tower on the local ecosystem is unknown and would require further study.

1.4 Closed-Cycle System Design Description

The conceptual closed-cycle design at Greenidge (Figure 7) would convey warmed CW exiting the condensers to a new cooling tower pump basin (outlet reservoir) to be constructed on the site of the current parking lot on the northeast side of the plant building near the substation, where it would be pumped to the cooling towers. The cooled water from the towers would return by gravity to a newly constructed intake reservoir beneath the site of the #4 pump house to complete the cycle. Service water cooling would also be supplied by the cooling towers. This particular closed-cycle design ensures that there would be no major change to the existing condensers and associated piping in order to maintain the existing low hydraulic pressures. The existing circulating water pumps would not need to be upgraded to allow for pumping at higher heads.

Each reservoir will have a capacity of 204,000 gallons. Dimensions of 30' x 30' x 30' for the reservoirs would provide sufficient volume for stable operation and retention.

A new pump house would be constructed directly over the outlet reservoir. Three cooling tower feed pumps (each with its own bay in the reservoir defined by a 6 inch thick concrete wall to prevent interference from other pumps in operation), each capable of transporting at least 22,700

GPM flow of heated water from the bottom of the discharge reservoir to the top of the cooling tower basin will be installed, to match the current pump flow rates into the condenser. The three cooling tower feed pumps will be 510 HP each. This will allow for a small (5%) margin to provide the ability to equal the flow of the current pumps supplying the condenser and to overcome any unforeseen head losses. Electrical controls, such as a power center for 4180 V service, etc., will need to be installed near these pumps.

From the new cooling tower outlet reservoir, each of the three pumps will have a short dedicated (~30 ft) length of 36" diameter pipe that will join a main pipe running up the ridge to the tower. A butterfly valve will be positioned where each individual pump line attaches to the main pipe, which will provide the flow control to match the pumping of the inlet side into the condenser. Check valves will be built at the discharge end of each pump. The pipe diameter of the main to and from the tower will be 5.5 feet. This will ensure an appropriate water velocity given the volume of flow. Approximately 550 feet of piping will run from the discharge reservoir pump to the end of the feeder pipe on the northeastern edge of the cooling tower. From this supply pipe, 24 inch riser lines with butterfly throttling valves would feed each cell. The return line will run from the cooling tower basin down the ridge and into the inlet reservoir.

A 36" line for blowdown into the Keuka discharge canal will also be required . This can be connected into the existing Unit 4 discharge line, and operate by gravity feed. The makeup-blowdown system would be designed for an increase in the concentration of the total dissolved solids in the intake water by a factor of 5.

The tower and the cooling system would require 40 months for their total design and construction, assuming all permits could be obtained. Greenidge would require a four month shutdown in order to retrofit the new closed-cycle system into the existing once-through system and to complete start-up and test procedures.

1.5 Cooling Tower Design

The plume-abated cooling tower costs, thermal performance, sizing, and environmental characteristics were based on typical conservative industry practices and standards. Budgetary cost and sizing information for the cooling tower was supplied by SPX Corporation, a major cooling tower manufacturer. The cost and sizing information were based on engineering specifications compiled by Burns Engineering and sent to SPX after a review of the required conditions at Greenidge, and the developed closed-cycle retrofit design. Based on the information from SPX, the cooling tower at Greenidge would be a Model F488-6.0-05 Field Erected, Plume-Abated industrial counterflow cooling tower. Each of the five cells would be served by a 32 ft diameter, 9-bladed nosise abated fan using a 250 HP motor. The tower is comprised of a fiber-reinforced polymer (FRP) structure which has a long life, requires low maintenance and would not leach into the blowdown. The finned tubing comprising the plume-abatement section would consist of corrosion-resistant, 22 BWG, ASTM 304 stainless steel.

The cooling tower will need to be supported with 40 foot pilings at 18 foot centers.

Near the tower, a motor control center would be built to house the controls for both the fans and the finned tube surface control louvers. The electrical power needs of the cooling tower would require a 460V system with a capability of 0.8 MW. This power would be provided from the station and would require the installation of cables and a transformer.

Even with the addition of sound attenuation features, the tower would still produce some noise from both the water flow and the fans. As can be seen from Table 2, the overall noise level at a 50' distance from the tower are guaranteed to be at or under 75 dBA. The noise levels generated should be manageable near the plant building, over 300 feet away.

Table 2- Sound Guarantee Levels at 50' from Cooling Tower

F488-6.0-05 PPWD Tower with 1 ft FB20/1 Layer of Enkamat Splash Attenuation

		Frequency, Hz								**Overall**
Distance	**Location**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dBA**
50 ft	Air Outlet	80	77	70	63	56	43	34	25	66
50 ft	Air Inlet	82	78	76	70	68	64	59	56	74
50 ft	Dry Inlet	76	74	67	60	56	53	50	42	64
50 ft	Tower Total	84	81	77	71	68	65	59	56	75

The drift rate would be the minimum design level currently guaranteed by the supplier at 0.001 % of the water circulated. A practical, cost-effective plume point design temperature of 15°F was selected as appropriate for the area. At temperatures above that value, except for a wispy, weak fan stack exit, no plume should be visible. At temperatures below that value, a plume would occur.

The cooling tower budget quote from SPX is shown in Table 5. This 5 cell tower would be designed to cool 68,100 gpm through a range of 15° F. The range is defined as the difference between the hot and cold water temperatures entering and exiting the tower. The temperature difference between the cooled water and the wet bulb temperature of the air entering the cooling tower is known as the approach. For the tower, with an inlet wet bulb temperature of 77° F, the approach would be 8°F for the specific Greenidge conditions. This design thermal performance level is comparable to the current state of the art of practical cooling tower technology. Though lower approaches would provide colder water, towers designed for a lower approach are currently considered theoretical for towers of this large size and at the relatively low design wet bulb temperature that occur in the region of the plant. The design ambient wet bulb temperature of 77°F was selected from long-term weather statistics of Penn Yan, NY. That is, specifically the wet bulb that would not be exceeded for more than 1% of the time of warm weather months of the typical year. Based on experience, a value of 2° F was added to that temperature to account for the expected exit plume recirculation as a result of winds parallel to the tower (any other orientation would produce an appreciably greater recirculation). At the design point, the water temp would be 85°F, which is estimated to be a sufficiently cool peak CW inlet temperature to satisfy the station generation requirements.

Meteorological data used for the analysis was collected at Penn Yan Airport, NY. The periods used to determine seasonal average wet and dry bulb temperatures run from January to December 2009. This period coincides with the most recent plant data used in the analysis. Summer was calculated with the average daily high temperatures in order to evaluate the load shedding potential.

The lead time for the Greenidge retrofit project to be completed is estimated at 40 months. A four-month period of plant shutdown would be necessary to construct and install the new tower, intake bay, discharge basin, condenser discharge piping modifications, new pump house and pumps to the tower, the makeup and blow down system, the tie-ins to the existing system, and for start-up and testing of this retrofitted closed-cycle system. A summary of the expected time needed for the Greenidge cooling tower retrofit project is given below:

Table 3- Cooling Tower Retrofit Projected Timeframe to Completion

Project Task	Estimated Time Required
Permitting	12 months
Retrofit Planning & Design	12 months
Purchasing & Delivery	12 months
Cooling System Modifications	3 months
Cooling Tower Construction	3 months
Startup	1 Month
TOTAL:	**40 Months**

It must be noted that a series of permits and permissions will be required for this project, and the receipt of these is not assured. Local authorities will need to grant the permits and permissions for the construction of the tower, with their potentially lengthy review of the impacts on the local community both during and after construction. The increase in airborne emissions resulting from the less efficient cooling of the closed-cycle system will require approval from environmental agencies. New Source Review, Prevention of Significant Deterioration and New Source Performance Standards programs could be required. Time needed to comply with regulations and to receive approvals is hard to ascertain beforehand, but could be extensive and could easily add at least a year to the completion date of the project.

1.6 Closed-Cycle Cooling System Retrofit Capital Costs

1.6.1 General Cost Estimate Bases

The capital cost estimates for the retrofitted cooling towers were based on the conceptual closed-cycle cooling system design created for AES Greenidge. The retrofitted cooling tower cost alternative was estimated from a combination of material quantities identified specifically for Greenidge, a budgetary estimate from a major vendor for the cooling tower, industry pricing for construction, and costs from other projects that were adjusted for identifiable differences in project sizes and operations. Means Heavy Construction Cost Estimating software (2010 edition) was utilized for many of the construction costs. Labor costs were based on union work in the communities sharing the same area code prefix as Dresden, NY, and pricing was based on January 1, 2010 data.

Also used in estimating capital costs were:

- Present-day prices and fully contracted labor rates as of the first quarter of 2010.
- A 48-hour work week with single-shift operation for construction activities that do not impact plant operations. This study does not consider any local restriction of work periods due to noise or other local ordinances.
- Direct costs for material and labor. [The direct costs include distributable costs for site non-manual supervision, temporary facilities, equipment rental, and support services incurred during construction.]
- Construction management costs equal to 7% of the direct costs. .
- Engineering and design at 5% of the direct costs.
- Indeterminate & contingency costs equal to 15% of the direct, distributable, and indirect costs of each technology option. (Indeterminate costs include uncertainties in design and construction based on the use of conceptual designs. Contingency costs include uncertainties not included in the indeterminate costs, e.g., labor difficulties, delivery delays, weather, etc.).

The estimated capital costs however do not include:

- Interest during construction
- Costs to perform additional laboratory or field studies that may be required, e.g., hydraulic modeling, soil sampling, and wetlands delineation (if any) and environmental mitigation.
- Internal AES costs for administration of project contracts and for the engineering and construction management.
- Permitting costs. A nominal value of 5% was included in the estimate to cover building and construction permits only. The permitting cost include all environmental permits, CO_2 mitigation, NSPS, NSR, PSD and could significantly exceed that value.
- Price escalations beyond the first quarter of 2010.
- Treatment of blow down before being released.
- Physical screening such as a berm or landscaping to minimize the aesthetic effects of the new cooling tower.

Estimated construction costs for retrofitting the closed-cycle cooling system for Greenidge's Unit 4 are presented in Table 4.

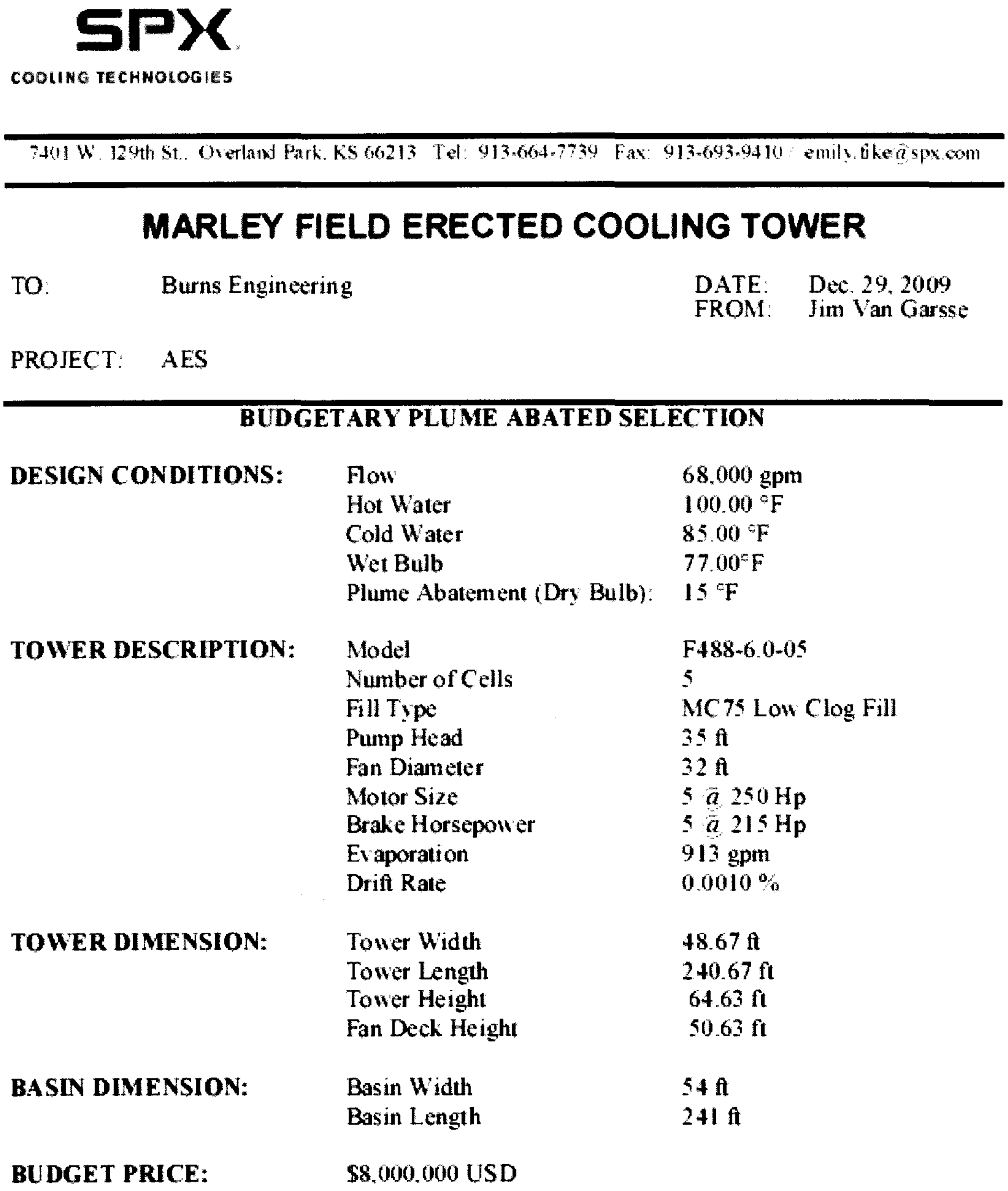
Table 4- Capital Costs of a Closed Cycle Retrofit at AES Greenidge

CAPITAL COST OF CLOSED-CYCLE SYSTEM WITH WET PLUME-ABATED, COUNTERFLOW MECHANICAL DRAFT COOLING TOWER & REQUIRED SYSTEM COMPONENTS

ITEM	DESCRIPTION	BASIS	COST
1	One 5-cell Furnished & Erected Class F488-6.0-05 Plume-Abated Wet Cooling Tower Oriented in EW Direction, Noise attenuation	Dec. 2009 BES Ltr Spec & 12/29/2009 Budgetary Estimate from SPX	8,000,000
2	New CWS Piping Costs, including piping, elbows, valves, excavation, backfill, tie-ins, interferences	Means 2010 Q1	2,827,710
3	Cooling Tower Basin Cost, including site work, access road, backfill, and grade, piles, pile caps, Slab on Grade 6", Fdn walls	Means 2010 Q1	1,540,714
4	Wire CT fans MCC, switchgear, electricals, noise attenuation	Managing Waste Heat-Statistics	2,431,667
5	Inlet & Outlet Reservoir, pump house construction, Cooling Tower supply pumps, motors, and electricals	Means & pro-rate past pump estimates	2,586,375
6	Tower Acceptance Testing	Am Society Mech Engrs Test Code PTC 23-2003	65,000
7	**TOTAL DIRECT COSTS**		**$17,451,466**
8	Permit Cost Estimate	0.05	872,573
9	Construction Management	0.07	1,221,603
10	Engineering	0.08	1,396,117
11	Contingencies	0.15	2,617,720
12	**TOTAL ESTIMATED RETROFITTED PLUME ABATED CLOSED-CYCLE COOLING SYSTEM PROJECT CAPITAL COSTS (Jan 2010 COSTS)**		**$23,559,479**

A budgetary estimate of the cooling tower itself as provided by SPX, a major manufacturer of cooling towers, is provided in Table 5.

Table 5- AES Greenidge Cooling Tower Budgetary Estimate



SPX
COOLING TECHNOLOGIES

7401 W. 129th St., Overland Park, KS 66213 Tel: 913-664-7739 Fax: 913-693-9410 / emily.fike@spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO:	Burns Engineering	DATE: FROM:	Dec. 29, 2009 Jim Van Garsse
PROJECT:	AES		

BUDGETARY PLUME ABATED SELECTION

DESIGN CONDITIONS:	Flow	68,000 gpm
	Hot Water	100.00 °F
	Cold Water	85.00 °F
	Wet Bulb	77.00°F
	Plume Abatement (Dry Bulb):	15 °F
TOWER DESCRIPTION:	Model	F488-6.0-05
	Number of Cells	5
	Fill Type	MC75 Low Clog Fill
	Pump Head	35 ft
	Fan Diameter	32 ft
	Motor Size	5 @ 250 Hp
	Brake Horsepower	5 @ 215 Hp
	Evaporation	913 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Width	48.67 ft
	Tower Length	240.67 ft
	Tower Height	64.63 ft
	Fan Deck Height	50.63 ft
BASIN DIMENSION:	Basin Width	54 ft
	Basin Length	241 ft
BUDGET PRICE:	$8,000,000 USD	

Construction on the Greenidge site will face the following challenges:

- The space upon which the inlet and outlet reservoirs are to be constructed is very limited. The existing Unit 4 pump house will need to be dismantled and then reconstructed over the holding basin. Construction equipment will necessarily be in close proximity to the substation and to the plant building.
- Access to the tower build site by heavy equipment will be difficult and will require construction of a new roadway.

The sequence and durations for the engineering, procurement, and construction activities associated with the closed-cycle cooling system alternative (including all components) would be:

1. Permitting, Engineering and design - 24 months
2. Specifying and purchasing -12 months
3. Modification of existing inlet & discharge bays, construction of makeup & blowdown system, constructing the CWS lines under, around, and through interferences, tying the closed-cycle cooling piping into the existing plant, and construction of the system 3 months. (This activity, along with #5 below, would require a plant shut-down for 4 months)
4. Construction of cooling tower - 3 months
5. Start-up and testing -1 month

1.7 Adverse Impacts on Plant Operation

Additional auxiliary power would be needed to operate the 5 fan motors and the 3 new cooling tower feed pumps required by the closed cycle retrofit. The result of this estimate is shown Table 6. The extra power amounts to a 1.9 MW increase in auxiliary power requirements for the operation of the closed-cycle system with the plume-abated tower. Over a one-year period, this comes to 12,000 MW additional station service as compared to the existing once-through system. This shortfall will be made up by the burning of over 1,400 tons more coal at Greenidge, creating detrimental environmental effects and costing the plant $107,000 in added fuel costs.

Table 6- Auxiliary Power Requirements for Plume-abated Cooling Tower at Greendige

Based on calculations and estimates of BES Greenidge Closed-Cycle design, Pump BHP Data and budget estimates of CT size by SPX

TYPE OF COOLING SYSTEM	**Brake Horsepower**		**MW**
Discharge Reservoir Cooling Tower Supply Pumps	1,530		
Tower Fans	1,075		
Total Additional Aux Power-BHP/MW	**2,605**		**1.9**

Retrofitting a plume-abated tower into the current once-through system would also cause other adverse effects on the Greenidge Unit 4's operations. The net plant heat rate would be impacted because backpressure on the turbine would rise due to the higher seasonal condenser inlet water temperatures from the cooling tower as compared to the present once-through inlet water temperatures. Increased plant trips (forced outages) are anticipated along with the subsequent negative environmental impacts of startup, shutdown and malfunction emissions because the complexity of the plant would have increased. Operating costs would include the extra fuel (and subsequent added emissions of NOx, SO_2, PM10, PM2.5, CO and CO_2) to generate the current station power level. These factors would further reduce the net annual power output of the plant.

The station would be impacted with loss of all revenue during the entire four month period when the plant is shut down for the retrofit modifications and startup/testing. At $63/MWh [1]and 72% capacity factor, the nominal loss of revenue during that shutdown period was estimated as $13,907,000.

Annual extra maintenance costs of the plume-abated closed-cycle cooling systems for Greenidge were estimated to be $150,000. This cost is based on one full time staff member to maintain the tower and the other related closed-cycle equipment and components.

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[1] Loss of revenue does not include variable cost to produce the energy

Additional potentially negative effects resulting from the retrofit of a plume-abated cooling tower at Greenidge include, but are not limited to electric system reliability, icing build-up on critical electrical system components and transmission lines, permitting issues and modifications associated with the New Source Review, Prevention of Significant Deterioration and New Source Performance Standards programs. The New Source Review allows for a major and critical review of plant emissions upon any major modification to the facility, such as a closed-cycle retrofit, and the Prevention of Significant Deterioration and New Source Standards Programs would apply, as the plant would now be an emitter of particulate matter from the cooling towers.

1.8 Closed-Cycle Retrofit Power Output Loss Evaluation & Costs

Fuel costs associated with operation of the closed-cycle system design were included in the evaluation as a separate aspect of the overall evaluation. During operation of the closed-cycle cooling system designs, Greenidge's net electrical energy losses were related to reduced plant efficiency. The comparisons of both cooling system options to the existing operation were based on estimated incremental turbine characteristics in order to reduce errors.

Greenidge's Unit 4 post- cooling tower retrofit performance was compared to the existing plant operating performance by evaluating the change in turbine net heat rate associated with the effect of the cooling tower at anticipated seasonal dry and wet bulb temperatures. Seasonal site wet bulb temperatures, and seasonal cooling tower plume recirculation estimates were utilized to establish the operating turbine backpressures and thence the net plant heat rate for the closed-cycle system. The turbine's incremental net heat rate response to changes in backpressure was estimated for the existing plant from the current condenser performance and a regression analysis of the exhaust pressure correction factor curve.

Based on information supplied by AES, the cost of coal in the study was estimated at a nominal $75/ton, equivalent to approximately $2.62/MMBtu. A capacity factor of 72% was used in the analysis.

The extra energy (supplied by burning additional fuel) needed by season is presented in Table 7. These estimates include the auxiliary power requirements of the tower and are broken down based on the average meteorological conditions and inlet water temperatures at Greenidge for each season. Average daily temperatures include both day and night readings, and hence appear lower than one might otherwise expect. Maximum average daily temperatures were included for the summer to demonstrate the effect on condenser backpressure and plant efficiency.

Table 7- Performance Impact of Retrofitting a Closed Cycle System at AES Greenidge

ESTIMATED PERFORMANCE W/ CLOSED CYCLE SYSTEM RETROFIT

Season of Year	**WET-DRY MD Spring**	**WET-DRY MD Summer-Ave**	**WET-DRY MD Summer-Max**	**WET-DRY MD Fall**	**WET-DRY MD Winter**
Ambient Wet bulb temp-F	41.7	62.9	77.0	47.3	23.1
Avg. Dry bulb temp-F	47.1	66.7	76.0	50.3	25.6
Recirculation-F	2.0	2.0	2.0	2.0	2.0
Inlet Air WB temp-F	43.7	64.9	79.0	49.3	28.5
Q-Tower Duty Btu/hr from Cond	4.247E+08	4.247E+08	4.247E+08	4.247E+08	4.247E+08
Cooling range-F (w.4%aux heat)	17.7	17.7	17.7	17.7	17.7
Tower Approach-F	18.0	11.7	8.4	16.1	25.1
Tower Cold Water Temp-F	61.7	76.7	87.4	65.4	53.6
Return Temp to Condensers-F	61.7	76.7	87.4	65.4	53.6
% Cond tube plugged	0.03	0.03	0.03	0.03	0.03
Design Bundle Cleanliness%	85	85	85	85	85
Condenser Temp Rise-F	17	17	17	17	17
Tin-F	61.7	76.7	87.4	65.4	53.6
Tin/100-F	0.62	0.77	0.87	0.65	0.54
Tube surface available-sqft	48,500	48,500	48,500	48,500	48,500
GPM Flow	68,000	68,000	68,000	68,000	68,000
Tube velocity- fps	7.40	7.40	7.40	7.40	7.40
HEI Temperature Correlation Coefficient	0.9	1.0	1.1	1.0	0.9
Heat Transfer Coefficient.-Btu/hr-ft2-F	572	626	650	588	530
Estimated Condenser Steam Temp-F	92.2	105.4	115.6	95.3	85.6
Est. Turbine Exhaust Pressure-in hga	1.53	2.22	2.95	1.67	1.27
1 inhga-Base Plant Heat Rate-B/kw-hr	7,804	7,804	7,804	7,804	7,804
Additional Penalty for Aux Power	141	141	141	141	141

ESTIMATED EXISTING PERFORMANCE W/ ONCE-THRU SYSTEM

Condenser Temp Rise-F	17	17	17	17	17
Avg. Water Inlet Temperature-F (avg plant data)	46.4	70.0	70.0	61.3	44.5
Tin/100-F	0.46	0.70	0.70	0.61	0.45
Tube surface available-sqft	48,500	48,500	48,500	48,500	48,500
GPM Flow	68,000	68,000	68,000	68,000	68,000
Tube velocity- fps	7.40	7.40	7.40	7.40	7.40
HEI Temperature Correlation Coefficient	0.8	1.0	1.0	0.9	0.8
Heat Transfer Coefficient.-Btu/hr-ft2-F	444	551	551	519	434
Estimated Condenser Steam Temp-F	82.59	101.20	101.20	93.85	81.36
Est. Turbine Exhaust Pressure-in hga	1.17	1.97	1.97	1.60	1.13
SEASONAL CLOSED-CYCLE ADDED FUEL COSTS					
Penalty Plant Heat Rate-B/kw-hr	250.23	216.39	436.54	161.63	184.71
Extra lb of Coal Burned with Once-Thru System	3,183,961	2,753,408	5,554,557	2,056,654	2,350,246
Seasonal Extra Fuel Cost at $2.62/mmBTU & 72% CF	**$108,544**	**$93,866**	**$189,360**	**$70,113**	**$80,122**
YEARLY TOTAL:	**$352,646**				

Unit 4's heat balances and turbine response curve was used to determine the increased incremental heat rate. Tower recirculation was judged from past studies. The seasonal cooling tower performance was estimated from the counter-flow characteristic projected to average Penn Yan seasonal wet bulb temperatures from the cooling tower design condition performance. The condenser average apparent cleanliness was estimated at a standard industry value of 85%. The cost of power was estimated at $63/MWh.[2]

The results indicate that the annual extra costs incurred by retrofitting a closed-cycle cooling system at Greenidge are: $353,000 for the additional fuel due to negative heat rate effects, $107,000 for added auxiliary power; and $150,000 for maintenance of the new equipment. The total cost is $610,000 per year. These costs are summarized in Table 8. As is evident, based on the estimate at the maximum wet bulb temperature during peak demand conditions, load shedding needed to maintain the turbine below their backpressure limit would not be expected.

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[2] Loss of revenue does not include variable cost to produce the energy

Table 8 Summary of Additional Annual Cost Components Associated with Implementing a Closed-cycle System at Greenidge

Greenidge Extra Closed-Cycle Annual Fuel Costs	$ 353,000
Closed-Cycle Extra Maintenance Costs	$150,000
Auxiliary Power Costs	$107,000
Total Annualized Extra Cost of Closed-Cycle Operation	**$610,000**

To make up for the power lost to the lower efficiency and the additional auxiliary power requirements of the closed-cycle system, an additional five thousand tons of coal is required This increased coal usage at Greenidge will raise permitting issues and modifications associated with the New Source Review, Prevention of Significant Deterioration and New Source Performance Standards programs. The New Source Review allows for a major and critical review of plant emissions upon any major modification to the facility, such as a closed-cycle retrofit, and the Prevention of Significant Deterioration and New Source Standards Programs would apply, as the plant would incur increased emissions of criteria air pollutants (i.e, NOx, SO2, PM10, PM2.5) .

2. REFERENCES

Heat Exchange Institute (HEI) Standards for Steam Surface Condensers, 10th Edition, 2006.

Cooling Tower Institute, Counterflow Cooling Tower Performance Curves, CTI, 1967.

JM Burns; D Brochard, “Cooling Towers”, Section 4.8, Handbook of Energy Systems Engineering, J. Wiley & Sons, 1985.

JM Burns, et al., “Accurate Condenser Performance Monitoring Guidelines Provided by New Condenser Test Code”, EPRI Heat Rate Improvement Conf., 1994.

Burns JM, Burns DC, Burns JS, “Estimates Required to Achieve the Next Level of CWA 316(b) Compliance”, IJPGC, Electric Power, 2004.

Dickey and Cates, The Marley Company, "Managing Waste Heat with the Water Cooling Tower", 2nd edition, Apr. 2, 1973,

Cameron Hydraulic Data, Ingersoll Rand Co., 1965.

DOE/EA1493. August 2004..

Iowa Environmental Mesonet- Iowa State University Dept. of Agronomy.

Means Heavy Construction Cost Estimating Software, 2010. Q1 2010 Update.

Greenidge Operating Data- 2007- 2009, AES, 2010.

SPX, Budget RFQ-AES Greenidge, Dec. 29, 2009.

ASME PTC 23-2003, Cooling Tower Performance Test Code, 2003.

New York State Department of Environmental Conservation SPDES Permit NY-0001325. Feb. 1, 2010.

Mosier, David. ASA. Coal cost figure, Heating value of coal. Jan. 18, 2010.

Google. Maps and photos in plant vicinity- March 2010.

Weather Underground. Historical Data.

NYSEG, "Topographic Map: 1988 Plant Area", Drawing No. GD-16986. Dec. 15, 1988.

General Electric. "Heat Balances for New York State Electric & Gas Corporation Greenidge Station Unit No. 4 Dresden, New York." 1987.

ENGINEERING & COST ASSESSMENT OF RETROFITTING VARIABLE FREQUENCY DRIVES AT AES GREENIDGE GENERATING STATION UNIT 4

Date: July 25, 2010

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1. Introduction

The intent of this report is to assess the feasibility and impact of retrofitting variable speed circulating water (CW) pumps (also referred to as "VSP's", "variable frequency drives", or "VFD's") at AES Greenidge Generating Station ("Greenidge") for the Unit 4 condenser in order to reduce impingement/ entrainment of aquatic organisms by reducing the plant's water intake.

The penalties and costs of operation at different seasonal flow rates will be provided so that seasonal operation of each option can be considered.

Costs in terms of fuel penalties (expressed in BTUs) and direct capital costs were developed. These costs can be weighed against the potential reduced entrainment and impingement losses.

1.1 Summary/ Conclusion of Evaluation Results

- The amount of water usage reduction attainable through the retrofitting of VFDs at Greenidge is minimal. This is for two main reasons: (1) the plant is already operating with less than its three pumps for much of the year and (2) operational constraints, such as maintaining minimum flow velocity through the tubes and the SPDES intake-discharge temperature difference permit limitations, constrain the lowest permissible flow rate.
- The total maximum level of reduction in water usage possible with VFD option from typical 2007- 2009 levels is about 11.4% of total flow, or a reduction of 7,600 GPM.
- Technical restrictions that apply to all options as to the lower limit of flow at which the plant can operate and produce full power are established by the water velocity through the condenser, condenser backpressure, and temperature rise and discharge temperature limits. For AES Greenidge Unit 4, the lowest level which can be considered for any season without exceeding one of these restrictions is 37,455 GPM, or 55% of total flow. Even this flow level can only be considered in spring and winter; otherwise, it will cause SPDES permit intake-discharge temperature difference violations.

- The capital cost of implementing the VFD Option, including engineering, purchasing, specification, and installation, is estimated at $684,000.
- The cost of the yearly penalty at the combined maximum seasonal flow reduction points is $58,915, with an additional 786 tons of coal burned to maintain current electrical loads. Other values based on different seasonal flow operating levels can be determined by the tables provided.

1.2 Modifications Required for Variable Speed Pumps

Modification of the existing pumps will require replacing the existing pump motors with new ones designed for variable speed operation. Variable frequency controls and new hardware connecting the power supply and pump drives will also be needed.

Conversion of all three CW pumps would be required for a variable speed operation to function properly at Greenidge. Retrofitting only one or two pumps would not be feasible, as the head from the stronger pumps would interfere with and restrict the flow from a variable speed pump on a lower setting.

1.3 Cost Estimate of Installing Variable Speed Pumps

Below is an estimate of what it would cost to purchase and install the variable frequency drives and pump motors for the pumps at Greenidge's Unit 4. The pricing estimate is based on previous estimates for a similar unit in 1997, increased by the Engineering News Record Cost Index from 1997 to 2010. Engineering, specification, purchase, and installation costs were estimated at 50% of the equipment costs. It has been assumed that the pumps themselves will not be replaced and that no resonant pump frequencies will occur that would cause any other major modifications to be implemented. A plant shut-down of one week would be required to install the new pump drives; presumably this work could be included during a scheduled outage.

Variable Speed Pump Conversion - Direct Costs	
Control Hardware (each)	$63,485
Motors (each)	$88,502
Engineering, Purchasing, Specification, Installation per pump	$75,994
Total Cost Per Pump	$227,981
Total cost for 3 Pumps	**$683,943**

Figure 1- Variable Speed Pump Conversion Direct Costs

The variable speed pumps (and particularly, their controls) have very strict requirements regarding their operating environment. These controls must be well-sheltered from the elements. The controls also produce significant heat and must be kept at temperatures below 104°F. This means that extremely good ventilation and even air conditioning must be installed in the location where the variable speed pumps are housed. For each of the three CW pumps at Greenidge, the dimensions of each control box are estimated at 92" high x 36" deep x 72" long. Each control box weighs several tons. Additional cost, space, and structural requirements for housing and protecting the hardware to meet these requirements may double the above estimates.

1.4 Plant Performance Estimation Methodology

For the purposes of the study, the plant has furnished operational data for Unit 4. The data for three full years of operation (Jan 2007-December 2009) was used as a basis for the VFD study. This period captures a large number of data points including operation at or near full load, which allows the characteristics of the condenser to be modeled, while providing three full years upon which to consider seasonal variations in climate. The data set includes hourly data measurements of gross generation, circulating water flow, intake water temperature, discharge water temperature, and backpressure. A summary of the generation recorded in this data set is shown in Table 1.

Table 1- Greenidge Unit 4 Generation: 2007 - 2009

GREENIDGE UNIT #4 GENERATION: 2007-2009					
	Annual Generation (MWhr)		Avg. Hourly Generation (MW)		
YEAR	Gross	Net	Gross	Net	Capacity Factor
2007	712,867	655,413	81.4	74.8	71.3%
2008	731,054	670,384	83.6	76.7	72.9%
2009	477,716	434,976	54.5	49.7	47.3%

The temperature rise is the difference between the intakeand discharge water temperatures. It reflects the heat absorbed by the cooling water. Figure 2 shows a plot of the inlet temperatures for the data period selected for this study. Inlet water temperatures are consistent with each other over the seasonal period. The change in the backpressure due to the reduction in CW flow allows a quantitative estimate of the ultimate effect on generation in terms of the added heat needed to make up the lost generation due to the higher backpressure.

One can determine the penalty on the plant heat rate by multiplying the base plant heat rate, taken from the plant heat balance as 7,804 BTU/KW-Hr, with the change in backpressure at the new flow, and multiplying it again by the slope of a representative turbine response curve. With that information, the daily extra fuel BTUs can be estimated.

Where needed, a 72.1% capacity factor was assumed for the calculation. The cost of coal was provided by AES as $75/ton, and the heating value of coal was assumed to be 13,000 BTU/lb. The cost of coal was calculated at $2.62/ MM-BTU.

Apparent cleanliness is a reflection of the actual performance of the condenser versus the expected performance of the condenser based on its design parameters. All factors which affect performance, not just tube cleanliness, are reflected in this figure. Calculating the apparent cleanliness to a reasonable degree of accuracy, requires properly positioned and accurate measurements of discharge temperatures and flow rates at electrical outputs close to full load.

Apparent cleanliness values over the three-year period showed great variability. An analysis of the apparent cleanliness of the Greenidge Unit 4 is beyond the scope of this study. However, results over the entire three-year period suggests that there was variability in the plant measurements. The average apparent cleanliness for outputs from the most recent year (2009) at or above 100 MW was 58%. This figure was used in subsequent calculations for the purposes of this study.

Seasonal temperatures for this analysis are derived from the data with the following dates: Spring is from March 1st to May 31st, Summer is from June 1st to August 31st, Fall is from September 1st through November 31st, and Winter is from December 1st to the last day of February. In regards to SPDES discharge limits, the data are divided into summer and winter periods. The winter period is defined as those periods in which the daily average water temperatures remain at or below 52 degrees F for five or more consecutive days. The summer period is defined as all other times not meeting the criteria of the winter period. The SPDES seasonal period will be referenced as such.

The condenser performance was modeled according to principles set forth in the Heat Exchange Institute's Standards for Steam Surface Condensers, Tenth Edition. Plant personnel have indicated that about 3% of the tubes are plugged.

Flow rates are expressed as a percentage of the current full flow of all three existing CW pumps. The 100% flow value therefore corresponds to 68,100 GPM.

From the given inlet and discharge temperatures, the gross heat load was calculated. This value was then used in conjunction with varying flow rates to determine what discharge temperature would result from the chosen CW flow level. The change in the backpressure due to the reduction in CW flow allows a quantitative estimate of the ultimate effect on generation.

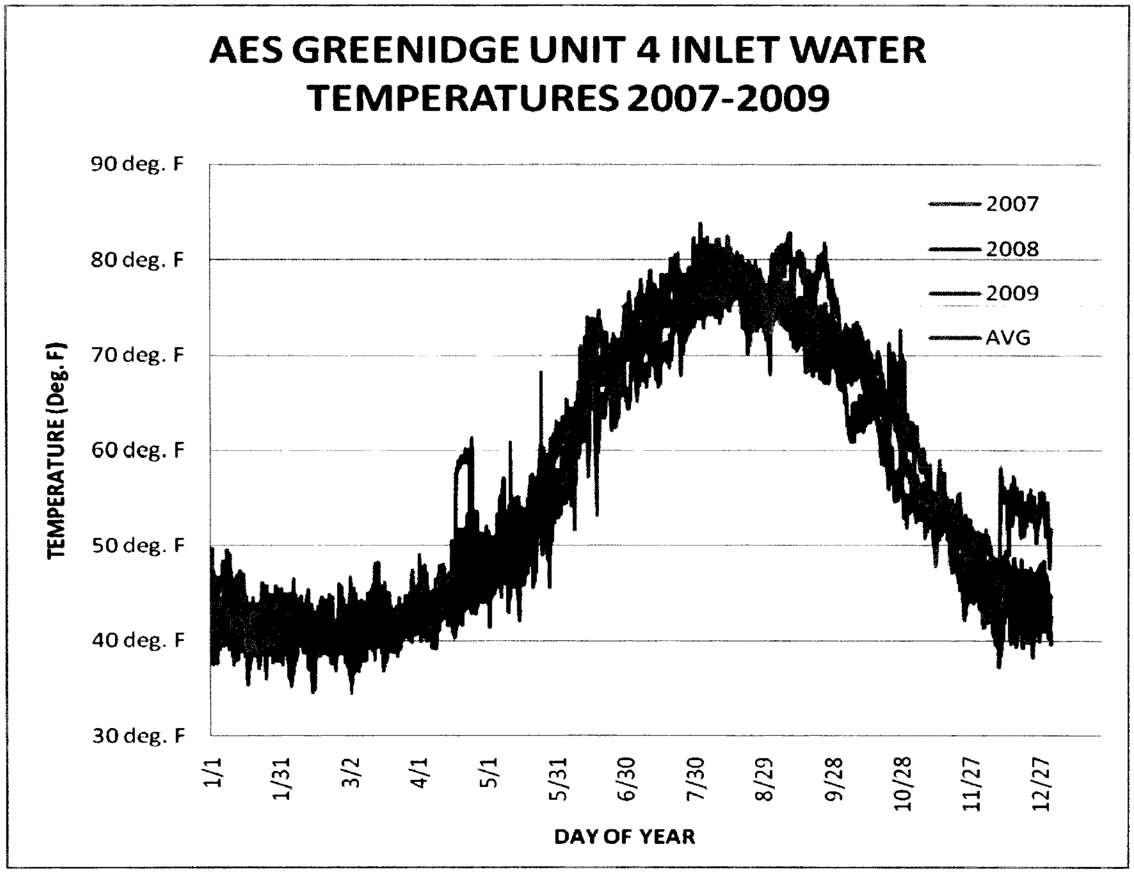

Figure 2- Greenidge Unit 4 Inlet & Outlet Temperatures

Although AES Greenidge is outfitted with three CW pumps, it often operates with only two pumps. In fact, the yearly average pump flow rate percentage for Unit 4 over the three-year data period of 2007-2009 was only about 75% of total three-pump operation.

The breakdown of average flows for each season is shown in Table 2. Because Greenidge is currently operating below full flow capacity, the benefit from a VFD retrofit, both in terms of flow reduction and auxiliary power reduction, is minimal.

Table 2- Greenidge Unit 4 Average Condenser Cooling Water Flows 2007-2009

Season	Avg. Seasonal Flow (GPM)	Avg. Seasonal Flow (% of max. flow)
SPRING	45,342	66.7%
SUMMER	60,955	89.6%
FALL	52,634	77.4%
WINTER	45,341	66.7%
Yearly Avg.	51,133	**75.2%**

The VFD savings in this report are expressed in terms of the flow option chosen against the average station water usage per season over the three-year data period.

1.5 Flow Reduction Limitations

The first limiting factor of the amount which the flow through Greenidge Unit 4 can be reduced is the water velocity through the condenser tubes. A water velocity through the tubes of less than 3.5 ft/sec would cause poor heat transfer performance, siltation, and fouling to the point where normal operation of the condenser (i.e., anywhere near full output) would be imprudent.

The 2007-2009 data set bears this out. Although, on very rare occasions (1.7% of the time), only one pump was used on Unit 4 for cooling purposes, and, during these times, no electricity (< 1MWh gross output) was generated.

Note that the flow through the condenser when the water flow is set to 47% of maximum flow falls below the 3.5 ft/sec threshold. As a result, selections at or below these flow rates can be dismissed in subsequent analyses as impractically low for normal condenser operation. , Even operation at 50% flow, though possible, could still result in severe impacts to condenser performance by reducing apparent cleanliness through the mechanisms of siltation and biofouling over time. This could result in more frequent maintenance and tube cleanings .

Backpressure also limits the extent to which flow reduction through the condenser is possible without forcing the plant to reduce its output. The Greenidge Unit 4 condenser has an operational alarm point of 4.5 InHgA. When this limit is reached, the unit must reduce load to prevent damage to and possible failure of the turbine and the voiding of any turbine warranty. As shown in Figure 3, the lower the flow level, the more the backpressure limit will be exceeded, particularly in the summer months. Using the performance model of the Unit 4 condenser as applied to the historical temperature data, it was determined that, for flows at 37,455 GPM, or 55% of the total flow, the incidence of forced load reduction would occur almost eight times less often than at 47% of flow. In order to minimize derating incidents to manageable levels, and to maintain a water velocity through the tubes adequate to avoiding tube fouling, the minimal flow level considered in this study is 55%.

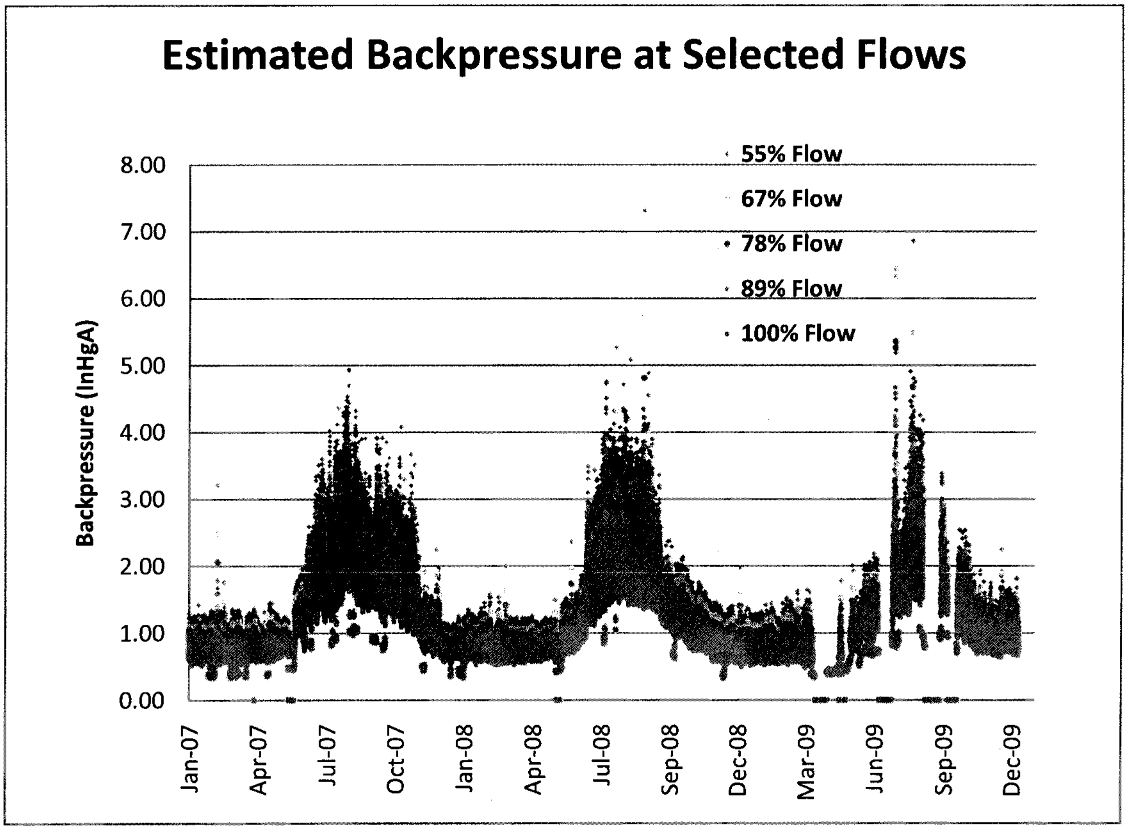

Figure 3- Estimated Backpressure at Selected Flows

Figure 3 is a plot of the estimated backpressures of the condenser during flows of 55%, 67%, 78%, 89%, and 100% of total flow available. Of course, the higher the cooling water flows through the condenser, the lower the backpressure will be. Even when the backpressure does not exceed critical limits requiring plant load reduction, the lower cooling water flows will adversely impact generation by requiring more coal to be burned to maintain electrical generation.

At any time of year, a reduction in CW flow by operating variable speed CW pumps under 100% flow will increase the temperature rise of the water because a smaller quantity of water will be absorbing the same amount of waste heat energy. This will mean that the plant discharge CW will be much warmer, increasing the potential for the SPDES thermal permit limit to be exceeded.

The current SPDES permit specifies that, in winter periods, the discharge temperature may not exceed 86°F. In summer periods, the discharge temperature limit is 108°F. At the lowest flow considered (55% of flow), the discharge temperature would on rare occasions exceed the discharge limits. Based on the three-year data period, no cooling water discharge temperatures would exceed the discharge temperature limit of 86°F during SPDES winter periods.

During SPDES summer period, at 55% of total flow, six days per year fall above the 108°F discharge temperature threshold, all occurring in the months of July and August. In comparison, at 67% of flow (equivalent to current two-pump operation), it is estimated that less than one exceedance per year would occur during the summer and winter periods..

A stricter limitation to Greenidge Unit 4's possible flow reduction is applied by the limit on the temperature rise, also known as the delta T limit, or "intake-discharge temperature difference" as defined by the plant SPDES permit. The temperature rise is defined as the temperature difference between the discharge and intake temperatures, and is restricted in order to minimize adverse effect on aquatic species. According to the current SPDES permit for Greenidge, two differing delta T limits are to be applied, depending on whether the time is defined as summer or winter period. For the SPDES-defined summer period, the delta T must be less than or equal to 26 degrees F. During the SPDES-defined winter period, the delta T limit is restricted to 31 degrees F or less.

The historical operating data provides a basis for predicting what the discharge temperature would be at varying flow rates. In this manner, the incidence of exceeding the delta T limits in the summer and winter periods at varying flows can be estimated. The number of days annually in which the delta T limit is exceeded is broken down into seasonal incidences and rounded to the nearest whole day, and is expressed in Figure 4. The estimation is based on a generation pattern identical to that of the historical period.

Results of the calculation demonstrate at which seasons a given flow rate is appropriate for a given season. The criterion for acceptance used in this study is that exceedances of the SPDES delta T limit over 1.1 percent of the time (about 1 day per season) is unacceptable.

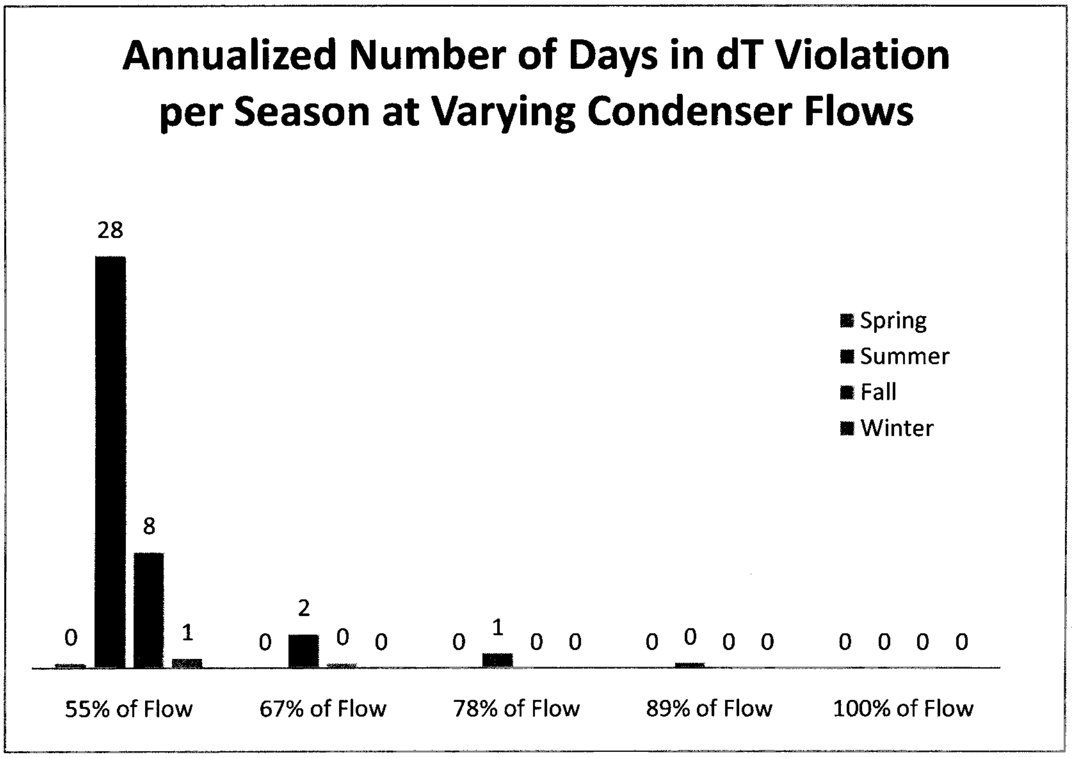

Figure 4- Annual Number of Days of ΔT Exceedances per Year by Season

At 55% of total flow, excessive exceedances occur in the summer and fall. At 67% of total flow, summer operation exceeds the ΔT levels beyond acceptable limits. The remaining flow rates evaluated rarely exceed the ΔT limits during all seasons.

1.6 Variable Speed Pump Energy Savings

Operating the pumps at a variable speed under the seasonal average flows listed in Table 2 would result in savings of energy used to power the CW pumps, while operating at higher flows would result in greater energy requirements. Pump laws can be used to describe the relationship between auxiliary power used to generate a given flow. The pump speed is directly proportional to the flow rate. In addition, the power required by the pump motor is directly proportional to the cube of the pump speed. However, the variable speed pumps, with their sophisticated controls required to reduce impeller speed, have a significant inefficiency relative to the single-speed pumps, which reduces the energy savings by roughly 50%.

Each of the three circulating water pumps is rated at 300 horsepower, and all three operating together consume approximately 0.67 MW during full speed operation. This figure can then be multiplied by the percentage of CW flow used per season to determine average auxiliary power used by the pumps.

The savings from operating the variable speed pumps will depend upon the level to which pump flows are reduced or increased over the seasonal average, and how long the variable speed pumps are in operation. Table 3 expresses the auxiliary power savings or penalty in terms of percentage of total flow chosen for a given season as compared with the average flow for that season as given in Table 2. Seasons are defined as 3-month periods of Spring, Summer, Fall, and Winter. Coal cost of $75/ton and a plant heat rate of 7,804 BTU/kw-h were used to determine the fuel savings in BTU and dollars. Savings are expressed as positive numbers.

Using this matrix, the savings for any variation in seasonal operation at the preselected flow levels can be determined. To get a yearly value, a flow selection from each season must be added together. For example, if you were running at 78% in the spring, 89% in the summer, 67% in the fall, and 67% in the winter, the total yearly savings in auxiliary power would equal -$1,735 + $1,082 + $3,047 + $467= $2,861 in power savings per year.

Table 3- Variable Speed Pump Energy & Water Usage Savings/Penalties

Season run at Variable Speed	Variable Pump Speed	% of original power used	Classical power savings vs 100%	% Power Savings after efficiency Loss (vs. 100%)	Savings vs. Seasonal Aux Power (MW/ H)	Fuel Savings per day (BTUs)	Savings/ Season (BTU)	Savings ($/Period)	Water Usage Savings (% of Max Yearly Flow)
SPRING	55%	17%	83%	42%	0.06	8.53E+06	7.85E+08	$2,058	2.94%
	67%	30%	70%	35%	0.01	1.90E+06	1.75E+08	$459	0.00%
	78%	47%	53%	26%	-0.05	-7.19E+06	-6.62E+08	($1,735)	-2.85%
	89%	70%	30%	15%	-0.12	-1.89E+07	-1.74E+09	($4,572)	-5.63%
	100%	100%	0%	0%	-0.22	-3.40E+07	-3.13E+09	($8,204)	-8.40%
SUMMER	55%	17%	83%	42%	0.21	3.20E+07	2.94E+09	$7,719	8.73%
	67%	30%	70%	35%	0.17	2.54E+07	2.33E+09	$6,118	5.79%
	78%	47%	53%	26%	0.11	1.63E+07	1.50E+09	$3,921	2.93%
	89%	70%	30%	15%	0.03	4.48E+06	4.13E+08	$1,082	0.16%
	100%	100%	0%	0%	-0.07	-1.06E+07	-9.74E+08	($2,554)	-2.61%
FALL	55%	17%	83%	42%	0.13	1.94E+07	1.76E+09	$4,619	5.59%
	67%	30%	70%	35%	0.08	1.28E+07	1.16E+09	$3,047	2.68%
	78%	47%	53%	26%	0.02	3.73E+06	3.39E+08	$889	-0.15%
	89%	70%	30%	15%	-0.05	-7.96E+06	-7.24E+08	($1,900)	-2.89%
	100%	100%	0%	0%	-0.15	-2.29E+07	-2.09E+09	($5,471)	-5.63%
WINTER	55%	17%	83%	42%	0.06	8.88E+06	7.99E+08	$2,095	2.88%
	67%	30%	70%	35%	0.01	1.98E+06	1.78E+08	$467	0.00%
	78%	47%	53%	26%	-0.05	-7.49E+06	-6.74E+08	($1,767)	-2.79%
	89%	70%	30%	15%	-0.12	-1.97E+07	-1.77E+09	($4,654)	-5.50%
	100%	100%	0%	0%	-0.22	-3.54E+07	-3.18E+09	($8,351)	-8.22%

Note: Flows likely to Cause Frequent SPDES Permit ΔT Limit Exceedances Are Obscured

The water usage savings compared to water usage of the historical period (2007-2009)can also be determined from the above table. For the example above, yearly water savings over the water usage of the historical period would equal -2.85% + 0.16% + 2.68% + 0.00% = -0.01%, or a tiny increase in flow of 68,100 GPM * 0.0001= 6.8 GPM. Interestingly, savings in auxiliary power can be made without a corresponding significant reduction in flow due to the seasonal variation in electrical output and flow.

1.7 Seasonal Plant Performance Penalty with Variable Flow Operation

The combination of the limit on flow reduction established by ΔT values and required minimal flow velocities through the tubes, coupled with the fact that Greenidge operates below full flow, means that the water usage savings made possible by retrofitting variable frequency drives will be minimal.

As described in Section 1.5, the increase in backpressure resulting from the flow reduction negatively impacts performance. Table 4 shows the penalty in terms of seasonal or annual operation based on the flow adjustment through the condenser compared to the average seasonal values as reflected in the historical data set. This component of the penalty would be the same for any means of varying the flow, provided that all other factors are kept constant. However, many CW flow management options have other effects in addition to modifying flow through the condenser which affect the net result of the penalty. For example, using variable speed pumps will affect auxiliary power, as discussed in Section 1.6.

Table 4- Seasonal Performance Penalties at Greenidge Unit 4 based on Varying Flow

	89% Flow				**78% Flow**			
Operational Period	Avg Penalty Plant Heat Rate (BTU/kw-hr)	Added Btus Fuel Required each Day	Added Lb. coal Burned (13,000 BTUs/ lb)	Added Cost/year ($2.62/MM-BTU)	Avg Penalty Plant Heat Rate (B/kw-hr)	Added Btus Fuel Required each Day	Added Lb. coal Burned (13,000 BTUs/ lb)	Added Cost/year ($2.62/MM-BTU)
Spring	-36.30	-7.42E+07	-525,342	**-$17,893**	-21.26	-4.35E+07	-307,731	**-$10,481**
Summer	1.91	3.92E+06	27,725	**$944**	40.58	8.31E+07	587,920	**$20,025**
Fall	-26.76	-5.44E+07	-380,831	**-$12,971**	-1.60	-3.25E+06	-22,763	**-$775**
Winter	-38.02	-8.09E+07	-560,141	**-$19,078**	-22.30	-4.75E+07	-328,598	**-$11,192**

	67% Flow				**55% Flow**			
Operational Period	Avg Penalty Plant Heat Rate (BTU/kw-hr)	Added Btus Fuel Required each Day	Added Lb. coal Burned (13,000 BTUs/ lb)	Added Cost/year ($2.62/MM-BTU)	Avg Penalty Plant Heat Rate (B/kw-hr)	Added Btus Fuel Required each Day	Added Lb. coal Burned (13,000 BTUs/ lb)	Added Cost/year ($2.62/MM-BTU)
Spring	0.03	5.71E+04	404	**$5,024**	32.65	6.68E+07	472,588	**$16,096**
Summer	96.37	1.97E+08	1,396,209	**$47,555**	184.12	3.77E+08	2,667,486	**$90,855**
Fall	34.35	6.98E+07	488,782	**$16,648**	90.12	1.83E+08	1,282,475	**$43,681**
Winter	0.02	4.99E+04	345	**$12**	34.39	7.32E+07	506,666	**$17,257**

The seasonal plant performance penalties of operating at a level below 100% of flow are shown in Table 4. Table 4 penalties are based upon average results of the change in condenser backpressure calculated from hourly inlet temperatures for the historical period covered in the data analysis. Again, flows likely to cause frequent exceedances of the SPDES Permit ΔT Limits have been obscured.

1.8 VFD Usage Effect on Plant Performance

Combining the variable speed pump energy savings and the performance penalty provides the net operational effect on performance for the VFD option in relation to historical seasonal water usage, as shown in Table 5. To determine the annual effect, the values that reflect the level of flow desired for each season would need to be added. Benefits are positive numbers, while penalties are negative. For example, the annual performance effect in dollars for operating at 89% in spring and 78% at all other times would be $13,326 - $16,107 + $1,664 +$12,081 = $10,964 net benefit on performance.

In summary, the performance impact of the VFD options is relatively small, but the reduction in flow usage is also minimal.

Table 5- Greenidge Unit 4 Net Plant Performance Penalty by Season

PERIOD		Flow Level (percentage of full flow)			
		89%	78%	67%	55%
SPRING	Addt'l. BTUs required	-6.83E+09	-4.00E+09	5.25E+06	6.14E+09
	Pump Energy Savings	-1.74E+09	-6.62E+08	1.75E+08	7.85E+08
	Net Addt'l Fuel BTUs required	**-5.09E+09**	**-3.34E+09**	**-1.70E+08**	**5.36E+09**
	Net Added Tons Coal Burned	**-178**	**-117**	**-6**	**187**
	Performance Benefit+/Penalty-($)	**$13,326**	**$8,748**	**$445**	**-$14,040**
SUMMER	Addt'l. BTUs required	3.60E+08	7.64E+09	1.82E+10	3.47E+10
	Pump Energy Savings	4.13E+08	1.50E+09	2.33E+09	2.94E+09
	Net Addt'l Fuel BTUs required	**-5.21E+07**	**6.15E+09**	**1.58E+10**	**3.17E+10**
	Net Added Tons Coal Burned	**-2**	**215**	**553**	**1,110**
	Performance Benefit+/Penalty-($)	**$137**	**-$16,107**	**-$41,443**	**-$83,143**
FALL	Addt'l. BTUs required	-4.95E+09	-2.96E+08	6.35E+09	1.67E+10
	Pump Energy Savings	-7.24E+08	3.39E+08	1.16E+09	1.76E+09
	Net Addt'l Fuel BTUs required	**-4.23E+09**	**-6.35E+08**	**5.19E+09**	**1.49E+10**
	Net Added Tons Coal Burned	**-148**	**-22**	**182**	**521**
	Performance Benefit+/Penalty-($)	**$11,073**	**$1,664**	**-$13,604**	**-$39,066**
WINTER	Addt'l. BTUs required	-7.28E+09	-4.27E+09	4.49E+06	6.59E+09
	Pump Energy Savings	-1.77E+09	3.39E+08	1.78E+08	7.99E+08
	Net Addt'l Fuel BTUs required	**-5.51E+09**	**-4.61E+09**	**-1.73E+08**	**5.79E+09**
	Net Added Tons Coal Burned	**-193**	**-161**	**-6**	**202**
	Performance Benefit+/Penalty-($)	**$14,428**	**$12,081**	**$454**	**-$15,164**

Note: Flows likely to Cause Frequent SPDES Permit dT Limit Exceedances Are Obscured

2. REFERENCES

Engineering News Record, Historical Cost Indices, 2010.

Heat Exchange Institute (HEI) Standards for Steam Surface Condensers, 10th Edition, 2006.

JM Burns, et al., "Accurate Condenser Performance Monitoring Guidelines Provided by New Condenser Test Code", EPRI Heat Rate Improvement Conf., 1994.

Burns JM, Burns DC, Burns JS, "Estimates Required to Achieve the Next Level of CWA 316(b) Compliance", IJPGC, Electric Power, 2004.

Cameron Hydraulic Data, Ingersoll Rand Co., 1974.

Greenidge Operating Data- Jan. 2007- Dec. 2009, AES, 2010.

Greenidge No. 4 Unit: Condenser & Auxiliaries, NYSEG, 1953.

Mosier, David. Coal cost figure, Heating value of coal. . ASA. Jan. 18, 2010.

New York State Department of Environmental Conservation SPDES Permit NY-0001325. Feb. 1, 2010.

Google. Maps and photos in plant vicinity- March 2010.

General Electric. "Heat Balances for New York State Electric & Gas Corporation Greenidge Station Unit No. 4 Dresden, New York." 1987.

APPENDIX E

Operational Data Summary

Hourly operational datasets for net generation, cooling water intake and discharge temperatures, and cooling water flow are available for 2007 through 2009. Daily values for generation and temperature are available for 2005 and 2006, and for flow from Sep 2005 through 2006. Flow values are monthly averages for Jan 2005 through Aug 2005. All flow and generation values in the following table represent AES Greenidge Unit 3 and Unit 4 combined.

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
1-Jan-05	59				94				45				48				3			
2-Jan-05	74				94				45				48				3			
3-Jan-05	74				94				46				50				4			
4-Jan-05	66				94				46				49				3			
5-Jan-05	90				94				45				50				5			
6-Jan-05	97				94				43				49				6			
7-Jan-05	79				94				43				47				4			
8-Jan-05	93				94				42				48				6			
9-Jan-05	83				94				43				48				5			
10-Jan-05	75				94				44				47				3			
11-Jan-05	88				94				44				49				5			
12-Jan-05	93				94				43				49				6			
13-Jan-05	87				94				45				50				5			
14-Jan-05	76				94				45				49				4			
15-Jan-05	25				94				42				47				5			
16-Jan-05	0				94				42				45				3			
17-Jan-05	0				94				42				49				7			
18-Jan-05	134				94				41				51				10			
19-Jan-05	140				94				39				50				11			
20-Jan-05	151				94				42				52				10			
21-Jan-05	142				94				42				51				9			
22-Jan-05	135				94				39				47				8			
23-Jan-05	115				94				39				47				8			
24-Jan-05	142				94				40				50				10			
25-Jan-05	139				94				42				52				10			
26-Jan-05	137				94				41				51				10			
27-Jan-05	144				94				40				50				10			
28-Jan-05	127				94				41				50				9			
29-Jan-05	9				94				39				42				3			
30-Jan-05	93				94				42				48				6			
31-Jan-05	130				94				42				52				10			
1-Feb-05	134				92				42				51				9			
2-Feb-05	143				92				42				52				10			
3-Feb-05	134				92				42				51				9			
4-Feb-05	63				92				43				45				2			
5-Feb-05	66				92				42				46				4			
6-Feb-05	70				92				43				46				3			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
7-Feb-05	55				92				43				45				2			
8-Feb-05	63				92				44				46				2			
9-Feb-05	68				92				43				46				3			
10-Feb-05	87				92				42				47				5			
11-Feb-05	78				92				41				45				4			
12-Feb-05	86				92				42				47				5			
13-Feb-05	65				92				41				44				3			
14-Feb-05	88				92				41				46				5			
15-Feb-05	69				92				43				46				3			
16-Feb-05	76				92				43				46				3			
17-Feb-05	86				92				42				47				5			
18-Feb-05	96				92				41				47				6			
19-Feb-05	105				92				41				48				7			
20-Feb-05	97				92				41				47				6			
21-Feb-05	95				92				41				46				5			
22-Feb-05	91				92				43				48				5			
23-Feb-05	93				92				43				48				5			
24-Feb-05	101				92				42				48				6			
25-Feb-05	105				92				42				48				6			
26-Feb-05	97				92				42				48				6			
27-Feb-05	91				92				41				46				5			
28-Feb-05	96				92				41				46				5			
1-Mar-05	95				94				41				46				5			
2-Mar-05	100				94				41				48				7			
3-Mar-05	102				94				41				48				7			
4-Mar-05	105				94				43				49				6			
5-Mar-05	106				94				42				49				7			
6-Mar-05	86				94				43				48				5			
7-Mar-05	91				94				44				49				5			
8-Mar-05	99				94				41				48				7			
9-Mar-05	64				94				40				42				2			
10-Mar-05	145				94				43				52				9			
11-Mar-05	132				94				43				51				8			
12-Mar-05	41				94				43				44				1			
13-Mar-05	98				94				43				49				6			
14-Mar-05	136				94				44				53				9			
15-Mar-05	133				94				44				53				9			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
16-Mar-05	131				94				45				53				8			
17-Mar-05	123				94				45				53				8			
18-Mar-05	138				94				44				53				9			
19-Mar-05	97				94				45				48				3			
20-Mar-05	90				94				44				48				4			
21-Mar-05	98				94				45				51				6			
22-Mar-05	102				94				44				51				7			
23-Mar-05	108				94				44				51				7			
24-Mar-05	110				94				43				50				7			
25-Mar-05	92				94				44				49				5			
26-Mar-05	1				94				42				38				-4			
27-Mar-05	51				94				44				45				1			
28-Mar-05	80				94				45				48				3			
29-Mar-05	92				94				44				49				5			
30-Mar-05	102				94				45				50				5			
31-Mar-05	103				94				45				51				6			
1-Apr-05	82				94				45				49				4			
2-Apr-05	95				94				45				51				6			
3-Apr-05	118				94				44				50				6			
4-Apr-05	156				94				44				55				11			
5-Apr-05	137				94				44				53				9			
6-Apr-05	146				94				46				56				10			
7-Apr-05	160				94				46				57				11			
8-Apr-05	135				94				46				55				9			
9-Apr-05	29				94				46				46				0			
10-Apr-05	42				94				46				48				2			
11-Apr-05	123				94				47				55				8			
12-Apr-05	115				94				47				53				6			
13-Apr-05	121				94				46				54				8			
14-Apr-05	87				94				46				50				4			
15-Apr-05	87				94				47				52				5			
16-Apr-05	92				94				47				53				6			
17-Apr-05	77				94				48				51				3			
18-Apr-05	90				94				49				54				5			
19-Apr-05	89				94				49				54				5			
20-Apr-05	90				94				46				51				5			
21-Apr-05	92				94				46				52				6			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
22-Apr-05	93				94				47				53				6			
23-Apr-05	91				94				48				53				5			
24-Apr-05	93				94				47				53				6			
25-Apr-05	92				94				46				51				5			
26-Apr-05	94				94				46				51				5			
27-Apr-05	86				94				47				51				4			
28-Apr-05	92				94				48				54				6			
29-Apr-05	76				94				48				52				4			
30-Apr-05	93				94				49				54				5			
1-May-05	88				94				49				53				4			
2-May-05	88				94				47				52				5			
3-May-05	79				94				47				51				4			
4-May-05	83				94				48				53				5			
5-May-05	58				94				49				52				3			
6-May-05	91				94				50				55				5			
7-May-05	89				94				50				55				5			
8-May-05	67				94				50				54				4			
9-May-05	92				94				52				57				5			
10-May-05	84				94				53				58				5			
11-May-05	102				94				51				57				6			
12-May-05	90				94				49				56				7			
13-May-05	88				94				52				58				6			
14-May-05	86				94				52				57				5			
15-May-05	78				94				51				55				4			
16-May-05	86				94				50				56				6			
17-May-05	89				94				51				57				6			
18-May-05	94				94				52				59				7			
19-May-05	101				94				54				61				7			
20-May-05	73				94				58				62				4			
21-May-05	1				94				61				54				-7			
22-May-05	66				94				56				59				3			
23-May-05	94				94				55				62				7			
24-May-05	78				94				55				60				5			
25-May-05	1				94				55				51				-4			
26-May-05	14				94				54				52				-2			
27-May-05	3				94				54				51				-3			
28-May-05	9				94				54				57				3			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
29-May-05	0				94				54				55				1			
30-May-05	0				94				55				57				2			
31-May-05	84				94				57				62				5			
1-Jun-05	79				95				60				64				4			
2-Jun-05	87				95				60				65				5			
3-Jun-05	82				95				58				63				5			
4-Jun-05	94				95				61				66				5			
5-Jun-05	93				95				66				70				4			
6-Jun-05	150				95				63				73				10			
7-Jun-05	143				95				64				73				9			
8-Jun-05	138				95				68				77				9			
9-Jun-05	155				95				68				78				10			
10-Jun-05	147				95				65				74				9			
11-Jun-05	162				95				70				82				12			
12-Jun-05	146				95				70				81				11			
13-Jun-05	155				95				72				82				10			
14-Jun-05	158				95				73				84				11			
15-Jun-05	112				95				72				79				7			
16-Jun-05	103				95				73				79				6			
17-Jun-05	108				95				72				79				7			
18-Jun-05	105				95				72				80				8			
19-Jun-05	79				95				72				77				5			
20-Jun-05	117				95				72				80				8			
21-Jun-05	117				95				73				81				8			
22-Jun-05	135				95				73				83				10			
23-Jun-05	131				95				72				82				10			
24-Jun-05	130				95				69				79				10			
25-Jun-05	142				95				72				81				9			
26-Jun-05	129				95				73				82				9			
27-Jun-05	148				95				77				88				11			
28-Jun-05	155				95				76				87				11			
29-Jun-05	152				95				75				86				11			
30-Jun-05	144				95				77				87				10			
1-Jul-05	147				81				78				87				9			
2-Jul-05	140				81				78				87				9			
3-Jul-05	130				81				77				86				9			
4-Jul-05	144				81				75				84				9			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
5-Jul-05	149				81				77				86				9			
6-Jul-05	139				81				77				86				9			
7-Jul-05	99				81				79				82				3			
8-Jul-05	106				81				79				82				3			
9-Jul-05	91				81				79				81				2			
10-Jul-05	114				81				79				84				5			
11-Jul-05	156				81				80				90				10			
12-Jul-05	164				81				81				92				11			
13-Jul-05	160				81				81				91				10			
14-Jul-05	160				81				81				90				9			
15-Jul-05	83				81				83				92				9			
16-Jul-05	52				81				84				94				10			
17-Jul-05	51				81				81				91				10			
18-Jul-05	154				81				83				93				10			
19-Jul-05	157				81				84				93				9			
20-Jul-05	155				81				86				95				9			
21-Jul-05	131				81				86				93				7			
22-Jul-05	145				81				85				93				8			
23-Jul-05	110				81				85				91				6			
24-Jul-05	149				81				84				93				9			
25-Jul-05	148				81				85				94				9			
26-Jul-05	150				81				85				93				8			
27-Jul-05	153				81				82				92				10			
28-Jul-05	139				81				83				92				9			
29-Jul-05	142				81				84				93				9			
30-Jul-05	161				81				85				97				12			
31-Jul-05	152				81				86				96				10			
1-Aug-05	153				83				86				95				9			
2-Aug-05	149				83				87				96				9			
3-Aug-05	158				83				88				98				10			
4-Aug-05	159				83				87				94				7			
5-Aug-05	158				83				87				91				4			
6-Aug-05	138				83				86				88				2			
7-Aug-05	115				83				86				84				-2			
8-Aug-05	134				83				86				85				-1			
9-Aug-05	129				83				86				82				-4			
10-Aug-05	118				83				85				79				-6			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
11-Aug-05	133				83				86				80				-6			
12-Aug-05	155				83				86				82				-4			
13-Aug-05	54				83				87				86				-1			
14-Aug-05	0				83				86				82				-4			
15-Aug-05	153				83				86				80				-6			
16-Aug-05	140				83				86				81				-5			
17-Aug-05	138				83				85				92				7			
18-Aug-05	144				83				84				94				10			
19-Aug-05	159				83				83				94				11			
20-Aug-05	145				83				80				90				10			
21-Aug-05	162				83				84				96				12			
22-Aug-05	153				83				83				93				10			
23-Aug-05	152				83				83				93				10			
24-Aug-05	147				83				82				92				10			
25-Aug-05	147				83				82				91				9			
26-Aug-05	158				83				81				92				11			
27-Aug-05	141				83				79				88				9			
28-Aug-05	145				83				79				88				9			
29-Aug-05	158				83				79				90				11			
30-Aug-05	161				83				80				90				10			
31-Aug-05	156				83				81				91				10			
1-Sep-05	146				96				80				90				10			
2-Sep-05	156				101				80				90				10			
3-Sep-05	154				101				80				90				10			
4-Sep-05	141				97				81				90				9			
5-Sep-05	143				92				79				89				10			
6-Sep-05	159				101				79				90				11			
7-Sep-05	152				101				79				89				10			
8-Sep-05	147				97				79				88				9			
9-Sep-05	119				79				79				87				8			
10-Sep-05	47				33				74				76				2			
11-Sep-05	90				33				71				82				11			
12-Sep-05	180				33				75				87				12			
13-Sep-05	125				33				77				91				14			
14-Sep-05	51				33				79				90				11			
15-Sep-05	54				33				79				91				12			
16-Sep-05	52				33				77				88				11			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
17-Sep-05	51				33				78				81				3			
18-Sep-05	49				33				77				80				3			
19-Sep-05	43				33				77				78				1			
20-Sep-05	40				69				76				77				1			
21-Sep-05	105				91				76				83				7			
22-Sep-05	133				101				77				85				8			
23-Sep-05	140				101				78				87				9			
24-Sep-05	138				101				76				86				10			
25-Sep-05	128				101				75				84				9			
26-Sep-05	64				53				75				78				3			
27-Sep-05	73				77				74				79				5			
28-Sep-05	130				96				74				82				8			
29-Sep-05	139				96				74				82				8			
30-Sep-05	136				101				72				80				8			
1-Oct-05	147				101				72				81				9			
2-Oct-05	148				101				73				82				9			
3-Oct-05	150				101				73				83				10			
4-Oct-05	148				101				73				83				10			
5-Oct-05	142				101				73				82				9			
6-Oct-05	109				101				73				81				8			
7-Oct-05	106				101				73				83				10			
8-Oct-05	79				101				68				71				3			
9-Oct-05	127				101				67				75				8			
10-Oct-05	140				101				69				78				9			
11-Oct-05	139				101				71				80				9			
12-Oct-05	143				101				70				79				9			
13-Oct-05	158				101				69				79				10			
14-Oct-05	161				101				70				81				11			
15-Oct-05	145				101				69				79				10			
16-Oct-05	45				33				65				68				3			
17-Oct-05	46				33				63				68				5			
18-Oct-05	48				33				63				66				3			
19-Oct-05	108				101				63				71				8			
20-Oct-05	131				101				64				72				8			
21-Oct-05	141				101				65				74				9			
22-Oct-05	139				101				64				73				9			
23-Oct-05	141				97				64				73				9			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
24-Oct-05	145				94				64				74				10			
25-Oct-05	150				94				61				73				12			
26-Oct-05	132				97				59				68				9			
27-Oct-05	129				101				58				66				8			
28-Oct-05	115				101				59				65				6			
29-Oct-05	45				101				57				60				3			
30-Oct-05	80				101				59				63				4			
31-Oct-05	51				101				58				61				3			
1-Nov-05	62				101				59				63				4			
2-Nov-05	52				96				58				62				4			
3-Nov-05	102				97				59				66				7			
4-Nov-05	157				101				61				70				9			
5-Nov-05	124				101				61				67				6			
6-Nov-05	113				101				61				67				6			
7-Nov-05	134				101				60				68				8			
8-Nov-05	113				101				60				66				6			
9-Nov-05	132				101				59				67				8			
10-Nov-05	130				101				57				65				8			
11-Nov-05	102				101				57				62				5			
12-Nov-05	39				101				56				56				0			
13-Nov-05	38				101				56				56				0			
14-Nov-05	56				101				56				58				2			
15-Nov-05	136				101				57				65				8			
16-Nov-05	137				101				58				65				7			
17-Nov-05	121				101				56				62				6			
18-Nov-05	142				101				55				63				8			
19-Nov-05	122				101				53				59				6			
20-Nov-05	105				101				55				59				4			
21-Nov-05	123				101				56				62				6			
22-Nov-05	134				101				54				62				8			
23-Nov-05	142				101				52				61				9			
24-Nov-05	140				101				51				58				7			
25-Nov-05	116				101				50				56				6			
26-Nov-05	49				100				45				48				3			
27-Nov-05	137				94				49				57				8			
28-Nov-05	133				94				51				60				9			
29-Nov-05	110				94				54				59				5			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
30-Nov-05	127				94				54				62				8			
1-Dec-05	128				94				52				60				8			
2-Dec-05	98				94				51				57				6			
3-Dec-05	40				94				47				49				2			
4-Dec-05	128				94				49				57				8			
5-Dec-05	134				94				50				59				9			
6-Dec-05	137				94				49				59				10			
7-Dec-05	141				94				48				58				10			
8-Dec-05	151				94				48				58				10			
9-Dec-05	149				94				46				56				10			
10-Dec-05	126				94				47				54				7			
11-Dec-05	152				94				44				54				10			
12-Dec-05	100				94				47				57				10			
13-Dec-05	156				94				48				59				11			
14-Dec-05	156				94				47				58				11			
15-Dec-05	155				94				43				54				11			
16-Dec-05	153				94				47				57				10			
17-Dec-05	153				94				48				59				11			
18-Dec-05	152				94				49				58				9			
19-Dec-05	148				94				47				57				10			
20-Dec-05	142				94				47				55				8			
21-Dec-05	150				94				47				57				10			
22-Dec-05	153				94				47				57				10			
23-Dec-05	145				94				44				53				9			
24-Dec-05	133				94				49				56				7			
25-Dec-05	129				94				50				56				6			
26-Dec-05	120				94				48				54				6			
27-Dec-05	141				94				46				55				9			
28-Dec-05	123				94				47				53				6			
29-Dec-05	121				94				48				53				5			
30-Dec-05	116				94				46				51				5			
31-Dec-05	70				94				47				53				6			
1-Jan-06					94				47				53				6			
2-Jan-06					94				47				53				6			
3-Jan-06	0				94				47				56				9			
4-Jan-06	123				94				48				56				8			
5-Jan-06	141				94				48				56				8			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
6-Jan-06	146				94				46				53				7			
7-Jan-06	145				94				45				47				2			
8-Jan-06	120				94				45				45				0			
9-Jan-06	48				94				44				44				0			
10-Jan-06	34				94				47				53				6			
11-Jan-06	38				94				48				54				6			
12-Jan-06	117				94				50				55				5			
13-Jan-06	137				94				49				49				0			
14-Jan-06	129				94				47				47				0			
15-Jan-06	61				94				42				44				2			
16-Jan-06	12				94				43				49				6			
17-Jan-06	43				94				45				55				10			
18-Jan-06	87				94				46				53				7			
19-Jan-06	146				94				47				53				6			
20-Jan-06	133				94				49				53				4			
21-Jan-06	134				94				48				52				4			
22-Jan-06	122				94				49				54				5			
23-Jan-06	113				94				49				53				4			
24-Jan-06	124				94				48				52				4			
25-Jan-06	120				94				46				52				6			
26-Jan-06	114				94				44				50				6			
27-Jan-06	128				94				47				53				6			
28-Jan-06	127				94				48				49				1			
29-Jan-06	128				67				48				55				7			
30-Jan-06	96				61				50				57				7			
31-Jan-06	95				61				46				55				9			
1-Feb-06	92				61				47				55				8			
2-Feb-06	100				61				49				57				8			
3-Feb-06	100				61				49				56				7			
4-Feb-06	98				61				49				57				8			
5-Feb-06	96				84				51				55				4			
6-Feb-06	95				94				45				50				5			
7-Feb-06	98				94				44				49				5			
8-Feb-06	112				94				45				51				6			
9-Feb-06	119				94				44				51				7			
10-Feb-06	129				94				45				53				8			
11-Feb-06	131				94				45				52				7			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
12-Feb-06	140				94				44				49				5			
13-Feb-06	136				94				45				52				7			
14-Feb-06	129				94				48				54				6			
15-Feb-06	132				94				49				53				4			
16-Feb-06	133				73				48				53				5			
17-Feb-06	123				65				47				54				7			
18-Feb-06	93				94				44				50				6			
19-Feb-06	98				94				42				50				8			
20-Feb-06	127				94				45				52				7			
21-Feb-06	136				94				46				54				8			
22-Feb-06	118				94				48				54				6			
23-Feb-06	138				94				48				54				6			
24-Feb-06	133				94				46				52				6			
25-Feb-06	133				94				45				52				7			
26-Feb-06	125				94				45				51				6			
27-Feb-06	131				94				45				53				8			
28-Feb-06	132				94				45				52				7			
1-Mar-06	141				94				46				53				7			
2-Mar-06	139				94				46				53				7			
3-Mar-06	140				94				44				52				8			
4-Mar-06	140				94				45				51				6			
5-Mar-06	139				94				46				51				5			
6-Mar-06	126				94				47				53				6			
7-Mar-06	120				94				46				53				7			
8-Mar-06	130				94				47				52				5			
9-Mar-06	134				94				45				44				-1			
10-Mar-06	116				94				48				51				3			
11-Mar-06	40				71				49				54				5			
12-Mar-06	96				61				50				57				7			
13-Mar-06	95				61				52				57				5			
14-Mar-06	91				61				49				54				5			
15-Mar-06	86				61				46				53				7			
16-Mar-06	80				61				44				51				7			
17-Mar-06	92				61				45				52				7			
18-Mar-06	83				61				44				52				8			
19-Mar-06	89				68				44				51				7			
20-Mar-06	90				94				44				50				6			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
21-Mar-06	96				94				45				53				8			
22-Mar-06	126				94				45				53				8			
23-Mar-06	145				94				47				54				7			
24-Mar-06	143				94				48				54				6			
25-Mar-06	138				94				48				53				5			
26-Mar-06	129				94				48				52				4			
27-Mar-06	124				94				48				54				6			
28-Mar-06	118				94				50				55				5			
29-Mar-06	132				94				50				57				7			
30-Mar-06	130				94				50				58				8			
31-Mar-06	131				94				51				58				7			
1-Apr-06	136				94				50				56				6			
2-Apr-06	129				94				48				53				5			
3-Apr-06	127				94				49				57				8			
4-Apr-06	109				94				48				57				9			
5-Apr-06	139				94				47				56				9			
6-Apr-06	142				94				47				56				9			
7-Apr-06	146				94				48				56				8			
8-Apr-06	145				94				46				54				8			
9-Apr-06	144				94				48				54				6			
10-Apr-06	143				94				49				56				7			
11-Apr-06	120				94				49				55				6			
12-Apr-06	134				94				51				59				8			
13-Apr-06	128				94				49				56				7			
14-Apr-06	142				94				49				54				5			
15-Apr-06	135				94				51				54				3			
16-Apr-06	112				94				50				53				3			
17-Apr-06	105				94				50				51				1			
18-Apr-06	15				94				51				54				3			
19-Apr-06	0				94				53				60				7			
20-Apr-06	72				94				54				61				7			
21-Apr-06	133				94				54				62				8			
22-Apr-06	134				94				50				57				7			
23-Apr-06	137				94				48				54				6			
24-Apr-06	133				94				51				57				6			
25-Apr-06	126				94				51				56				5			
26-Apr-06	130				94				49				50				1			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
27-Apr-06	93				94				50				50				0			
28-Apr-06	41				94				50				55				5			
29-Apr-06	48				94				52				60				8			
30-Apr-06	91				94				54				62				8			
1-May-06	132				94				55				63				8			
2-May-06	136				94				56				62				6			
3-May-06	133				94				56				62				6			
4-May-06	118				94				56				62				6			
5-May-06	124				94				57				63				6			
6-May-06	119				90				55				58				3			
7-May-06	116				78				54				57				3			
8-May-06	90				78				55				60				5			
9-May-06	72				78				56				61				5			
10-May-06	89				78				57				62				5			
11-May-06	96				74				58				63				5			
12-May-06	97				61				55				64				9			
13-May-06	99				61				57				63				6			
14-May-06	94				61				57				65				8			
15-May-06	80				61				57				65				8			
16-May-06	92				73				56				61				5			
17-May-06	92				66				55				61				6			
18-May-06	90				61				56				62				6			
19-May-06	84				61				57				64				7			
20-May-06	82				61				58				65				7			
21-May-06	85				61				57				63				6			
22-May-06	87				63				54				63				9			
23-May-06	76				71				56				61				5			
24-May-06	88				61				57				64				7			
25-May-06	86				61				56				64				8			
26-May-06	86				61				54				61				7			
27-May-06	90				61				56				62				6			
28-May-06	92				61				58				66				8			
29-May-06	87				61				59				66				7			
30-May-06	93				79				60				64				4			
31-May-06	85				94				62				69				7			
1-Jun-06	101				94				62				69				7			
2-Jun-06	139				94				66				73				7			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
3-Jun-06	124				94				66				73				7			
4-Jun-06	125				94				64				69				5			
5-Jun-06	113				94				63				70				7			
6-Jun-06	97				94				64				70				6			
7-Jun-06	126				94				64				71				7			
8-Jun-06	121				94				63				69				6			
9-Jun-06	125				94				64				70				6			
10-Jun-06	124				64				62				68				6			
11-Jun-06	116				61				61				66				5			
12-Jun-06	78				61				61				68				7			
13-Jun-06	66				75				63				67				4			
14-Jun-06	83				78				64				68				4			
15-Jun-06	88				82				67				71				4			
16-Jun-06	88				94				68				74				6			
17-Jun-06	88				94				67				73				6			
18-Jun-06	122				94				68				74				6			
19-Jun-06	120				94				67				75				8			
20-Jun-06	128				94				69				75				6			
21-Jun-06	145				94				71				77				6			
22-Jun-06	127				94				72				79				7			
23-Jun-06	119				94				73				83				10			
24-Jun-06	131				94				76				85				9			
25-Jun-06	152				94				78				86				8			
26-Jun-06	144				94				77				86				9			
27-Jun-06	136				98				75				83				8			
28-Jun-06	141				101				73				79				6			
29-Jun-06	138				101				76				82				6			
30-Jun-06	131				101				77				81				4			
1-Jul-06	130				101				77				81				4			
2-Jul-06	96				101				76				80				4			
3-Jul-06	102				101				78				82				4			
4-Jul-06	112				101				79				85				6			
5-Jul-06	116				101				79				84				5			
6-Jul-06	129				101				80				86				6			
7-Jul-06	110				101				80				86				6			
8-Jul-06	121				101				80				85				5			
9-Jul-06	122				101				77				83				6			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
10-Jul-06	111				101				77				83				6			
11-Jul-06	117				101				80				87				7			
12-Jul-06	128				101				79				86				7			
13-Jul-06	133				101				80				87				7			
14-Jul-06	128				101				82				89				7			
15-Jul-06	138				101				81				89				8			
16-Jul-06	132				101				83				91				8			
17-Jul-06	136				101				85				92				7			
18-Jul-06	133																			
19-Jul-06	140																			
20-Jul-06	137								86				92				6			
21-Jul-06	141								83				84				1			
22-Jul-06					83				85				92				7			
23-Jul-06					101				85				90				5			
24-Jul-06	120				101				84				91				7			
25-Jul-06	113				101				82				90				8			
26-Jul-06	127				101				82				89				7			
27-Jul-06	135				101				82				90				8			
28-Jul-06	138				101				83				90				7			
29-Jul-06	144				101				84				91				7			
30-Jul-06	131				101				86				93				7			
31-Jul-06	133				101				86				93				7			
1-Aug-06	131				101				87				95				8			
2-Aug-06	135				101				88				96				8			
3-Aug-06	147				101				90				96				6			
4-Aug-06	147				101				89				97				8			
5-Aug-06	128				101				88				96				8			
6-Aug-06	136				101				86				93				7			
7-Aug-06	132				101				83				91				8			
8-Aug-06	132				101				84				92				8			
9-Aug-06	136				101				83				90				7			
10-Aug-06	133				101				84				91				7			
11-Aug-06	126				101				85				91				6			
12-Aug-06	125				101				83				90				7			
13-Aug-06	120				101				83				89				6			
14-Aug-06	121				101				82				89				7			
15-Aug-06	119				101				83				90				7			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
16-Aug-06	125				101				82				88				6			
17-Aug-06	132				101				82				90				8			
18-Aug-06	123				101				82				91				9			
19-Aug-06	136				101				81				89				8			
20-Aug-06	144				101				82				90				8			
21-Aug-06	140				101				83				91				8			
22-Aug-06	138				101				82				90				8			
23-Aug-06	129				101				83				91				8			
24-Aug-06	132				101				82				92				10			
25-Aug-06	140				101				82				90				8			
26-Aug-06	146				101				82				89				7			
27-Aug-06	131				101				80				85				5			
28-Aug-06	127				101				80				88				8			
29-Aug-06	117				101				80				88				8			
30-Aug-06	136				101				79				84				5			
31-Aug-06	127				101				79				85				6			
1-Sep-06	111				86				78				81				3			
2-Sep-06	110				72				77				82				5			
3-Sep-06	85				68				74				81				7			
4-Sep-06	80				68				74				77				3			
5-Sep-06	97				88				73				76				3			
6-Sep-06	71				93				74				77				3			
7-Sep-06	87				85				74				69				-5			
8-Sep-06	90				85				74				76				2			
9-Sep-06	1				85				75				80				5			
10-Sep-06	80				85				76				81				5			
11-Sep-06	101				85				74				77				3			
12-Sep-06	99				97				73				75				2			
13-Sep-06	88				91				72				75				3			
14-Sep-06	84				85				73				75				2			
15-Sep-06	90				85				75				78				3			
16-Sep-06	83				85				74				76				2			
17-Sep-06	95				85				74				74				0			
18-Sep-06	77				85				75				77				2			
19-Sep-06	60				85				74				77				3			
20-Sep-06	91				85				73				76				3			
21-Sep-06	89				85				72				74				2			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
22-Sep-06	87				85				70				73				3			
23-Sep-06	81				85				71				74				3			
24-Sep-06	82				85				72				74				2			
25-Sep-06	90				85				72				75				3			
26-Sep-06	86				85				71				73				2			
27-Sep-06	85				85				70				73				3			
28-Sep-06	73				85				70				73				3			
29-Sep-06	83				84				69				69				0			
30-Sep-06	89																			
1-Oct-06	69				31				71				81				10			
2-Oct-06					10				71				82				11			
3-Oct-06					0				70				83				13			
4-Oct-06					0				69				83				14			
5-Oct-06					0				69				82				13			
6-Oct-06					0				68				81				13			
7-Oct-06					0				69				83				14			
8-Oct-06					0				68				71				3			
9-Oct-06					0				67				75				8			
10-Oct-06					0				58				78				20			
11-Oct-06					0				67				80				13			
12-Oct-06					0				67				79				12			
13-Oct-06					0				67				79				12			
14-Oct-06					0				67				81				14			
15-Oct-06					0				66				79				13			
16-Oct-06					0				64				68				4			
17-Oct-06					33				64				68				4			
18-Oct-06	21				33				63				66				3			
19-Oct-06	10				33				62				71				9			
20-Oct-06	9				33				62				72				10			
21-Oct-06	34				33				62				74				12			
22-Oct-06	37				33				62				73				11			
23-Oct-06	33				33				62				73				11			
24-Oct-06	32				28				61				74				13			
25-Oct-06	44				33				60				73				13			
26-Oct-06	26				33				61				68				7			
27-Oct-06	37				33				60				66				6			
28-Oct-06	44				33				60				65				5			

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
29-Oct-06	40				33				57				60				3			
30-Oct-06	23				33				60				63				3			
31-Oct-06	22				33				59				61				2			
1-Nov-06	39				33				60				67				7			
2-Nov-06	36				33				59				66				7			
3-Nov-06	40				33				59				68				9			
4-Nov-06	42				33				58				68				10			
5-Nov-06	43				33				58				66				8			
6-Nov-06	34				33				58				65				7			
7-Nov-06	33				33				58				66				8			
8-Nov-06	33				33				57				63				6			
9-Nov-06	33				33				56				62				6			
10-Nov-06	31				33				55				61				6			
11-Nov-06	32				33				55				59				4			
12-Nov-06	32				33				56				63				7			
13-Nov-06	32				33				55				62				7			
14-Nov-06	31				33				54				63				9			
15-Nov-06	33				33				55				64				9			
16-Nov-06	32				33				55				64				9			
17-Nov-06	31				33				55				65				10			
18-Nov-06	32				33				55				64				9			
19-Nov-06	30				33				54				62				8			
20-Nov-06	31				33				54				60				6			
21-Nov-06	27				33				54				61				7			
22-Nov-06	24				47				54				63				9			
23-Nov-06	22				79				52				59				7			
24-Nov-06	21				79				52				59				7			
25-Nov-06	19								52				60				8			
26-Nov-06	20				60				50				57				7			
27-Nov-06					45				50				58				8			
28-Nov-06	16				79				51				59				8			
29-Nov-06	1				79				52				58				6			
30-Nov-06	21				79				51				57				6			
1-Dec-06	26				79															
2-Dec-06	12				69															
3-Dec-06	22				33															
4-Dec-06	19				33															

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
5-Dec-06	17				66															
6-Dec-06	0				79				39				40				1			
7-Dec-06	35				79				43				48				5			
8-Dec-06	42				79				44				52				8			
9-Dec-06	43				79				44				51				7			
10-Dec-06	91				79				46				49				3			
11-Dec-06	88				79				48				56				8			
12-Dec-06	47				79				49				55				6			
13-Dec-06	100				79				49				55				6			
14-Dec-06	90				79				52				56				4			
15-Dec-06	95				79				52				56				4			
16-Dec-06	103				79				49				58				9			
17-Dec-06	107				79				48				56				8			
18-Dec-06	117				79				50				59				9			
19-Dec-06	103				79				49				59				10			
20-Dec-06	121				79				48				59				11			
21-Dec-06	130				79				49				59				10			
22-Dec-06	147				79				48				57				9			
23-Dec-06	138				63				49				52				3			
24-Dec-06	127				62				48				51				3			
25-Dec-06	66				62				47				51				4			
26-Dec-06	56				62				47				51				4			
27-Dec-06	60				62				46				51				5			
28-Dec-06	62				62				46				52				6			
29-Dec-06	74				62				47				53				6			
30-Dec-06	89				62				46				50.7				4.7			
31-Dec-06	71				62				46				51.6				5.6			
1-Jan-07	82	50	99	22	45	37	45	2	47	45.4	49.3	1.2	58.9	53.6	63.5	3.7	12	7.5	14.4	2.9
2-Jan-07	80	50	98	22	45	44	45	0	46.9	45.7	49.7	1	59	54.2	62.8	3	12.2	7.5	15.9	3.1
3-Jan-07	47	0	51	10	45	43	45	1	46.2	45.3	46.8	0.5	53.7	47.6	54.5	1.4	7.5	1.3	8.2	1.4
4-Jan-07	0	0	0	0	45	44	45	0	45	43.6	46.5	0.8	44.5	43.3	46	0.7	-0.5	-0.7	-0.2	0.1
5-Jan-07	0	0	0	0	45	39	45	2	46.3	45.5	46.9	0.4	46	45.2	46.7	0.5	-0.3	-0.6	-0.1	0.1
6-Jan-07	0	0	0	0	45	42	45	1	47	46.1	48.4	0.7	46.7	45.8	48.2	0.8	-0.3	-0.7	0	0.2
7-Jan-07	27	0	98	37	45	45	45	0	45.8	44.9	46.8	0.7	49.7	44.8	60.8	5.6	3.9	-0.8	15	5.7
8-Jan-07	72	49	100	17	45	45	45	0	47.1	46	49.6	1.1	57.9	53.7	64.2	3.1	10.8	7	15	2.6
9-Jan-07	85	54	95	11	45	45	45	0	46.7	44.6	48.1	1	59.2	55.2	61.1	1.7	12.5	8.1	14.5	1.8
10-Jan-07	89	50	101	14	45	45	45	0	44.2	42.7	46.9	1.2	57.3	52.8	60.6	2	13.1	7.9	15	2.2

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
11-Jan-07	78	44	99	22	45	45	45	0	42.7	41.2	44.7	1.1	54.5	48	59.3	4.1	11.8	6.5	14.8	3.3
12-Jan-07	81	51	101	21	45	45	45	0	44.4	42.6	47	1.6	56.5	51.2	61.7	4	12	7.7	14.9	2.9
13-Jan-07	85	52	101	18	45	45	45	0	45	43.8	46.1	0.6	57.3	52.7	60.3	2.7	12.3	7.7	15.2	2.6
14-Jan-07	97	84	102	5	45	45	45	0	45.5	43.7	47.5	1.2	59.9	57.9	62	1.1	14.4	11.8	15.4	0.9
15-Jan-07	84	52	102	19	45	45	45	0	45.4	42.8	47.1	1	58	53	62	2.9	12.6	8	15.2	2.7
16-Jan-07	64	51	82	8	45	45	45	0	42.1	41.4	43	0.5	52	49.9	55.1	1.5	9.9	7.9	13.1	1.4
17-Jan-07	72	56	85	10	45	45	45	0	41.4	39.9	43.6	1.1	52.7	48.5	56	2	11.3	8.4	13.3	1.3
18-Jan-07	81	51	102	18	45	45	45	0	41.3	38.5	43.9	1.6	53.6	50.1	57	2.1	12.3	8.2	15	2.6
19-Jan-07	78	50	92	14	45	45	45	0	42	40.8	43.8	0.7	53.7	49.8	57.8	2.2	11.7	7.8	14	1.9
20-Jan-07	78	52	92	9	45	45	45	0	41	39.8	43.8	1.2	53.3	50.1	57.5	1.9	12.3	7.6	16.7	2
21-Jan-07	76	58	95	11	45	45	45	0	40.6	38.3	43.6	1.5	52.3	48.2	57.3	2.4	11.6	9.7	14.6	1.5
22-Jan-07	66	50	99	16	45	45	45	0	39.8	38.4	41.8	0.9	50.1	48	54.9	2.1	10.3	8.2	14.8	2.2
23-Jan-07	81	59	99	12	45	45	45	0	44.2	40.5	46.2	1.4	56.9	52	60.4	2.4	12.7	8	15.7	2
24-Jan-07	75	38	99	18	45	45	45	0	43.4	41.5	45	1.3	55.4	49.3	59.5	2.8	12.1	6.8	15.2	2.5
25-Jan-07	82	38	101	24	48	45	79	9	40.4	38.6	42.9	1.2	53	47.9	55.5	2.8	12.6	6	16.3	3.9
26-Jan-07	126	57	145	27	79	79	101	5	40.4	38.7	44.1	1.6	54.8	47.8	60	3.4	14.4	8.3	16.2	2.6
27-Jan-07	143	134	151	4	79	79	79	0	40.9	39	44.9	2.1	56.2	53.9	60.4	2	15.3	14.6	15.9	0.4
28-Jan-07	129	76	150	22	79	79	79	0	42.5	40.5	44.3	1.4	56.8	51.9	60	2	14.4	8.5	16.1	2.3
29-Jan-07	148	145	150	1	79	79	79	0	42.2	39.7	45.8	1.8	57.5	55.3	61	1.8	15.4	14.5	15.9	0.3
30-Jan-07	137	117	145	8	79	79	79	0	43.3	40.7	45.5	1.6	57.4	51.7	60	2.2	14.1	10.9	15.3	1.2
31-Jan-07	131	118	139	5	79	79	79	0	44.1	41.1	45.6	1.1	57.3	52.6	59.9	1.7	13.2	11.1	14.7	0.8
1-Feb-07	131	117	135	4	79	79	79	0	40.8	39.3	43	0.9	53.9	50.4	55.8	1.3	13	11	13.9	0.7
2-Feb-07	111	40	133	25	79	79	79	0	41.9	40.9	45	1	53.5	44	56.5	2.4	11.6	-0.1	13.8	2.9
3-Feb-07	44	24	47	5	79	79	79	0	40.4	39.3	43.6	1.1	40.2	39.1	43	1.1	-0.3	-0.6	0.1	0.2
4-Feb-07	94	23	138	40	79	79	79	0	40.4	38	45	1.7	50.5	38	59.1	6.8	10	-0.2	15.3	5.7
5-Feb-07	125	76	147	20	79	79	79	0	41.6	38.5	43.5	1.2	56.2	50.4	60.1	2.5	14.6	9.2	16.6	2.4
6-Feb-07	137	123	147	10	79	79	79	0	41.6	38.2	44.8	1.8	57.5	54	60.5	1.9	16	15.3	16.7	0.4
7-Feb-07	146	125	151	5	79	79	79	0	42	39.4	44	1.4	57.6	53.9	59.8	1.6	15.6	11.7	16.4	1.1
8-Feb-07	140	115	149	10	79	79	79	0	42.8	40.7	43.6	0.8	57.2	51.7	59	2.5	14.4	10	15.8	1.9
9-Feb-07	97	44	152	52	79	79	79	0	41.8	40.2	44.6	1.6	49.7	39.7	60.2	9.2	7.9	-0.7	16.5	8.2
10-Feb-07	43	24	92	18	79	79	79	0	39.9	38.8	41.5	0.7	41.3	38.8	50.9	3.9	1.4	-0.6	10.1	3.5
11-Feb-07	140	119	148	10	79	79	79	0	40.6	38.8	42.7	1.3	55.6	50.5	58.6	2.3	15	11.7	16.2	1.3
12-Feb-07	134	97	148	14	79	79	79	0	43.4	41.2	45.5	1.4	57.5	50.9	61	2.5	14.1	9	16.9	1.8
13-Feb-07	130	87	149	24	79	79	79	0	41.2	38.8	43.9	1.7	55.4	47.7	60.1	3.8	14.3	8.2	19.9	3.2
14-Feb-07	128	92	146	12	79	79	79	0	36.4	34.6	38.4	1.1	52.9	47.2	66.9	3.7	16.5	8.8	29.6	3.8
15-Feb-07	134	94	147	17	79	79	79	0	37.4	34.9	42.1	1.9	52.6	47	56.5	2.7	15.2	11.2	17	1.6
16-Feb-07	128	115	136	5	79	79	79	0	42	39.7	43.7	1.1	55.5	53	57.3	1.2	13.5	11.3	15.2	0.8

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
17-Feb-07	132	96	143	13	79	79	79	0	40.5	38.4	44.3	1.9	54.7	47.1	59.4	2.5	14.2	8.6	15.8	1.9
18-Feb-07	140	132	143	3	79	79	79	0	42.2	39.6	44.7	1.9	57.5	52.8	60.1	2	15.2	13.2	17.2	0.7
19-Feb-07	137	122	144	6	79	79	79	0	40.4	38.7	42.2	1.1	55.9	54.4	58.9	1.1	15.5	14.3	17.5	1
20-Feb-07	90	51	122	17	55	45	79	15	40.5	38.7	43.7	1.5	54.6	48.2	58.8	2.6	14.1	9	15.8	2.1
21-Feb-07	81	53	97	15	45	45	45	0	43.3	41.8	45	0.9	56.4	52.1	58.7	1.7	13	9.3	15.3	2.1
22-Feb-07	77	54	90	11	45	45	45	0	43	41.7	44.7	0.9	55.3	51.2	58.6	2.1	12.3	9	14.8	1.7
23-Feb-07	90	67	96	8	45	45	45	0	39.9	38.7	41.5	0.6	55.1	52.9	61.2	1.8	15.2	12.7	21.2	1.8
24-Feb-07	89	75	93	4	45	45	45	0	38.6	37.8	39.6	0.6	53.2	50.4	55.2	1.2	14.6	12.4	17	1.4
25-Feb-07	75	53	87	11	45	45	45	0	39.8	38.9	41.4	0.6	52.1	48.4	54.5	1.8	12.3	9	13.8	1.5
26-Feb-07	83	68	86	4	45	45	45	0	40.1	39.5	41.6	0.5	53.6	50.4	55.4	1.1	13.5	10.6	14.3	0.8
27-Feb-07	79	52	86	10	45	45	45	0	42.8	41.1	44.1	0.8	55.5	51.7	57.6	1.4	12.7	8.6	14.1	1.5
28-Feb-07	81	64	87	7	45	45	45	0	42.1	40.9	43.5	0.9	55	51.8	56.7	1.1	12.9	10.1	15.1	1.3
1-Mar-07	81	67	85	4	45	45	45	0	41.7	40.5	43.7	0.9	54.8	53.6	57.1	1	13.1	12.8	13.6	0.2
2-Mar-07	67	0	80	21	45	45	45	0	43.9	41.6	46.8	1.4	55.3	43.5	59.3	3.3	11.5	-0.3	13.5	3
3-Mar-07	0	0	0	0	45	45	45	0	41.3	38.3	44.2	1.4	41	38	43.6	1.4	-0.3	-0.7	0.1	0.2
4-Mar-07	75	0	98	30	45	45	45	0	40.2	38.1	42.9	1.4	51.9	38.6	58.3	5.9	11.7	0.5	15.8	4.7
5-Mar-07	97	77	102	5	45	45	45	0	40.9	38.5	42.9	1.5	56.4	51.5	58.2	1.8	15.5	13	17.7	1.1
6-Mar-07	90	74	100	9	45	45	45	0	37.9	36.8	40.9	0.8	52.8	49.7	56.5	2	14.9	12.5	18.1	1.6
7-Mar-07	92	70	96	7	45	45	45	0	39.4	37.8	40.9	1	54.1	49.8	56	1.5	14.7	11	15.7	1.1
8-Mar-07	96	70	103	9	45	45	45	0	39.2	38.2	43.4	1.1	54.6	50.2	59.2	2.1	15.4	11.6	16.8	1.5
9-Mar-07	99	80	102	5	45	45	45	0	40.3	38.2	43.1	1.3	56	53.8	59.1	1.2	15.7	12.1	16.7	0.9
10-Mar-07	59	0	103	51	45	45	45	0	40.7	39.8	42.3	0.7	50.3	40.2	57.3	7.4	9.6	-1.1	16.4	8
11-Mar-07	64	0	91	30	45	45	45	0	41	39.3	42.8	1.2	51	39.7	57	5.5	10	-0.6	14.3	4.8
12-Mar-07	96	84	102	5	45	45	45	0	43.3	40.9	46	1.6	58.5	55.1	62.1	2.3	15.2	13.3	16.3	0.9
13-Mar-07	67	0	102	41	45	45	45	0	44.9	42.6	48.1	1.8	55.5	43.9	63.3	6.9	10.7	-0.6	16.3	6.8
14-Mar-07	95	73	100	7	45	45	45	0	45.6	42.8	48.3	1.7	60.4	55.4	63.5	2.4	14.8	12.6	16	0.8
15-Mar-07	86	52	101	14	45	45	45	0	41.8	40.5	44.5	0.9	55.5	50.6	58.6	2.3	13.7	8.6	16.7	2.5
16-Mar-07	97	87	101	4	45	45	45	0	40.1	37.3	44.5	1.9	55.2	52	60.1	2.1	15.1	12.8	16.1	0.6
17-Mar-07	92	87	95	2	45	45	45	0	38.1	36.8	41.7	1.1	52.3	50.9	55.7	1	14.2	13.5	15.1	0.4
18-Mar-07	80	55	85	9	45	45	45	0	39.2	37.8	40.2	0.7	52.1	46.7	53.9	1.5	12.9	8.9	13.9	1.1
19-Mar-07	81	54	85	8	45	45	45	0	39.4	38.9	39.8	0.2	52.1	48.5	53.6	1.5	12.7	8.8	14	1.5
20-Mar-07	81	71	85	3	45	45	45	0	40.2	38.9	41.4	0.7	53.2	51.5	55	0.8	13.1	11.5	13.8	0.6
21-Mar-07	77	57	80	6	45	45	45	0	40.3	38.9	41.4	0.9	52.5	49.7	54.5	1.2	12.2	8.8	13.3	1
22-Mar-07	48	0	80	29	45	45	45	0	41.8	40.6	43.4	1	49.8	41.7	53.5	4.1	8	-0.5	12.4	4.7
23-Mar-07	0	0	0	0	45	45	45	0	41	39.7	42.3	0.8	40.7	39.6	42	0.8	-0.3	-0.8	0	0.3
24-Mar-07	47	0	99	44	45	45	45	0	41.4	39.2	43.5	1.4	48.7	39.1	58.6	8.4	7.3	-0.4	16.1	7
25-Mar-07	73	50	100	17	45	45	45	0	42.1	41.4	42.8	0.4	54	50.7	58.1	2.7	11.8	8.3	16.2	2.7

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
26-Mar-07	82	51	100	14	45	45	45	0	43.2	42.1	44.6	0.8	56.3	51.3	59.1	2.5	13.1	8.6	16	2.4
27-Mar-07	87	52	100	17	45	45	45	0	42.8	41.5	44.4	0.9	57	52.2	59.5	2.5	14.2	8.8	16.5	2.7
28-Mar-07	93	51	100	13	45	45	45	0	44	42.6	45.2	0.7	58.7	51.5	60.8	2.4	14.7	8.3	16.3	2.2
29-Mar-07	95	71	100	6	45	45	45	0	43.3	41.5	45.8	1.2	58.2	56.6	60.7	1.2	14.9	13.2	15.6	0.7
30-Mar-07	95	61	100	9	45	45	45	0	43	41.5	44.5	1.1	57.7	50.9	60.2	2	14.7	8.7	15.7	1.4
31-Mar-07	86	56	100	14	45	45	45	0	43.9	42.5	45.5	0.8	58	52.5	60.9	2	14	8.7	15.9	2
1-Apr-07	67	52	83	10	45	45	45	0	43.4	43.3	44.1	0.2	54.2	52	56.6	1.4	10.8	8.7	13.2	1.4
2-Apr-07	96	85	100	5	45	45	45	0	44.3	43.4	46.5	1	59.3	56.8	62.1	1.6	15	13.4	16.2	0.8
3-Apr-07	87	52	101	17	45	45	45	0	44.9	43	47.7	1.2	58.7	53.3	63	3.1	13.8	8.4	16.4	2.7
4-Apr-07	91	54	101	16	45	45	45	0	45.4	43.5	47.9	1.4	59.7	56.4	62.3	1.6	14.3	9.1	15.7	2
5-Apr-07	93	52	100	13	45	45	45	0	43.2	42	44.6	0.6	57.9	52.6	59.7	1.8	14.7	8.7	16.1	1.9
6-Apr-07	79	50	99	20	45	45	45	0	42	40.4	43.7	0.8	54.7	49.4	58.9	3.4	12.7	8.3	15.9	3
7-Apr-07	92	59	100	12	45	45	45	0	41.9	40.5	43.2	0.9	56.2	50.1	58.3	2.4	14.2	8.8	15.7	2
8-Apr-07	82	53	96	13	45	45	45	0	42.6	41.5	43.4	0.5	55.6	51.4	57.7	1.8	13	8.5	15.3	1.8
9-Apr-07	85	53	90	10	46	45	68	5	42.8	41.2	43.9	0.7	56.1	51.3	58.4	1.7	13.3	8.5	14.6	1.6
10-Apr-07	84	62	90	5	45	45	45	0	42.7	41.2	44.1	0.7	56.2	54.7	57.1	0.7	13.5	13	14.5	0.4
11-Apr-07	83	60	85	6	45	45	45	0	43.8	42.1	45.6	1.3	57	52	58.9	1.5	13.2	9.3	14	0.9
12-Apr-07	79	50	85	10	45	45	45	0	43.3	42.4	44.9	0.6	55.8	51.1	57.6	1.7	12.5	8.1	13.8	1.7
13-Apr-07	82	76	85	3	45	45	45	0	44.4	42.7	46.3	0.9	57.4	55.9	58.8	0.9	13	9.6	13.8	0.9
14-Apr-07	81	79	82	1	45	45	45	0	43.5	41.6	45.2	0.8	56.5	55	57.6	0.7	12.9	12.2	13.5	0.3
15-Apr-07	75	50	83	9	45	45	45	0	43.1	41.6	44.2	0.8	55.2	53.2	57.4	1.2	12.1	9	13.5	1.4
16-Apr-07	69	50	75	9	45	45	45	0	41	40.7	41.7	0.2	53.7	50.5	57.9	1.7	12.7	9.2	17.2	1.8
17-Apr-07	72	50	75	7	45	45	45	0	41.4	40.3	42.7	0.7	54	50.7	55.8	1.3	12.6	8.7	13.8	1.3
18-Apr-07	68	49	75	11	45	45	45	0	43	41.8	44.7	1	54.5	51.3	56.9	2	11.4	8.8	12.7	1.4
19-Apr-07	55	0	75	22	45	45	45	0	44	42.1	46.3	1.4	53.2	43.7	55.7	3.1	9.2	-0.5	12.5	3.4
20-Apr-07	0	0	0	0	45	45	45	0	43.5	41.7	45.2	1.2	43.1	41.3	44.9	1.1	-0.4	-0.9	0	0.2
21-Apr-07	0	0	0	0	45	45	45	0	44.5	43.2	46	0.9	44.1	42.6	45.5	0.9	-0.4	-0.9	0.1	0.2
22-Apr-07	32	0	75	29	45	45	45	0	45.5	43.5	49	1.7	50.7	43.2	60.7	6.7	5.2	-0.6	12.3	5.2
23-Apr-07	83	50	98	16	45	45	45	0	46.4	44.5	48.3	1.2	60.3	55.5	64.3	2.5	13.9	8.8	16.8	2.7
24-Apr-07	85	50	101	21	45	45	45	0	45.4	43	48.6	1.6	59.1	51.9	63.5	3.5	13.7	8.4	16.4	2.9
25-Apr-07	88	50	100	20	45	45	45	0	44.4	43.4	46.2	0.9	58.5	52.3	61.3	3.6	14.1	8.4	16.6	3.1
26-Apr-07	91	50	100	14	45	45	45	0	45.2	43.9	46.2	0.6	60	54.8	62.8	2.1	14.8	9.3	17.3	2.1
27-Apr-07	88	50	100	18	45	45	45	0	45.3	44.3	46.8	0.8	58.8	53	62	2.7	13.5	8.2	16.1	2.4
28-Apr-07	91	51	100	12	45	45	45	0	46.2	45.4	46.9	0.3	59.4	54.5	61.2	1.8	13.3	8.2	15.2	1.8
29-Apr-07	72	50	99	21	45	45	45	0	46.8	45.4	48.9	1.2	57.7	52.4	63.2	3.8	10.9	7	15.1	3.1
30-Apr-07	86	50	100	20	45	45	45	0	48.9	47.2	50.7	1	61.5	55.9	64.9	3.3	12.6	7.7	14.9	2.7
1-May-07	90	54	100	15	45	45	45	0	47	45.5	48	0.6	60.3	55.5	62.2	1.8	13.3	8.2	14.7	1.9

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
2-May-07	90	50	101	18	45	45	45	0	47	45.3	50.2	1.4	60.1	53.6	64.6	3.4	13.1	8	15.2	2.6
3-May-07	76	50	100	17	45	45	45	0	48.1	45.8	51	1.5	59.4	53.7	64.2	3.5	11.3	7.6	14.6	2.4
4-May-07	78	51	100	17	45	45	45	0	49.1	47.4	51.1	1.3	60.7	56	64.3	2.7	11.6	7.7	14.9	2.5
5-May-07	72	55	89	10	45	45	45	0	50.3	47.8	53.4	1.7	60.9	57	65.9	2.6	10.6	8	13.5	1.5
6-May-07	68	50	82	11	45	45	45	0	49.7	48.1	52.4	1.2	60.1	57	64.4	2.1	10.4	8	12.3	1.5
7-May-07	74	51	88	13	45	45	45	0	48.6	46.2	50.7	1.6	59.7	54.9	63.7	2.7	11.1	7.8	13	1.8
8-May-07	77	51	86	10	45	45	45	0	48.8	47.4	50.6	1	60.2	57.1	63.2	2	11.4	7.2	13.1	1.7
9-May-07	77	50	85	9	45	45	45	0	49.3	47.7	52.4	1.1	60.9	56.4	63.7	1.9	11.7	7.5	13.4	1.5
10-May-07	83	57	86	6	45	45	45	0	49.8	47.5	51.7	1.2	62.3	59.5	64	1.3	12.5	9.5	13.1	0.7
11-May-07	81	55	85	7	45	45	45	0	51	49.7	53	1	63.1	61.6	65.4	0.9	12	9.5	12.9	1
12-May-07	78	51	86	11	45	45	45	0	53.7	52.7	54.8	0.6	65	61.6	67.1	1.8	11.3	7.7	12.7	1.6
13-May-07	81	50	85	8	45	45	45	0	53.1	51.3	55.1	1.2	65.1	59	67.5	1.9	12	7.7	12.9	1.1
14-May-07	80	53	85	9	45	45	45	0	51	49	53.2	1.2	62.8	59.2	65.8	1.9	11.9	7.9	13.1	1.5
15-May-07	80	52	85	10	45	45	45	0	49.6	47.6	51.5	1.2	61.9	57.5	64.3	1.9	12.3	8.2	13.5	1.4
16-May-07	74	50	85	12	45	45	45	0	50.2	49	51.7	0.6	61.6	57.2	64.1	2.1	11.4	7.5	13.3	2
17-May-07	64	0	85	34	45	45	45	0	50.9	49.6	52.2	0.9	60.5	50.4	64.8	4.8	9.6	-0.6	13.2	4.9
18-May-07	0	0	0	0	45	45	45	0	52.2	49.2	55	2	51.3	49.1	53.6	1.7	-0.9	-1.7	0	0.5
19-May-07	0	0	0	0	45	45	45	0	55	52.9	57.3	1.7	54.2	52	56.9	1.7	-0.8	-1.8	0	0.5
20-May-07	0	0	0	0	45	45	45	0	57.1	56.5	57.6	0.4	55.4	54.7	56.1	0.4	-1.6	-2.2	-0.9	0.4
21-May-07	0	0	0	0	45	45	45	0	55.9	54.7	56.9	0.7	55	54.2	55.7	0.5	-0.9	-1.5	0	0.4
22-May-07	0	0	0	0	45	45	45	0	55.5	53.7	57.3	1.2	54.8	53.4	56	0.8	-0.7	-1.6	0.1	0.5
23-May-07	0	0	0	0	45	45	45	0	57.1	55.1	59.6	1.5	55.8	54.3	57.4	1	-1.3	-2.3	-0.5	0.6
24-May-07	0	0	0	0	4	0	45	13	57	49.4	68	5.3	55.3	49.2	63.4	4.2	-1.7	-4.6	-0.2	1.1
25-May-07	0	0	0	0	0	0	0	0	52.8	49	55.6	2	52.6	48.9	55.3	2.1	-0.2	-0.6	0.4	0.3
26-May-07	70	15	101	27	0	0	0	0	56.9	54.5	59.5	1.8	67.6	57.4	74.5	5.5	10.7	2.9	15.5	3.9
27-May-07	93	58	100	11	0	0	0	0	58.5	56.9	59.6	0.8	72.6	68.4	74.8	1.6	14.1	9.5	15.7	1.7
28-May-07	96	60	102	9	0	0	0	0	59	56.9	61.2	1.1	73.8	69.5	76.3	1.7	14.7	11	15.9	1.3
29-May-07	97	68	102	9	0	0	0	0	59.4	57.7	61.7	1.2	74.2	69.5	77.4	1.9	14.9	10.3	15.9	1.4
30-May-07	98	81	101	4	18	0	45	22	60.2	59	62.2	0.7	75.5	74.3	76.9	0.8	15.3	14.7	16.2	0.4
31-May-07	97	91	100	2	45	45	45	0	61.2	59.6	63.1	1	75.9	73.1	78	1.2	14.7	11.9	15.6	0.8
1-Jun-07	99	83	101	4	45	45	45	0	60.6	59.8	62.2	0.6	75.7	72.8	77.3	1.1	15	13	15.9	0.8
2-Jun-07	99	89	102	3	45	45	45	0	62.3	61.4	63.6	0.7	77.7	73.5	79.2	1.3	15.3	11.7	16.2	0.9
3-Jun-07	83	50	101	20	45	45	45	0	62.2	60.9	63.5	0.8	75.5	71.2	78.2	2.4	13.3	8.1	15.7	2.8
4-Jun-07	87	50	100	20	45	45	45	0	64.1	62.2	65.4	1	77.4	71	80.9	3.7	13.3	8.5	15.9	2.8
5-Jun-07	87	55	101	14	45	45	45	0	62.5	58.3	64.3	1.7	76.3	67.1	79.5	3.5	13.8	8.8	15.7	2
6-Jun-07	95	81	100	5	45	45	45	0	61.2	57.1	64.4	2.6	75.8	66.4	79.3	3.5	14.6	9.3	15.8	1.3
7-Jun-07	87	50	100	17	45	45	45	0	61.6	55	64.3	2.3	75.4	70.2	79.7	3.1	13.8	8.8	15.7	2.5

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
8-Jun-07	92	54	101	14	45	45	45	0	60.3	51.7	65	4.8	74.6	60.3	80.9	6.8	14.3	8.6	16.3	2.5
9-Jun-07	99	92	102	2	45	45	45	0	65.3	63.6	67.2	1.2	80.3	76.6	82.5	1.5	15	12.6	15.7	0.7
10-Jun-07	96	78	100	6	45	45	45	0	67	64.5	70.9	2.2	82.1	77.9	86.1	2.4	15.1	12.8	16.3	0.8
11-Jun-07	90	70	100	12	45	45	45	0	68.1	65.8	70.8	1.8	82.2	76	86.8	3.1	14.2	10.2	16.1	2
12-Jun-07	94	71	100	8	45	45	45	0	70	68.2	72	1.3	85.1	79.8	88.5	2.2	15.1	11.3	16.6	1.4
13-Jun-07	94	57	101	12	45	45	45	0	71.5	69.9	74	1.3	86.7	80	91	2.4	15.2	8.6	17	1.8
14-Jun-07	90	51	101	18	45	45	45	0	70.6	67.6	73.2	1.7	85	79.2	89.6	3.2	14.4	8.4	16.7	2.9
15-Jun-07	68	22	99	19	45	45	45	0	71.5	70.2	73.9	1.3	82.9	78.3	87	3.1	11.4	7.2	16.4	2.9
16-Jun-07	0	0	0	0	45	45	45	0	71.5	69.6	73.8	1.3	71.1	69.3	73.2	1.2	-0.3	-0.7	0.2	0.2
17-Jun-07	41	0	100	44	45	45	45	0	70.5	67.6	72.4	1.6	76.8	67.9	88.1	7.6	6.3	-0.6	16	7
18-Jun-07	94	75	101	9	45	45	45	0	72.8	71.2	74.7	1.2	88.4	85	91.2	1.7	15.5	12	16.8	1.4
19-Jun-07	83	53	99	14	45	45	45	0	72.1	71.4	73.6	0.5	85.7	80.6	89	2.3	13.5	8.9	16.8	2.3
20-Jun-07	95	75	100	6	45	45	45	0	71.5	70.1	72.5	0.7	87.3	83.7	89.2	1.4	15.8	11.9	17.1	1.3
21-Jun-07	86	54	99	17	45	45	45	0	71.3	70.5	72.4	0.6	84.3	80	87.3	2.1	13	7.6	16.7	2.5
22-Jun-07	81	55	100	16	45	45	45	0	69.6	68.5	71.1	0.7	81.4	76.7	84.9	2.2	11.9	7.1	15.2	2.3
23-Jun-07	86	50	101	19	45	45	45	0	69.5	67.8	71.1	1	80.9	75.4	84.3	3.2	11.3	7.1	13.6	2.6
24-Jun-07	84	50	102	22	45	45	45	0	68.1	65.6	70.7	1.8	79.2	72.9	83.7	4.1	11	6.7	13.4	2.7
25-Jun-07	100	83	105	4	45	45	45	0	68.6	67	71.3	1.3	82	78	86.5	2	13.4	10.4	15.4	1
26-Jun-07	100	97	102	1	45	45	45	0	68.1	66.4	70.9	1	81.3	79.1	84.2	1.3	13.2	10.9	14.4	0.7
27-Jun-07	100	88	103	3	58	45	68	12	69.3	68.4	70.1	0.5	82.5	81.4	83.5	0.5	13.2	12.2	14	0.4
28-Jun-07	94	50	101	17	68	68	68	0	69.8	67.8	72.5	1.7	82.4	79.4	86.7	2	12.6	7.7	14.6	1.6
29-Jun-07	84	50	100	21	68	68	68	0	72.8	71.1	75.2	1.3	84.4	79.2	88.7	3.5	11.6	7.6	13.8	2.3
30-Jun-07	93	66	100	11	68	68	68	0	73.7	72.1	75.4	1.1	86.4	81.3	90	2.6	12.7	8.3	14.6	1.9
1-Jul-07	89	63	100	12	68	68	68	0	73.4	72.5	74.6	0.5	85.8	81	88.4	2.1	12.3	8.3	14.5	2
2-Jul-07	83	51	101	18	68	68	68	0	71.3	69.1	73.1	1.1	82.9	77.9	86.9	3.1	11.6	7.4	13.9	2.4
3-Jul-07	90	63	100	12	68	68	68	0	70.2	68.4	72.9	1.4	82.1	76.4	86.8	3.1	11.8	7.5	14.2	1.9
4-Jul-07	76	50	100	19	68	68	68	0	68.1	66.8	70	0.9	78.4	75.1	82.5	2.1	10.3	6.5	13.9	2.5
5-Jul-07	94	56	100	12	68	68	68	0	68.6	65.9	70.8	1.7	81.2	73.9	84.3	2.9	12.6	6.9	13.8	1.7
6-Jul-07	97	72	101	7	68	68	68	0	69.5	67.7	71.1	1.2	82.4	80.3	84.2	1.2	12.8	9.2	13.6	1
7-Jul-07	90	50	101	17	68	68	68	0	71.1	69.4	73.4	1.3	83.2	77.1	86.8	3.1	12.1	7	13.8	2.2
8-Jul-07	84	50	99	16	68	68	68	0	71.5	70.5	72.3	0.6	82.8	77.8	85.4	2.4	11.3	6.7	13.4	2.2
9-Jul-07	92	79	100	7	68	68	68	0	71.3	70.4	72.7	0.5	83.5	81.4	85.8	1.2	12.2	10.5	13.4	0.8
10-Jul-07	89	83	99	5	68	68	68	0	73.2	71.6	74.9	1.2	86.8	83	90.4	2.4	13.6	11	16.1	1.7
11-Jul-07	81	51	86	8	68	68	68	0	72.8	71.9	73.5	0.4	83.8	80.4	85.1	1.1	11	7.4	12.1	1.1
12-Jul-07	65	1	86	25	68	68	68	0	72.1	70.8	73.2	0.8	81.3	71.9	84.1	2.7	9.2	-0.3	11.9	3
13-Jul-07	1	1	1	0	68	68	68	0	72.2	71.1	73.5	0.8	71.9	70.7	73.1	0.8	-0.4	-0.8	0.1	0.2
14-Jul-07	3	1	33	8	68	68	68	0	72.6	71.1	74	1	72.7	70.8	78.4	1.6	0	-0.6	5.4	1.2

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
15-Jul-07	42	36	44	2	68	68	68	0	74.1	72.7	75.8	1.2	80.6	78.3	82.3	1.1	6.5	5.2	7.1	0.4
16-Jul-07	44	41	63	5	68	68	68	0	74.5	73.2	75.9	1	81.2	79.7	83.1	1.2	6.7	6.1	7.5	0.4
17-Jul-07	97	78	103	6	68	68	68	0	74.8	73.7	75.7	0.6	88.2	85.6	90.4	1.4	13.5	10.8	15.1	1.1
18-Jul-07	87	1	103	33	68	68	68	0	75.1	73.6	77	1.1	87.5	74.5	91.9	4.3	12.4	-0.6	14.9	4.2
19-Jul-07	1	1	1	0	68	68	68	0	74	73.7	74.6	0.2	73.8	73.4	74.4	0.2	-0.2	-0.6	0.1	0.2
20-Jul-07	59	1	76	21	68	68	68	0	73.9	73.2	74.8	0.4	83.4	74	90.3	4.3	9.4	0.1	16.4	4.2
21-Jul-07	86	50	100	18	68	68	68	0	74.1	72.2	76.3	1.5	86.3	80	92.3	3.9	12.2	7.1	16.6	2.8
22-Jul-07	97	67	101	7	68	68	68	0	74.6	72.7	76.4	1.3	88.4	84.6	90	1.4	13.8	11.6	14.6	0.7
23-Jul-07	82	50	101	17	68	68	68	0	74.8	73.3	76.5	0.9	86.2	81.5	89.9	2.5	11.5	7.6	14.9	2.4
24-Jul-07	63	50	100	21	68	68	68	0	74.9	73.6	77	1.1	84.3	81.1	91.1	3.7	9.4	7.3	14.7	2.6
25-Jul-07	66	50	99	20	68	68	68	0	74.7	73	76.2	0.9	84	81	89.2	2.9	9.3	7.2	13.6	2.5
26-Jul-07	99	96	100	1	68	68	68	0	74.5	73	76.5	1.2	87.9	85.8	89.8	1.3	13.4	12.8	13.9	0.3
27-Jul-07	100	98	101	1	68	68	68	0	74.1	72.9	75	0.7	87.5	86.5	88.6	0.6	13.4	13	13.8	0.2
28-Jul-07	97	58	102	10	68	68	68	0	75.2	72.4	78.5	2.4	88.9	81.2	93.3	3.4	13.7	8.5	16.6	1.6
29-Jul-07	100	95	101	1	68	68	68	0	78.3	76.3	80.5	1.5	92.1	89.8	94.9	1.7	13.9	13.3	14.8	0.4
30-Jul-07	96	63	101	10	68	68	68	0	78.7	76.9	80.7	1.2	92	86.4	95	2	13.2	8.2	14.3	1.4
31-Jul-07	103	97	122	8	83	68	101	17	79.3	77.8	81.5	1.2	93.1	91.1	96	1.5	13.8	12.9	15.3	0.5
1-Aug-07	122	116	123	2	101	101	101	0	80.7	78.1	83.8	2	94.6	91.5	97.7	2.3	14	13.2	15	0.5
2-Aug-07	124	122	125	1	101	101	101	0	80.6	78.3	82.2	1.3	94.8	92.7	97.3	1.5	14.2	13.6	15.3	0.4
3-Aug-07	108	95	124	13	82	68	101	17	78.3	76.8	80.3	1.1	91.7	90.1	93.3	0.9	13.4	12.6	14.2	0.4
4-Aug-07	108	97	116	8	92	68	101	15	79.9	77.7	82.4	1.8	93.8	91.3	98.4	2.4	13.9	11.3	16.2	1
5-Aug-07	99	69	116	15	101	101	101	0	79.7	78.1	81	0.9	90.9	85.6	94.3	2.6	11.2	7.3	14.3	2
6-Aug-07	75	20	110	35	101	101	101	0	79.7	78.2	81.6	1.1	87.9	77.8	94.8	6	8.2	-0.6	13.4	5.1
7-Aug-07	106	102	119	4	101	101	101	0	79.1	77.9	80.6	0.8	90.7	89.3	92.3	0.9	11.6	10.7	12.2	0.4
8-Aug-07	128	116	133	5	101	101	101	0	79.6	77.2	82.2	1.9	91.1	88.4	95.1	2.1	11.6	10.9	13.5	0.5
9-Aug-07	117	97	132	14	101	101	101	0	80.8	79.7	82.2	0.7	92.3	90.8	94	0.8	11.5	10.7	13.3	0.6
10-Aug-07	91	23	108	23	101	101	101	0	80.2	79.1	81.6	0.5	90.8	78.5	93.6	3.5	10.5	-0.6	12.7	3.2
11-Aug-07	37	24	47	9	101	101	101	0	78.9	77.2	81.2	1.3	78.5	77	81	1.3	-0.4	-0.9	0	0.3
12-Aug-07	100	37	146	37	101	101	101	0	79.5	78.1	81.1	1	87.5	78.1	94.8	5.6	8	-0.7	13.8	5
13-Aug-07	132	77	147	25	101	101	101	0	80.2	78.1	82.5	1.6	92.4	85.6	96.9	3.9	12.2	6.9	14.7	2.7
14-Aug-07	131	90	145	17	101	101	101	0	78.8	77.8	79.8	0.5	91.3	86	93.2	1.8	12.4	7.2	14.1	1.7
15-Aug-07	128	78	143	19	101	101	101	0	78.7	76.9	80.6	1.3	90.6	85.3	93.6	2.5	11.9	7.5	13.3	1.7
16-Aug-07	120	45	143	31	101	101	101	0	78.3	76.6	80.4	1.2	89.1	77.8	93.4	4.3	10.8	-0.1	13.3	4.1
17-Aug-07	129	109	141	12	101	101	101	0	78	76.5	79.5	0.9	90.7	89.1	93.6	1.2	12.8	11.9	14.2	0.4
18-Aug-07	111	83	118	10	101	101	101	0	77.6	76.2	78.8	0.7	89.8	85.1	92.1	1.6	12.2	8	13.6	1.5
19-Aug-07	103	70	119	19	101	101	101	0	76.2	74.4	77.9	0.9	87.2	82.1	91.1	3.2	11.1	6.8	13.2	2.5
20-Aug-07	117	75	141	26	101	101	101	0	76.3	75.1	78.1	0.7	87.8	82.6	90.1	2	11.5	7	13.4	2.3

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
21-Aug-07	111	75	143	21	101	101	101	0	73.5	72.3	74.9	0.7	84.5	80.9	88.6	2.2	11	7.1	16.3	2.4
22-Aug-07	130	80	145	20	101	101	101	0	71.4	70.1	72.3	0.7	84.3	79.2	86.5	1.9	12.9	8	14.5	1.6
23-Aug-07	102	72	138	22	101	101	101	0	72.5	71.1	73.6	1	81.5	78.1	86	2.7	9	6.9	13.5	2.3
24-Aug-07	117	76	141	22	101	101	101	0	74.5	72.4	77.3	1.7	85.7	79.7	90	3.2	11.2	6.9	13	1.9
25-Aug-07	86	80	99	5	72	68	101	11	75.2	73.7	77.6	1.1	87.4	85.4	90.1	1.3	12.2	11.3	13.3	0.6
26-Aug-07	81	76	83	2	68	68	68	0	75.2	74	76.4	0.7	86.8	84.4	91.2	1.7	11.6	9.5	15.3	1.2
27-Aug-07	73	59	80	9	68	68	68	0	75.7	73.6	78	1.7	86.2	83.4	89.2	1.4	10.5	8.3	12.6	1.4
28-Aug-07	77	59	81	6	68	68	68	0	76.6	75.3	78	0.8	87.5	85.3	90	1.4	10.9	8.6	12.3	0.9
29-Aug-07	79	74	81	1	68	68	68	0	75.3	73.7	77.4	1.2	86.4	84.6	89.8	1.6	11.2	10	12.4	0.6
30-Aug-07	72	38	80	13	68	68	68	0	74.7	73.4	75.8	0.9	84.9	81.2	89	1.8	10.2	6	13.7	1.7
31-Aug-07	69	38	75	12	68	68	68	0	75.9	74.1	77.5	1	86.3	80.8	90.1	3	10.4	5.4	13.5	2.4
1-Sep-07	65	50	75	10	68	68	68	0	75.7	74.1	77.1	0.8	85.8	82.3	89.2	1.8	10.1	7.4	13.7	1.5
2-Sep-07	64	50	74	9	68	68	68	0	74.6	73.2	76.9	1	83.8	80.8	87.2	2.1	9.2	7.3	11.9	1.4
3-Sep-07	68	51	75	10	68	68	68	0	75.3	74	76.9	0.9	85	81.6	87.7	2	9.7	6.8	11.1	1.4
4-Sep-07	57	1	75	26	68	68	68	0	75.2	73.8	76.9	1	83.6	75.3	87.6	3.2	8.4	-0.8	11.3	3.7
5-Sep-07	1	1	1	0	68	68	68	0	74.5	73.3	75.5	0.7	74.1	73.1	75	0.5	-0.5	-1	-0.1	0.2
6-Sep-07	1	1	1	0	68	68	68	0	74.8	73.6	76.3	0.9	74.3	73.2	75.5	0.8	-0.5	-1.1	0.1	0.3
7-Sep-07	1	1	1	0	68	68	68	0	74.7	73.7	75.9	0.6	74.3	73.2	75.4	0.7	-0.4	-0.9	-0.1	0.2
8-Sep-07	1	1	1	0	68	68	68	0	73.9	73.4	74.9	0.4	73.4	72.8	74.1	0.4	-0.5	-0.8	0.2	0.3
9-Sep-07	1	1	18	4	68	68	68	0	73	72.2	74	0.5	72.9	72.1	73.5	0.4	-0.1	-0.6	1	0.4
10-Sep-07	97	50	101	11	68	68	68	0	75	72.1	77.7	1.8	88.5	79.6	92	2.8	13.4	6.8	16.3	1.9
11-Sep-07	97	84	98	3	68	68	68	0	74.7	73.8	75.7	0.6	87.9	86.9	89.3	0.7	13.2	12.4	13.6	0.3
12-Sep-07	77	50	95	17	58	45	68	12	74.1	73.1	75	0.6	84.7	81.5	87.8	2.1	10.6	7.2	12.8	2
13-Sep-07	92	74	99	9	45	45	45	0	72.9	71.1	74.8	1.1	85.4	82.3	88.9	2.2	12.6	9.6	15.5	1.6
14-Sep-07	91	50	99	16	45	45	45	0	73	72.1	74.1	0.6	85.4	80.7	88.8	2	12.4	7.5	15.5	2.1
15-Sep-07	88	54	99	15	49	45	68	9	72.1	70.2	74	1	84.5	78.4	88	2.5	12.4	7.2	14.7	2
16-Sep-07	78	49	98	21	68	68	68	0	70.1	68.2	71.8	1.1	81	75.8	85.1	3.5	10.9	6.9	13.4	2.8
17-Sep-07	86	55	95	14	68	68	68	0	70.1	68.4	71.6	1	82.2	77.8	87	2.3	12.1	7.5	16.8	2
18-Sep-07	42	1	96	40	68	68	68	0	70	69.4	70.7	0.4	75.9	69.5	83.2	5.5	5.8	-0.7	13.5	5.7
19-Sep-07	1	1	1	0	68	68	68	0	69.1	67.8	70.4	0.8	68.9	67.5	70.4	0.9	-0.3	-0.7	0.1	0.2
20-Sep-07	1	1	1	0	68	68	68	0	69.8	68.6	71	0.9	69.5	68.3	70.8	0.9	-0.3	-0.6	-0.1	0.1
21-Sep-07	1	1	6	1	68	68	68	0	70.7	69.2	72.6	1.1	70.5	69.1	72.2	1.2	-0.2	-0.6	1.3	0.4
22-Sep-07	72	34	99	24	68	68	68	0	72.3	70.8	74.3	1.2	82.2	75.5	87.6	4.2	9.9	4.2	14.6	3.1
23-Sep-07	87	50	100	19	68	68	68	0	71.6	70.2	72.8	0.8	83.9	77.9	88	2.9	12.3	7.7	16.3	2.4
24-Sep-07	90	50	101	18	68	68	68	0	71.1	69	73.4	1.4	83.4	77.8	88.3	3	12.3	7.4	14.9	2.3
25-Sep-07	88	50	102	19	68	68	68	0	71.6	70.2	73	0.9	83.1	78.6	86.1	2.4	11.5	7.3	13.4	2.3
26-Sep-07	94	50	101	14	68	68	68	0	72.2	70.5	73.9	1	84.3	78.3	86.6	2.4	12.2	6.8	13.3	1.8

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
27-Sep-07	98	87	101	3	68	68	68	0	72.9	71.5	75.1	1.2	85.9	84.3	89.2	1.4	13	12.1	14.9	0.5
28-Sep-07	93	69	101	11	68	68	68	0	72.6	71.1	74.6	0.9	84.9	79.2	87.5	2.2	12.3	7.4	13.9	2
29-Sep-07	88	50	101	18	68	68	68	0	71.8	70.8	73.2	0.7	83.9	78.7	86.3	2.4	12.1	7	13.6	2.1
30-Sep-07	82	50	101	22	68	68	68	0	70.4	69	71.3	0.7	81.5	76.9	85	2.9	11.2	7.1	14	2.7
1-Oct-07	87	50	100	20	68	68	68	0	69.5	68.4	70.4	0.6	81.3	76.6	83.8	2.5	11.8	6.9	13.9	2.5
2-Oct-07	88	53	101	15	68	68	68	0	68.1	67.4	68.7	0.4	80	75.8	81.6	1.6	11.9	7.6	13.7	1.8
3-Oct-07	79	49	103	22	68	68	68	0	68.3	67.1	69.3	0.8	78.7	74.1	82.1	3	10.4	6.7	12.8	2.4
4-Oct-07	78	50	101	21	68	68	68	0	69.9	68.2	71.5	1.1	80.1	75.7	84.4	3.5	10.3	6.7	13.4	2.6
5-Oct-07	92	59	101	12	68	68	68	0	70.6	69.4	72	0.7	82.8	78.2	85.9	2	12.2	7.5	14	1.7
6-Oct-07	97	94	100	2	68	68	68	0	70.6	69.6	72.1	0.7	83.5	82.4	85.6	0.9	12.8	11.8	13.9	0.4
7-Oct-07	91	52	101	15	68	68	68	0	71.1	70	72.5	0.5	83.3	77.9	85.8	2.1	12.3	7.3	13.7	1.8
8-Oct-07	91	52	100	17	68	68	68	0	71	69	73.5	1.5	82.7	76.5	86.1	3.2	11.7	7.4	13.3	2.1
9-Oct-07	96	76	101	7	68	68	68	0	72.1	71.2	73	0.6	84.9	82.6	86.8	0.9	12.8	10.4	13.9	0.9
10-Oct-07	95	53	102	13	68	68	68	0	71.2	69.9	72.3	0.7	84.4	78.7	87.5	2.2	13.2	7.7	15.7	1.9
11-Oct-07	89	50	100	17	68	68	68	0	69.9	69	70.8	0.5	82.5	78.9	85.7	1.7	12.6	8.7	14.9	1.7
12-Oct-07	91	55	102	13	68	68	68	0	66.5	65.1	69	1.1	79.5	74.3	84.3	2.3	12.9	8.1	18.1	2.2
13-Oct-07	86	50	101	21	68	68	68	0	65.4	64.4	67.2	0.9	76.7	71.3	80.1	3.2	11.3	6.8	13.5	2.6
14-Oct-07	95	52	100	12	68	68	68	0	66.5	65.9	67.2	0.4	79	73.6	80.4	1.7	12.5	7.4	13.5	1.5
15-Oct-07	91	55	101	16	68	68	68	0	65.9	65	66.7	0.5	77.9	73	79.6	2	12	7.5	14	1.9
16-Oct-07	93	52	99	13	68	68	68	0	66.2	65	67.6	0.9	78.7	72.9	81.3	2.4	12.5	7.4	16.1	2.1
17-Oct-07	92	50	101	15	68	68	68	0	66.1	65.1	67.4	0.6	77.8	73	79.7	2.2	11.7	7.3	13.3	1.8
18-Oct-07	92	52	100	14	68	68	68	0	66.2	65.8	66.8	0.3	78.1	73	79.1	1.7	11.8	7	13.2	1.6
19-Oct-07	90	52	99	13	68	68	68	0	66.3	65.6	67	0.4	77.9	73.2	80.5	2	11.6	6.9	13.8	1.8
20-Oct-07	79	50	100	22	68	68	68	0	65.9	65	67.1	0.5	76.2	72.3	79.2	2.7	10.2	6.1	13.2	2.8
21-Oct-07	79	50	100	23	68	68	68	0	64.5	63.3	65.3	0.7	74.8	69.9	78.6	3.2	10.3	6.2	13.5	2.8
22-Oct-07	87	50	99	17	68	68	68	0	64.9	64	66.3	0.8	75.9	71	78.7	2.4	11	6.5	12.7	2.1
23-Oct-07	90	51	99	15	68	68	68	0	65.9	65	66.9	0.5	77.6	72.6	80.8	2.3	11.7	6.3	14.7	2.3
24-Oct-07	91	51	100	14	68	68	68	0	65.6	64.9	66.3	0.4	77.7	73.1	80.8	1.9	12.2	7.2	14.8	2
25-Oct-07	86	50	99	18	68	68	68	0	65.3	63.5	67.2	1.1	77.3	71.1	83.5	3.5	12	6.8	16.9	2.8
26-Oct-07	75	51	96	20	68	68	68	0	63.1	62	64.3	0.7	73.8	70.2	78.3	2.7	10.8	6.7	16	3.2
27-Oct-07	87	51	97	14	68	68	68	0	63.4	62	64.8	0.9	75.2	72.1	78.3	1.5	11.8	9.6	16	1.3
28-Oct-07	89	52	95	11	68	68	68	0	62.4	60.9	64.4	1	74.4	72.4	80.1	2	12	9.4	16.6	1.4
29-Oct-07	87	52	96	14	68	68	68	0	61.7	60.7	63.1	0.8	72.8	67.3	75.1	2.1	11	6.6	12.5	1.8
30-Oct-07	87	52	95	13	68	68	68	0	62.2	60.8	63.8	0.9	74	68.7	80.8	2.9	11.9	7	17.1	2.4
31-Oct-07	81	50	94	16	68	68	68	0	61.4	60.1	62.3	0.6	72.4	67.9	75.8	2.1	11	7.1	15	2
1-Nov-07	84	50	93	13	68	68	68	0	62.3	60	63	0.8	73.2	68	75.6	2	10.9	7.2	13.6	1.5
2-Nov-07	90	81	94	3	68	68	68	0	61.6	60.7	62.5	0.5	73.1	71.3	74.9	0.9	11.5	9.1	13.8	1

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
3-Nov-07	91	88	93	1	68	68	68	0	61.1	59.9	62.6	0.8	73	71.4	76.8	1.3	11.9	10.9	14.3	0.8
4-Nov-07	89	89	91	0	68	68	68	0	60	59	60.8	0.6	72.4	71.8	73.1	0.4	12.4	12.1	12.8	0.2
5-Nov-07	87	82	89	2	68	68	68	0	58.3	57.7	58.9	0.4	71.2	70.3	71.7	0.4	12.9	12.5	13.3	0.2
6-Nov-07	81	51	89	13	68	68	68	0	59.5	58.7	60.2	0.4	71.7	67.8	73.5	1.7	12.2	8.7	13.6	1.6
7-Nov-07	83	52	88	9	68	68	68	0	58.4	57.6	59.9	0.6	70.8	67.2	72.7	1.4	12.4	8.5	14.3	1.4
8-Nov-07	84	78	86	2	68	68	68	0	56.6	55.1	57.8	0.9	69.1	67.6	70.4	0.8	12.6	10.8	13.3	0.5
9-Nov-07	75	1	89	22	68	68	68	0	56.5	54	58.6	1.4	68.1	53.7	71	4	11.6	-0.3	13.4	3
10-Nov-07	1	1	1	0	68	68	68	0	52.8	51	54.1	0.8	52.5	51.1	53.6	0.7	-0.3	-0.8	0.2	0.3
11-Nov-07	1	1	1	0	57	45	68	12	50.3	48.4	51.6	0.9	50.1	48	51.5	0.9	-0.2	-0.7	0.3	0.2
12-Nov-07	5	1	51	13	45	45	45	0	50.7	47.9	52.8	1.7	51.3	47.9	61.3	3.3	0.7	-0.4	8.5	2.2
13-Nov-07	88	50	96	14	45	45	45	0	57.4	53.8	59.1	1.3	71.4	62.6	74.9	3	14	8.3	18.4	2.4
14-Nov-07	84	50	102	22	45	45	45	0	55.8	54.2	57.7	1.2	68.6	64.6	71.8	2.3	12.8	8.1	15.7	3.1
15-Nov-07	82	49	99	15	45	45	45	0	56.9	55.1	57.7	0.6	69.5	63.3	72.5	2.4	12.6	7.7	15.1	2
16-Nov-07	77	49	95	20	45	45	45	0	53.8	52.8	55.2	0.7	66.6	61.3	70.9	3.2	12.7	7.6	17.3	3.5
17-Nov-07	73	51	93	17	45	45	45	0	53.9	53.1	54.9	0.5	65.1	61.2	68.8	2.8	11.2	7.6	14.3	2.5
18-Nov-07	83	67	86	4	45	45	45	0	53.3	52.4	54.7	0.5	66	62.3	67.3	1	12.6	9.2	13.9	0.9
19-Nov-07	93	62	101	10	45	45	45	0	52.9	51.2	54.8	1.3	67	65.3	69.4	0.9	14.1	11.1	15.4	1.3
20-Nov-07	90	55	100	16	45	45	45	0	52.5	50.8	54.2	1.3	66.4	59.8	69.2	3	13.9	8.7	15.8	2.1
21-Nov-07	97	88	99	3	45	45	45	0	54.3	53.3	55.3	0.6	69.1	67.3	70.5	0.8	14.8	13.2	16.1	0.6
22-Nov-07	92	62	100	10	45	45	45	0	53.7	51.2	55.6	1.5	68	64.6	70.4	1.8	14.3	9.7	16.1	1.6
23-Nov-07	95	64	100	8	45	45	45	0	50.9	50.2	52.6	0.7	65.8	61	68	1.3	14.9	10.6	15.6	1
24-Nov-07	75	50	101	23	45	45	45	0	49.5	47.3	51.6	1.5	61.1	55.6	66.9	4.3	11.7	8.1	15.5	3.2
25-Nov-07	92	62	100	11	45	45	45	0	50.7	49.6	51.7	0.5	64.8	60.9	66.4	1.6	14	10	15.5	1.6
26-Nov-07	97	86	100	3	45	45	45	0	49.4	47.6	51.3	1.1	64.1	62.9	65.8	0.8	14.7	13.8	15.4	0.5
27-Nov-07	92	77	98	6	45	45	45	0	51.3	50	51.9	0.4	65.5	61.6	66.9	1.4	14.2	10.8	15.4	1.2
28-Nov-07	90	72	94	5	45	45	45	0	49.2	47.9	51	0.7	62.8	60.5	64.4	0.9	13.6	9.5	15	1.2
29-Nov-07	86	52	92	10	45	45	45	0	48.2	46.4	50.3	1	61.4	57	63.8	1.8	13.2	9.5	15.1	1.4
30-Nov-07	85	64	92	8	45	45	45	0	47.1	44.7	49.7	1.4	60.2	55.9	63.6	1.9	13	9.5	14.3	1.3
1-Dec-07	88	70	92	6	45	45	45	0	45.8	44.3	47.1	0.8	61.4	58.1	66.5	2.7	15.6	12.7	21.7	2.9
2-Dec-07	89	68	92	5	45	45	45	0	42.5	41.4	44.3	0.9	57.7	55	59.7	1.2	15.1	11.5	18.3	1.6
3-Dec-07	86	71	90	5	45	45	45	0	43.6	42.4	45.3	0.8	57.7	53.2	59.8	1.5	14.2	10.8	16.4	1.3
4-Dec-07	84	60	89	8	48	45	68	8	43.3	41.9	44.5	0.7	56.9	52.2	61	1.6	13.6	9.9	16.9	1.3
5-Dec-07	87	78	89	3	45	45	45	0	44.9	43.8	46.6	0.8	57.8	54.1	59.7	1.2	12.9	10.1	13.6	0.8
6-Dec-07	83	67	90	9	45	45	45	0	44.3	42.6	45.5	0.9	56.8	53.2	58.8	1.9	12.5	10.2	13.8	1.2
7-Dec-07	89	80	94	4	45	45	45	0	40.9	39.5	43.7	1.3	54.5	53	56.8	1.1	13.6	12.4	14.6	0.6
8-Dec-07	81	52	91	15	45	45	45	0	43.5	40.9	46	1.9	55.8	49.7	59.3	3.7	12.4	8.5	14.3	2.1
9-Dec-07	89	74	92	4	45	45	45	0	46	45.4	47	0.4	59.2	57.8	60.2	0.7	13.2	12	14	0.5

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
10-Dec-07	87	86	89	1	45	45	45	0	46.3	45.8	46.9	0.3	59.1	58.4	60	0.4	12.7	12.3	13.2	0.2
11-Dec-07	82	65	88	6	45	45	45	0	46.1	45.1	46.6	0.5	58.5	56.2	59.7	1	12.4	10	13.5	1.1
12-Dec-07	85	56	90	9	45	45	45	0	46.4	44.9	48.2	1	59.3	55.3	61.2	1.3	12.9	8.3	14.2	1.4
13-Dec-07	88	73	92	4	45	45	45	0	44.6	43.2	46.2	1.2	58	55.5	59.3	1	13.5	11.9	14.3	0.6
14-Dec-07	73	50	83	11	45	45	45	0	45.1	43.5	46.8	1	56.5	52.1	59.2	2.2	11.4	8.2	12.9	1.5
15-Dec-07	72	66	77	3	45	45	45	0	43	41.2	44.1	0.7	54.1	52.5	56.4	1.1	11.2	8.7	12.4	0.9
16-Dec-07	66	1	80	23	45	45	45	0	40.3	39.4	41.6	0.6	51.3	41	53.8	3.3	11	-0.6	13.5	3.7
17-Dec-07	21	1	55	22	45	45	45	0	41.9	40.2	43.5	0.7	46.2	39.9	54.2	4.8	4.3	-0.3	10.7	4.1
18-Dec-07	73	60	82	7	45	45	45	0	43.4	42.2	44.6	0.6	55.6	52.9	57.7	1.1	12.2	9.2	14	1
19-Dec-07	77	72	85	5	45	45	45	0	40.8	39.2	45.2	1.5	53.2	51.4	56.5	1.5	12.5	11.3	14.2	0.8
20-Dec-07	78	52	91	15	45	45	45	0	43.2	41.2	44.6	0.6	55.9	52.4	58.2	2	12.7	9.2	14.5	1.8
21-Dec-07	89	80	92	3	45	45	45	0	41.8	39.8	43.5	1.1	55.6	51.9	57.7	1.4	13.8	11.6	14.7	0.6
22-Dec-07	86	69	91	6	45	45	45	0	42.7	40.2	44.2	1.4	55.6	51	57.9	2.2	12.9	10.4	14	1.2
23-Dec-07	83	59	89	7	45	45	45	0	44.6	43	46.7	1.1	57.7	53.2	60	1.6	13	9.8	14.1	1.1
24-Dec-07	65	53	77	6	45	45	45	0	44.4	42.8	46	0.9	55	53.1	57.8	1.2	10.6	8.6	11.9	1.1
25-Dec-07	70	54	77	7	45	45	45	0	44.4	42.9	45.3	0.6	55.5	53.6	57.2	1.1	11.1	9.2	12.3	1.2
26-Dec-07	88	61	113	12	56	45	79	16	45	44.2	46.5	0.7	58.1	54	60.5	1.5	13.1	9.4	14.3	1.1
27-Dec-07	98	20	122	29	79	79	79	0	45.5	43.7	46.6	0.8	57.7	45.4	61	3.9	12.2	-0.3	15.2	4.2
28-Dec-07	23	12	31	4	79	79	79	0	43.9	41	45.7	1.1	43.5	41.1	45.6	1	-0.4	-1	0.1	0.2
29-Dec-07	10	6	12	2	79	79	79	0	41.8	41.2	42.8	0.4	41.5	40.8	42.4	0.4	-0.3	-0.7	0	0.2
30-Dec-07	12	9	16	2	79	79	79	0	41.5	40.3	42.4	0.6	41.3	40.1	42.1	0.6	-0.2	-0.6	0	0.2
31-Dec-07	16	14	18	1	73	62	79	8	41.6	40.7	42.6	0.6	41.4	40.4	42.1	0.5	-0.3	-0.5	0.1	0.2
1-Jan-08	18	13	20	2	79	79	79	0	40.9	39.2	42.6	1.2	40.6	39.3	42.3	1.1	-0.3	-0.7	0.1	0.2
2-Jan-08	17	16	19	1	79	79	79	0	42.1	37.9	46.1	3	42	37.8	45.8	3.1	-0.1	-0.6	0.4	0.2
3-Jan-08	88	16	122	38	79	79	79	0	40.2	38	42.4	1.4	51	38.1	58.3	6.6	10.8	0.1	16	5.4
4-Jan-08	109	81	119	10	79	79	79	0	39.6	37.6	41.2	1.1	54.3	48.4	56.4	2	14.7	8.5	16.4	1.7
5-Jan-08	82	50	107	17	47	45	79	7	39.9	39.1	41	0.5	53	48	56.4	2.6	13.1	7.8	15.6	2.4
6-Jan-08	79	51	99	18	45	45	45	0	41.7	40.6	42.6	0.6	54	49.2	57.4	2.8	12.4	7.9	15.3	2.7
7-Jan-08	67	52	100	17	45	45	45	0	44.3	42.6	45.8	1.1	55	51.6	59	2.4	10.8	8.1	15.6	2.7
8-Jan-08	76	51	98	20	45	45	45	0	46.6	45.6	47.8	0.8	58.5	53.9	62.6	3.6	11.9	8.1	15.5	2.9
9-Jan-08	89	53	101	18	45	45	45	0	47.1	44.8	49.1	1.3	60.6	55	64.6	3.1	13.5	8	15.8	2.8
10-Jan-08	94	63	100	9	45	45	45	0	44.6	43.9	45.4	0.4	59.3	54.2	60.2	1.2	14.7	9	15.9	1.4
11-Jan-08	89	66	101	10	45	45	45	0	45.2	44.4	46.1	0.6	59.2	53	61.1	1.8	14	8.5	15.8	1.8
12-Jan-08	84	52	99	16	45	45	45	0	45.2	44.2	46.5	0.6	58.5	53.7	61	2.3	13.3	8.8	15.8	2.3
13-Jan-08	95	83	99	4	45	45	45	0	44	43.5	44.6	0.3	58.8	55.1	59.8	1.2	14.7	10.5	15.7	1.2
14-Jan-08	94	77	99	5	45	45	45	0	44	43.1	45.8	0.8	58.8	55.4	60.9	1.3	14.8	11.6	16	1
15-Jan-08	93	68	98	8	45	45	45	0	43.7	42.2	45.2	0.8	58.4	55.1	60.1	1.3	14.7	11.4	15.8	1.4

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
16-Jan-08	91	52	100	16	45	45	45	0	43.8	42.4	44.8	0.7	57.8	52.5	59.8	2.2	14	8.9	15.8	2.1
17-Jan-08	89	67	99	10	45	45	45	0	41.8	41	42.9	0.5	56	54.3	57.6	1.1	14.2	12.3	16.1	1.3
18-Jan-08	63	50	93	14	45	45	45	0	42.2	40.5	44	1	52.7	49.8	58.7	2.7	10.4	8.1	15.2	2.1
19-Jan-08	53	47	70	6	49	45	79	11	40.5	38.7	42.6	1.1	49.4	47.1	53.8	1.7	8.9	7.9	12.8	1
20-Jan-08	105	49	139	31	79	79	79	0	40.7	39.8	41.6	0.5	53	48.9	57.3	3.2	12.3	8.3	15.7	3
21-Jan-08	137	132	139	1	79	79	79	0	40.8	39.9	43.7	0.8	56.2	55.1	58.9	0.9	15.3	14.5	16	0.5
22-Jan-08	130	93	140	14	79	79	79	0	38.7	37	42.7	1.4	53.7	48	57.1	1.9	15	9.9	16	1.4
23-Jan-08	120	77	142	23	79	79	79	0	42.6	40.3	45.1	1.3	56.5	50.1	59.2	2.8	13.9	8.7	16.4	2.7
24-Jan-08	119	81	149	22	79	79	79	0	43.1	41	45	1.2	56.7	53.3	59.5	1.8	13.6	9.4	16.4	2.5
25-Jan-08	139	133	141	2	79	79	79	0	43.8	41.6	45.9	1.1	59.4	55.7	61.4	1.3	15.6	12.4	17	0.9
26-Jan-08	117	52	140	23	72	45	79	14	42	39.8	44.3	1.4	57.1	49.4	59.8	2.9	15.1	9.2	16.4	1.9
27-Jan-08	92	63	100	9	45	45	45	0	40.5	39.3	43.2	1.3	55.2	49.5	58.5	2.1	14.8	10	16.1	1.5
28-Jan-08	96	85	101	5	45	45	45	0	42.3	41.4	44.1	0.9	57.6	52.7	60.1	1.5	15.3	11.3	16.2	1.1
29-Jan-08	96	76	100	6	45	45	45	0	40.6	39.2	42.4	1.1	55.8	50.2	57.9	1.8	15.2	10.6	16.3	1.1
30-Jan-08	98	94	101	2	45	45	45	0	43.5	42	45.3	1.1	59.4	57.7	61.1	1.1	15.9	14.9	18.2	0.7
31-Jan-08	99	96	101	1	45	45	45	0	42.1	40.5	43.9	0.9	57.5	55.6	59.6	0.9	15.4	13.7	15.9	0.4
1-Feb-08	96	79	100	6	45	45	45	0	40.5	39.5	42.3	0.8	55.7	51	57.6	1.5	15.2	10.7	16.6	1.3
2-Feb-08	85	65	94	9	45	45	45	0	42.9	40.7	44.5	0.8	56.6	53.9	58.2	1.2	13.6	11.3	15.1	1.2
3-Feb-08	64	50	94	16	45	45	45	0	42.3	41.7	43.9	0.6	53	50.3	57.1	2.5	10.7	8.3	14.6	2.4
4-Feb-08	79	50	95	17	45	45	45	0	41.5	40.3	44.9	1.5	54.5	49.6	56.4	1.8	13	8.6	15.4	2.5
5-Feb-08	89	63	97	11	45	45	45	0	42.5	40.9	45.2	1.1	56.7	50.5	59.3	2.4	14.2	9.6	15.8	1.9
6-Feb-08	88	64	98	12	45	45	45	0	42.8	40.4	46.6	1.9	58.3	53.5	61.5	1.9	15.5	10.7	19.7	2.8
7-Feb-08	71	49	90	16	45	45	45	0	41.8	41.1	43.1	0.5	53.4	50	56.7	2.5	11.6	8.1	14.9	2.6
8-Feb-08	80	62	86	6	45	45	45	0	42.7	41.6	44	0.6	55.5	51.6	56.9	1.3	12.8	9.4	14	1.1
9-Feb-08	64	51	85	10	45	45	45	0	42.1	41.2	43.4	0.8	52.7	49.5	57	2	10.6	7.7	13.7	1.8
10-Feb-08	69	51	86	13	45	45	45	0	41	39.4	42.3	0.7	52.3	49	55.6	2	11.3	8.5	14.4	2.2
11-Feb-08	80	51	92	14	45	45	45	0	40	38.8	41.5	0.8	52.8	48.5	55	2.1	12.8	8.1	15.1	2.2
12-Feb-08	76	51	88	15	45	45	45	0	38.7	36.9	40.1	0.9	50.7	47.1	54.1	2	12	8.3	14.9	2.4
13-Feb-08	82	67	86	4	45	45	45	0	39.2	38.1	41.8	0.8	52.6	50.3	56	1.1	13.4	11.1	14.2	0.7
14-Feb-08	83	77	85	3	45	45	45	0	40.3	38.9	42.3	0.8	53.3	50.4	55.8	1.2	13	11.3	14.2	0.7
15-Feb-08	83	59	92	9	45	45	45	0	40	38.7	41.5	0.8	53.1	48.9	57.7	1.9	13	9.1	17.1	1.4
16-Feb-08	66	50	90	14	45	45	45	0	40.6	39.6	41.4	0.6	50.9	47.6	54.4	1.9	10.2	7.8	13.9	2
17-Feb-08	76	52	90	13	45	45	45	0	39.9	38.6	41	0.9	52.9	47.2	59.9	3.5	13	7.9	19.1	3.1
18-Feb-08	72	51	92	18	45	45	45	0	41.9	40.7	44.1	0.8	54.4	51.4	61.8	2.3	12.4	10.1	17.7	1.7
19-Feb-08	80	53	90	14	45	45	45	0	41.4	40.3	44.3	0.8	53.5	49.7	57.2	2	12.1	8.5	14.1	2.1
20-Feb-08	90	66	98	7	45	45	45	0	40.6	39.3	43.3	1.1	54	51.3	58.2	1.7	13.4	11.6	15.1	0.9
21-Feb-08	96	84	98	3	45	45	45	0	40.4	38.9	42.6	1.1	54.8	51.5	56.5	1.3	14.3	12.6	15	0.6

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
22-Feb-08	90	55	98	12	45	45	45	0	38.9	37.6	42.9	1.1	52.6	47.3	57	2	13.7	8.5	15	1.8
23-Feb-08	76	51	96	17	45	45	45	0	40	38.8	41.8	0.8	52	48.3	55.7	2.3	11.9	8	15.2	2.5
24-Feb-08	88	55	99	13	45	45	45	0	40.7	39.6	41.7	0.7	54	50.4	56	1.4	13.3	9.1	14.9	1.7
25-Feb-08	94	75	99	6	45	45	45	0	41.6	39.8	46.1	1.9	56	52	60.1	2	14.4	11.7	15.3	0.8
26-Feb-08	86	53	99	18	45	45	45	0	41.9	40	44.2	1	55.2	49.8	59.3	2.9	13.3	8.1	17.4	2.9
27-Feb-08	90	55	96	12	46	45	68	5	39.6	38.7	41.5	0.6	54.2	49.9	58.3	1.7	14.5	9.7	18.2	1.7
28-Feb-08	93	80	97	6	45	45	45	0	39.5	37.8	41.6	1	53.6	50.4	56.2	1.4	14.1	10.5	15.2	1.1
29-Feb-08	94	85	96	2	45	45	45	0	38.6	37.3	39.4	0.5	53.3	51.1	55.6	1	14.7	13	16.3	0.7
1-Mar-08	87	55	98	14	45	45	45	0	40.3	38	43.2	1.5	53.8	47.4	57.1	3.3	13.4	8.9	15.2	2.2
2-Mar-08	79	49	96	17	45	45	45	0	41.2	39.4	43.3	1	53.6	49	57.2	2.6	12.4	7.9	15	2.6
3-Mar-08	87	60	97	12	45	45	45	0	42.3	40.6	44.1	1.4	55.5	49.6	58.8	2.8	13.2	8.6	15	2.1
4-Mar-08	92	61	98	10	45	45	45	0	42.7	39.9	45.6	1.4	57	53.9	59.8	1.5	14.3	8.6	15.5	1.5
5-Mar-08	92	67	99	10	45	45	45	0	40.8	39.8	43.7	0.9	54.8	51.6	57.5	1.4	14	10.6	15.4	1.4
6-Mar-08	96	55	105	10	45	45	45	0	41.4	39.7	43.1	0.9	56	53.1	58	1.2	14.6	12.3	15.6	0.8
7-Mar-08	88	50	99	19	45	45	45	0	41.8	39.8	44.1	1	55.2	49.9	58.8	2.9	13.4	8	15.8	2.8
8-Mar-08	91	65	100	11	45	45	45	0	39.9	38.8	42.1	0.8	54.3	49.2	57.3	1.8	14.5	9.8	16	1.6
9-Mar-08	80	50	99	18	45	45	45	0	39.8	37.8	41.5	1	52.2	47.1	56.1	3	12.3	7.8	14.9	2.5
10-Mar-08	87	51	101	19	45	45	45	0	41	39.6	43.5	1.2	54.3	48.5	58.7	3	13.3	8.1	15.5	2.7
11-Mar-08	90	51	100	16	45	45	45	0	41.5	40.6	42.2	0.5	55	49.5	57.5	2.5	13.5	8.1	15.7	2.4
12-Mar-08	96	64	101	9	45	45	45	0	42.1	41.2	43.9	0.6	56.5	51.7	59.1	1.5	14.4	9.2	15.6	1.4
13-Mar-08	98	88	100	3	45	45	45	0	41.5	40.2	43.3	1	56.3	54.1	58	1	14.8	13.5	15.5	0.5
14-Mar-08	81	53	99	17	45	45	45	0	42.9	41.8	44	0.7	55.4	51.1	58	2.1	12.5	8.1	15	2.2
15-Mar-08	77	51	97	17	45	45	45	0	43	42.2	45.8	0.9	54.8	50.4	57.9	2.5	11.7	7.8	14.9	2.6
16-Mar-08	69	51	91	14	45	45	45	0	41.9	40.7	44.1	0.9	52.7	49.5	55.5	2.1	10.8	8.1	14	2.2
17-Mar-08	89	57	95	9	45	45	45	0	41.6	39.2	43.9	1.5	55.1	51.3	58.5	1.9	13.5	9.4	14.8	1.6
18-Mar-08	82	53	94	15	45	45	45	0	41.6	40.7	43.6	0.8	54.5	50.1	57.3	2.1	12.9	8.5	15.1	2.1
19-Mar-08	88	52	100	17	45	45	45	0	41.6	40.6	44.2	1.1	55	49.1	59.5	3.1	13.4	8.4	15.4	2.4
20-Mar-08	86	52	101	17	45	45	45	0	42.1	40.1	43.4	0.9	55.4	49.3	58.3	2.9	13.3	7.9	15.5	2.7
21-Mar-08	81	50	99	18	45	45	45	0	40.8	38.7	42.8	1.2	53.7	50.2	57.1	2.2	12.9	8.4	15.8	2.9
22-Mar-08	83	50	102	19	45	45	45	0	41.7	39.8	43.7	1	55	48.9	58.2	2.6	13.3	8.2	15.7	2.7
23-Mar-08	77	47	100	21	45	45	45	0	41.8	40.6	44.6	1	53.9	48.7	57.7	2.8	12.1	8.1	15.7	3.1
24-Mar-08	99	95	101	1	45	45	45	0	41.3	39.9	43.6	1.2	56.4	55	58.6	1.1	15.1	14.5	15.6	0.3
25-Mar-08	97	86	100	4	45	45	45	0	41.1	40	42.4	0.8	56	52	57.7	1.3	14.8	12	15.7	0.8
26-Mar-08	91	53	99	13	45	45	45	0	42.9	41.5	44.8	1.1	57	50.5	59.7	2.5	14.1	8.7	15.6	1.8
27-Mar-08	92	62	99	11	45	45	45	0	42.6	41.8	43.9	0.7	56.9	51.8	59.1	1.7	14.3	9.6	15.4	1.5
28-Mar-08	92	51	100	13	45	45	45	0	41.3	40.1	44.2	1.1	55.5	51.1	57.5	1.5	14.2	8.6	15.8	2.1
29-Mar-08	94	79	97	4	45	45	45	0	41.8	39.8	43.9	1.1	56.5	54.9	58.7	1.1	14.7	12.8	15.5	0.6

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
30-Mar-08	91	63	96	8	45	45	45	0	42.5	41.3	44.9	1.1	56.6	53	59.5	1.6	14	11.3	15.1	1.1
31-Mar-08	85	51	95	16	45	45	45	0	42.4	41.6	43.7	0.6	55.7	51.1	57.3	1.9	13.4	8.2	15	2.2
1-Apr-08	83	51	95	17	45	45	45	0	44.6	42.4	49	1.9	57.3	50.5	63.4	3.9	12.7	8	14.8	2.5
2-Apr-08	87	52	95	13	45	45	45	0	42	39.9	43.9	1.3	55.6	50.2	58.2	2.3	13.6	8.7	14.8	1.8
3-Apr-08	86	53	96	15	45	45	45	0	42.5	41	43.9	1.1	55.8	50	58.6	2.9	13.3	8.4	15.5	2.3
4-Apr-08	92	88	94	1	45	45	45	0	42.8	42	44	0.6	57.1	56.5	58.3	0.5	14.3	13.6	14.7	0.3
5-Apr-08	89	83	92	2	45	45	45	0	43.9	42.6	45.6	0.7	57.8	56.2	59.1	0.7	13.9	13.3	14.5	0.3
6-Apr-08	90	88	90	1	45	45	45	0	43.8	43.1	44.4	0.4	57.9	57	58.8	0.5	14.1	13.6	14.4	0.2
7-Apr-08	88	56	91	7	45	45	45	0	44.3	42.9	45.3	0.6	58.1	54.1	59.4	1.1	13.8	10.5	14.6	0.8
8-Apr-08	82	51	90	14	45	45	45	0	44	42.4	46.6	1.5	56.5	50.7	60.1	3.1	12.5	7.9	14.2	2.3
9-Apr-08	86	71	90	5	45	45	45	0	45	43.6	46.3	0.6	58.3	54.9	59.9	0.9	13.3	11.3	14.4	0.7
10-Apr-08	83	59	88	6	45	45	45	0	45.4	44	47	0.9	58.3	54.1	60.4	1.3	12.9	9.3	13.9	1.2
11-Apr-08	86	84	88	1	45	45	45	0	45.4	43.8	48	1.2	58.7	57.2	61.3	1.2	13.4	12.9	13.8	0.3
12-Apr-08	85	83	88	1	45	45	45	0	45.6	43.9	47.9	1.1	58.6	56.7	60.9	1.1	13	12.3	13.5	0.3
13-Apr-08	75	50	88	15	45	45	45	0	43.7	42.5	45.8	0.8	55.5	50.7	58.9	2.7	11.8	7.7	13.9	2.1
14-Apr-08	71	49	87	15	45	45	45	0	44.6	42.9	46.4	1	55.7	53.2	58.7	1.9	11.1	7.9	14.4	2.4
15-Apr-08	85	69	88	4	45	45	45	0	46.4	44.1	50.5	2.1	59.6	57	63.6	2	13.2	12.2	13.7	0.3
16-Apr-08	83	55	86	6	45	45	45	0	46.6	44.5	49.6	1.8	59.5	55.3	62.5	2	12.9	9.2	13.8	1
17-Apr-08	78	50	86	11	45	45	45	0	46.1	42.9	48.9	2	58.2	52.4	62.3	3.1	12.1	8.4	13.6	1.6
18-Apr-08	81	57	85	6	45	45	45	0	46.9	45.3	49.1	1.2	59.7	55.4	61.7	1.5	12.9	10.1	13.8	0.8
19-Apr-08	66	51	85	13	45	45	45	0	48.5	45.7	50.7	1.5	58.9	55.9	64.3	2.5	10.4	8.4	13.7	1.9
20-Apr-08	74	54	85	10	45	45	45	0	47.8	46.6	49.1	0.7	58.9	54.9	61.2	1.7	11.1	7.8	13	1.5
21-Apr-08	75	52	85	12	45	45	45	0	47.2	44.7	50.2	1.8	58.3	53.8	62.7	2.9	11.1	7.7	12.8	1.8
22-Apr-08	79	53	84	8	45	45	45	0	49.6	44.9	53.3	2.9	61.3	53.5	65.7	3.7	11.7	7.8	12.5	1.2
23-Apr-08	76	53	85	10	45	45	45	0	48.3	47	49.5	0.7	60	55.5	62.2	2.2	11.6	8.1	13.1	1.7
24-Apr-08	79	53	85	9	45	45	45	0	50	47.2	52.3	2	61.8	55.9	64.5	2.3	11.8	8.2	13.4	1.5
25-Apr-08	81	68	85	5	45	45	45	0	51.4	49.7	53.6	1	63.3	59.6	66.1	1.7	11.9	8.5	12.9	1.1
26-Apr-08	83	69	85	4	45	45	45	0	51.5	46.9	53.7	1.8	63.8	59.3	66.2	2	12.3	10.6	13	0.5
27-Apr-08	80	55	85	7	45	45	45	0	47.9	45.3	50.4	1.8	59.7	54.7	62.7	2.4	11.8	8.6	12.8	1.3
28-Apr-08	70	55	84	6	45	45	45	0	49.3	47.6	51.3	1.1	60	56.5	63.1	1.6	10.7	8.3	12.7	1.1
29-Apr-08	69	53	85	11	45	45	45	0	48.6	46	51.3	1.6	59.3	55	63.9	2.8	10.7	7.9	12.9	1.6
30-Apr-08	64	50	71	7	45	45	45	0	50.6	49.2	52.1	1	60.5	57.9	62.7	1.5	9.9	8	11.2	1
1-May-08	75	58	85	10	46	45	68	5	50.7	49.7	51.6	0.5	61.9	59.7	63.8	1.5	11.2	8.5	13.3	1.5
2-May-08	59	0	77	25	45	45	45	0	48.7	47.2	49.6	0.6	58.1	46.7	62	4.1	9.4	-0.6	12.4	3.6
3-May-08	0	0	0	0	51	45	68	10	47.6	45.8	49.3	0.9	47.2	45.8	48.6	0.7	-0.4	-0.8	0	0.3
4-May-08					68	68	68	0												
5-May-08	0	0	0	0	26	0	68	34	51.5	50	52.7	0.8	49.6	48.9	50	0.3	-2	-2.9	-1.1	0.6

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
6-May-08	0	0	0	0	0	0	0	0	53.9	52.3	55.3	1	51.7	49.8	52.5	0.8	-2.2	-3.2	-1.5	0.5
7-May-08	0	0	0	0	0	0	0	0	54.5	52.1	56.9	1.6	52.8	51	55	1.3	-1.6	-2.6	-0.7	0.6
8-May-08	0	0	0	0	33	0	45	20	51.2	47.7	57.2	3.8	50.4	47.4	54.9	2.8	-0.8	-3	0.4	1.1
9-May-08	0	0	0	0	45	45	45	0	49.4	48.1	51	1.1	49.4	48	51.1	1.1	0	-0.4	1	0.3
10-May-08	32	0	96	36	45	45	45	0	51.5	49.6	54.2	1.6	56.5	49.5	68.3	7.3	4.9	-0.5	15	5.8
11-May-08	57	50	86	10	45	45	45	0	52.9	49.9	54.2	1.1	62	58.5	68	2.2	9.1	7.5	14.8	1.8
12-May-08	81	51	102	23	45	45	45	0	48.6	45.7	52.2	1.8	61.1	54	66.6	4.5	12.5	8.1	15.8	3
13-May-08	73	50	102	22	45	45	45	0	51.1	48.5	53.6	2	62.3	56.8	68.3	3.4	11.3	8	15.7	3.2
14-May-08	69	51	101	19	45	45	45	0	52.6	50.5	55.2	1.4	63.5	58.9	69.7	3.8	10.9	8	15.3	3
15-May-08	69	50	99	20	45	45	45	0	51.7	49.9	54.1	1.3	62.5	58	67.3	2.7	10.8	8.1	15	2.5
16-May-08	77	51	103	22	45	45	45	0	53.1	52.5	53.9	0.4	64.9	60.8	69	3.4	11.8	8.1	16	3.3
17-May-08	51	50	53	1	45	45	45	0	51.7	49.8	53.4	1.2	60	57.9	62	1.3	8.4	8	9	0.2
18-May-08	54	49	74	7	45	45	45	0	50.5	49.6	51.4	0.5	59.4	58	63.8	1.3	8.9	8	13.4	1.3
19-May-08	78	49	101	22	45	45	45	0	50.9	49.6	52.1	0.9	63	57.9	67	3.4	12.1	8.2	15.6	3.1
20-May-08	88	51	103	18	45	45	45	0	52.3	50.5	54.8	1.2	65.4	59.4	69.6	3.1	13.2	8.1	15.7	2.6
21-May-08	87	50	103	19	45	45	45	0	52.7	52.2	53.5	0.4	66.1	60.7	68.5	2.6	13.3	8.3	15.4	2.4
22-May-08	81	49	101	23	45	45	45	0	53	51.6	54.5	0.9	65.5	60.4	69.7	3.6	12.5	8.3	15.5	3
23-May-08	72	50	101	20	46	45	68	5	53.7	51.9	55.8	1.2	64.7	60.6	70	3.3	11	7.8	15	2.6
24-May-08	61	46	97	16	45	45	45	0	54.4	53.3	55.5	0.8	63.7	61.1	68.4	2.2	9.3	7.2	14.6	2.2
25-May-08	70	46	101	22	45	45	45	0	54.9	52.6	57.9	1.7	65.3	60.2	70.5	3.9	10.4	7.2	14.8	2.9
26-May-08	55	46	95	14	45	45	45	0	54.1	51.6	57.1	1.5	62.8	59.3	67.1	1.8	8.7	7	14.3	1.9
27-May-08	82	46	103	21	45	45	45	0	53.5	52.6	54.4	0.7	66.2	61.5	69.2	2.7	12.7	7.3	15.5	3
28-May-08	64	47	96	12	45	45	45	0	55	52.6	57.3	1.4	64.7	61.4	69	2.1	9.8	7.3	13.3	1.7
29-May-08	87	53	100	15	45	45	45	0	56.7	54.6	60	1.9	69.8	63.1	73.8	3.1	13.1	8	15.5	2.4
30-May-08	89	55	99	13	45	45	45	0	55.8	53.9	57.3	0.8	69.3	64.8	72.2	2.2	13.5	9.7	15.2	1.8
31-May-08	94	67	100	10	45	45	45	0	54.4	53.3	55.5	0.6	68.9	62.8	70.7	1.6	14.4	9.2	15.7	1.3
1-Jun-08	81	48	99	19	45	45	45	0	55.4	54.5	56.2	0.6	67.7	62.5	70.9	2.6	12.3	7.9	15	2.4
2-Jun-08	96	72	102	9	45	45	45	0	57.3	55.1	58.9	1.4	71.7	64.1	74	2.5	14.5	8.7	15.4	1.4
3-Jun-08	88	47	100	19	45	45	45	0	58.5	57.3	60.3	0.8	71.6	65.2	74.5	2.9	13.1	7.6	14.9	2.5
4-Jun-08	89	46	102	17	45	45	45	0	59.7	58.1	61	1	73.5	67.2	77.3	2.8	13.9	8.3	16.7	2.4
5-Jun-08	89	51	100	16	45	45	45	0	59.4	58	61.2	0.8	73.9	67.9	76.2	2.5	14.5	8.7	16.5	2.2
6-Jun-08	102	54	121	20	72	45	79	14	58.9	56.7	62.3	2.1	73.6	66.9	77.7	3.1	14.6	9.2	16.1	1.8
7-Jun-08	86	69	120	21	79	79	79	0	60.6	59	62.1	0.8	71.4	67.1	77.6	3.5	10.8	7.4	15.6	3.1
8-Jun-08	101	63	122	23	79	79	79	0	61.6	60.7	63.3	0.7	74.7	69.4	78.8	3.1	13.1	8.3	16.4	3
9-Jun-08	107	68	123	18	70	45	79	15	62.3	60.7	64.6	1.2	76.9	70.3	80.1	2.7	14.6	8.7	16.4	2.3
10-Jun-08	89	47	99	17	45	45	45	0	63.2	61.4	64.6	1	77.8	69.5	80.4	3.4	14.5	8.1	16.4	2.6
11-Jun-08	98	80	101	4	45	45	45	0	63.9	61.3	66.6	2	79.1	72.3	82.4	2.6	15.1	9.7	16.1	1.2

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
12-Jun-08	98	92	100	2	55	45	68	11	67.7	65.7	71.1	1.9	81.6	80.3	84	1.1	13.9	12.1	15	1
13-Jun-08	95	50	101	12	68	68	68	0	66.4	58.1	69.2	3.5	79.7	71.7	82.6	3.6	13.3	7.2	16.7	2.1
14-Jun-08	98	87	101	4	68	68	68	0	64.1	57.3	68	3.4	77.1	69.3	81.2	3.5	13	9.9	14.3	0.9
15-Jun-08	91	50	99	15	68	68	68	0	68.3	67.4	69.4	0.6	80.5	75.2	83.1	2.2	12.2	6.6	14	1.9
16-Jun-08	79	46	101	22	68	68	68	0	67.9	66.6	69.7	0.8	78.5	74.7	82.6	2.7	10.6	5.9	14	3.1
17-Jun-08	85	46	101	22	68	68	68	0	68	67.1	69	0.4	79.5	74	82	2.8	11.5	5.8	13.6	2.8
18-Jun-08	87	45	101	20	68	68	68	0	68.2	66.8	69.8	1	79.8	74	83.1	3.2	11.6	6.7	13.9	2.7
19-Jun-08	92	46	101	17	68	68	68	0	68.2	67.4	68.8	0.4	80.7	75.4	82.3	2	12.5	7.4	13.8	2
20-Jun-08	95	60	103	11	68	68	68	0	68.6	66.9	70.6	1.2	81.2	75.8	83.8	2	12.6	8.2	14.1	1.4
21-Jun-08	89	59	102	14	68	68	68	0	68.5	67.5	69.8	0.7	80.7	75.7	84.8	2.3	12.2	7.7	15.6	2.1
22-Jun-08	82	48	102	22	68	68	68	0	68	66.7	69.3	0.7	78.8	73.5	83.3	3.4	10.8	5.8	14.6	3.1
23-Jun-08	94	62	100	11	68	68	68	0	69.5	68.8	70.4	0.4	81.9	78.2	83.9	1.5	12.4	8.7	14.3	1.3
24-Jun-08	91	54	99	10	68	68	68	0	70.3	68.5	72.2	1.2	82.9	79.4	86	1.8	12.5	10.1	14.5	1
25-Jun-08	85	46	102	23	68	68	68	0	70.5	69	71.8	0.9	82.6	76.7	86.3	3.2	12.2	7	14.7	2.5
26-Jun-08	99	87	103	5	68	68	68	0	70.8	70	71.4	0.4	84.2	82.1	85.5	0.7	13.4	10.7	14.8	0.8
27-Jun-08	80	45	101	21	68	68	68	0	70.8	69.9	71.6	0.5	82.2	77.8	85.9	2.8	11.4	7.2	14.3	2.6
28-Jun-08	91	50	100	16	68	68	68	0	69.4	67.8	70.4	0.7	82.1	77.1	84	2	12.6	8	14.1	1.9
29-Jun-08	75	47	100	20	68	68	68	0	69.9	68.2	71.6	1.3	80.7	75.8	85.2	3.1	10.8	7.1	14.1	2.6
30-Jun-08	95	51	100	12	68	68	68	0	71.8	70.6	73	0.6	84.6	81	86.6	1.1	12.8	8.4	14.7	1.2
1-Jul-08	87	49	100	16	68	68	68	0	73.7	71.3	76.6	2	85.4	80.9	90.4	2.6	11.7	7	13.8	2.2
2-Jul-08	88	45	102	18	68	68	68	0	73.9	73	74.6	0.5	86.3	80.1	89.9	2.9	12.4	7.1	15.8	2.6
3-Jul-08	94	45	104	15	68	68	68	0	72.6	71.6	73.6	0.6	85.5	78.4	87.7	2.4	12.9	6.7	14.7	2
4-Jul-08	75	0	104	45	68	68	68	0	72.9	70.4	76	2	83.8	73.9	90.8	5.7	10.9	-1	15.8	6.7
5-Jul-08	0	0	0	0	68	68	68	0	74.2	72.1	76.4	1.6	73.8	71.9	76.1	1.5	-0.4	-0.8	-0.1	0.2
6-Jul-08	57	0	96	42	68	68	68	0	75.8	73.8	77.9	1.4	84.2	73.8	92.9	7.8	8.5	-0.8	16.5	6.7
7-Jul-08	95	64	101	9	68	68	68	0	75.1	73.9	76.3	0.7	89.1	82.3	92.4	2.2	14	7.6	17.8	2
8-Jul-08	90	48	101	19	68	68	68	0	73.9	73	75.2	0.6	86.8	81.2	89.6	2.7	12.9	7.3	15	2.6
9-Jul-08	86	47	101	21	68	68	68	0	75.1	73.2	77.7	1.4	87.7	80.7	92.3	3.7	12.6	7.3	15.1	2.6
10-Jul-08	83	46	100	21	68	68	68	0	77.4	74.7	79	1.3	89	82.6	92.7	3.5	11.6	6.7	14.1	2.8
11-Jul-08	82	48	100	19	68	68	68	0	76.1	74.7	77.6	0.8	87.6	82.4	91	2.7	11.6	6.3	14.3	2.7
12-Jul-08	95	56	100	11	68	68	68	0	76.2	74.9	77.4	0.8	89.6	82	92.5	2.4	13.3	6.3	15.4	2
13-Jul-08	78	46	100	21	68	68	68	0	73.7	72.7	75.6	0.8	85.4	81	90.1	3	11.7	7.6	14.6	2.7
14-Jul-08	98	75	102	6	68	68	68	0	74	72.1	76.9	1.6	87.3	81.9	90.3	2	13.3	9.2	14.2	1.1
15-Jul-08	96	76	101	7	68	68	68	0	76.3	74	78.5	1.6	89.5	83.9	92.4	2.5	13.2	9.2	15	1.4
16-Jul-08	87	46	101	22	68	68	68	0	76.8	75.6	77.8	0.7	89.2	83	92.3	3.5	12.4	6.2	14.9	3.1
17-Jul-08	88	45	102	19	68	68	68	0	77.1	76.4	78.5	0.6	89.6	83.6	94	2.9	12.5	6.6	15.9	2.8
18-Jul-08	110	45	138	34	94	68	101	14	76.5	75.3	78.1	0.7	88.7	83.4	91.4	2.7	12.1	7.4	14.2	2.3

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
19-Jul-08	104	65	131	20	101	101	101	0	78.6	77.6	80.2	0.7	90.2	86.7	92.5	2	11.6	7.5	13.8	2.2
20-Jul-08	115	18	145	43	100	79	101	5	77.8	77.1	78.4	0.3	89.2	78.3	95.8	4.5	11.4	0.3	18.2	4.6
21-Jul-08	139	94	146	13	101	101	101	0	78.4	76.6	80.5	1.4	91.5	85.5	94	2	13.1	8.4	14	1.3
22-Jul-08	116	67	145	25	101	101	101	0	79	77.5	80.7	1	91.2	87.1	93.9	1.9	12.3	7.2	13.8	2.1
23-Jul-08	89	63	139	29	101	101	101	0	78.6	77.2	79.5	0.4	87.9	83.8	93	3.1	9.3	6.3	14.5	3.1
24-Jul-08	107	66	151	36	101	101	101	0	77	75.5	78.1	0.6	87.2	82.7	91.3	3.1	10.2	6.2	13.3	2.8
25-Jul-08	114	66	149	33	101	101	101	0	76.3	74.6	78.5	1.4	88.1	81.8	91.9	4.2	11.7	7	16	3.1
26-Jul-08	105	69	133	19	101	101	101	0	77.1	76	78	0.5	88.2	84.2	90.6	2.4	11.1	7.1	14.3	2.6
27-Jul-08	97	69	145	32	101	101	101	0	77.4	76	79.2	1	87.5	84.5	90.3	1.9	10.1	7	13.6	2.7
28-Jul-08	113	68	151	34	101	101	101	0	77.7	76.4	79.2	1	89.1	83.7	93.3	3.7	11.4	7	14.5	2.9
29-Jul-08	100	66	138	24	101	101	101	0	79.4	77.2	82.4	1.9	90.4	84.3	97.5	3.8	11	6.5	15.8	3.4
30-Jul-08	121	90	144	17	101	101	101	0	78.5	78.1	79.7	0.4	90.5	88.3	92.4	1.4	12	9.6	13.6	1.4
31-Jul-08	123	67	142	25	101	101	101	0	78.8	77.5	80.5	0.8	91.4	85.5	94.1	2.7	12.6	7.4	14.5	2.3
1-Aug-08	125	91	140	17	101	101	101	0	79.7	77.6	81.9	1.5	93	88	96.4	2.9	13.3	10.1	15.1	1.6
2-Aug-08	86	67	133	23	101	101	101	0	80.2	78.9	82.1	0.9	89.6	86.4	95.2	2.9	9.4	7	14.3	2.4
3-Aug-08	78	65	104	12	101	101	101	0	79.3	78.3	80.3	0.6	88.4	86.3	92.5	1.8	9	6.4	12.2	1.6
4-Aug-08	92	65	108	14	101	101	101	0	78.8	76.9	80.8	1.3	89.2	84.8	93.6	2.8	10.4	7	13.1	1.8
5-Aug-08	117	81	131	14	101	101	101	0	78.3	77.3	79.5	0.7	90.8	86.2	93.6	2	12.5	7.8	14.4	1.8
6-Aug-08	105	63	124	23	96	79	101	10	78.3	76.1	81.1	1.7	90.6	84.3	94	2.6	12.2	8.1	13.7	1.3
7-Aug-08	95	65	123	19	101	101	101	0	77.8	75.9	79.8	1.3	88.8	83.6	96.9	2.8	11	7.2	17.2	2.5
8-Aug-08	91	66	128	23	101	101	101	0	78.3	77.5	79.2	0.5	88.6	85.2	93.3	2.7	10.4	7	14.5	2.8
9-Aug-08	102	66	124	21	101	101	101	0	76.9	75.2	78.1	0.8	88.2	82.7	92.6	3.2	11.2	6.7	14.8	3
10-Aug-08	100	69	117	18	101	101	101	0	77.1	75	79.6	1.4	88.6	82.7	92.6	3.1	11.5	7.1	14.1	2.1
11-Aug-08	80	67	112	15	101	101	101	0	77.4	75.7	79.3	1.1	85.9	83.5	89.5	1.6	8.6	6.4	12.5	1.8
12-Aug-08	80	67	114	14	101	101	101	0	78	76.1	80	1.1	86.9	82.7	93.2	2.5	8.8	5.7	13.7	2
13-Aug-08	98	68	118	18	100	79	101	5	76.8	74.9	79.2	1.2	87.8	82.6	91.7	2.5	11	6.9	13.2	2.1
14-Aug-08	89	58	119	20	90	68	101	14	77.4	74.6	79.6	1.7	88.5	82.6	92.2	2.6	11.1	7.4	13.4	1.8
15-Aug-08	63	45	95	21	68	68	68	0	77.9	75.4	80.1	1.8	87.1	82.3	92.6	3.3	9.2	6.9	13	2.6
16-Aug-08	89	57	95	9	68	68	68	0	78.3	76.2	80.2	1.4	91.2	86.4	93.4	2	12.8	9.1	15	1.3
17-Aug-08	66	43	94	20	68	68	68	0	77.3	75.9	78.8	1	86.8	82.3	91.8	3.3	9.5	6.1	13.6	2.5
18-Aug-08	78	45	95	21	68	68	68	0	76.9	75.9	78.7	0.8	87.7	82.8	91.5	3.2	10.9	6.3	13.9	3
19-Aug-08	76	47	94	19	68	68	68	0	76.1	74.3	77.2	0.8	87.3	81.7	91	2.9	11.2	6.6	14.8	2.6
20-Aug-08	67	45	93	21	68	68	68	0	75.9	72.8	79.4	2.3	85.9	80.3	93.2	4.2	10	6.7	14.1	2.7
21-Aug-08	75	45	93	20	68	68	68	0	76	74.3	78.1	1.2	86.6	82.4	91.3	3.3	10.6	6.7	13.5	2.6
22-Aug-08	83	45	95	17	68	68	68	0	75.8	74.2	77.1	1	88	82	91.5	2.8	12.2	6.9	14.6	2.3
23-Aug-08	84	47	95	17	68	68	68	0	75.8	74.7	76.6	0.6	88	83.1	90.8	2.6	12.2	7.6	14.8	2.2
24-Aug-08	84	47	99	18	68	68	68	0	75.3	73.4	77.6	1.4	88	81.2	92.4	3.5	12.6	7.5	16.5	2.6

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
25-Aug-08	91	50	98	11	68	68	68	0	76.3	74.8	77	0.6	90.4	83.8	98.1	2.5	14.1	8.9	22.2	2.3
26-Aug-08	68	46	95	20	68	68	68	0	75.3	72.5	77.9	2	85.6	79.4	93.2	4.4	10.3	6.8	15.4	3
27-Aug-08	71	47	97	21	68	68	68	0	75.2	73	77.5	1.5	85.7	80.5	90.6	3.3	10.5	7.2	14.1	2.5
28-Aug-08	75	47	98	21	68	68	68	0	74.3	73.5	75.7	0.5	85	81.2	88.5	2.5	10.7	6.6	14.6	2.8
29-Aug-08	89	64	97	10	68	68	68	0	73.1	72.4	74.2	0.5	85.6	81.1	87.7	1.4	12.5	6.9	14.5	1.7
30-Aug-08	87	57	94	9	68	68	68	0	73.9	71.6	76.7	1.8	86.1	79.3	91.5	2.8	12.2	7.7	15.8	1.5
31-Aug-08	77	47	90	13	68	68	68	0	74.8	72	78.2	2.1	86.3	81.1	94.3	3.5	11.5	6.1	17.6	3
1-Sep-08	66	47	95	19	68	68	68	0	75.4	72.6	78.3	1.8	85.1	79.9	92	4.3	9.7	6.8	14.4	2.7
2-Sep-08	74	45	93	20	68	68	68	0	75.5	73.6	77.2	1.2	86.4	80.9	91.7	3.7	10.9	6.7	14.6	3
3-Sep-08	78	45	92	14	68	68	68	0	75.8	74.7	77.5	0.9	87.4	82.9	90.7	2.4	11.6	7.3	13.7	1.9
4-Sep-08	83	51	92	11	68	68	68	0	76.7	74.5	80	2	88.3	82.6	92.3	3.2	11.6	7.9	13	1.5
5-Sep-08	80	49	92	14	68	68	68	0	76.6	74.3	78.1	1.1	88.4	84.4	92	2.2	11.8	7.8	15	2.2
6-Sep-08	85	48	92	12	68	68	68	0	74.3	73.2	75.1	0.5	86.3	83.2	88	1.2	12	8.3	13.2	1.2
7-Sep-08	55	46	74	9	68	68	68	0	74.4	72.9	76.1	1	83.1	79.8	86.6	1.8	8.7	6.4	11.5	1.3
8-Sep-08	63	48	90	15	68	68	68	0	74.4	72.6	76.1	1.1	83.6	80.8	88.9	2.6	9.2	6.4	12.8	2.1
9-Sep-08	58	47	89	15	68	68	68	0	74.3	73.1	75.9	0.9	82.7	80.5	85.8	1.6	8.4	6.6	12.1	1.8
10-Sep-08	67	46	90	18	68	68	68	0	73.8	71.6	76.2	1.4	83.5	80	87.6	2.4	9.7	6.7	13	2.1
11-Sep-08	72	48	91	18	68	68	68	0	72.1	70.9	73.1	0.7	82.5	78.2	85.4	2.4	10.4	6.9	12.6	2.2
12-Sep-08	78	46	91	16	68	68	68	0	71.2	70.5	72.5	0.6	82.1	78.4	84.1	1.8	10.9	6.7	13.1	2.1
13-Sep-08	77	49	90	15	68	68	68	0	71.8	71.4	72.6	0.4	83	79.2	85.3	2.1	11.1	7.7	13.1	1.9
14-Sep-08	76	50	85	7	68	68	68	0	72.8	71.2	74.6	1.2	84	79.3	86.6	1.9	11.2	7.8	13	1.2
15-Sep-08	70	45	85	13	68	68	68	0	73.8	72.4	74.7	0.7	84.9	79.3	88.7	2.6	11.1	6.9	14	2.2
16-Sep-08	63	45	86	17	65	45	68	8	71.4	69.4	73.3	1.1	80.9	77.5	86.6	2	9.5	6.7	14.6	2.1
17-Sep-08	72	48	84	15	45	45	45	0	71.4	69.8	72.5	0.8	83.6	79.8	86.7	2.2	12.3	9	14.6	1.9
18-Sep-08	67	45	85	14	45	45	45	0	72	70.7	73.7	0.8	84.4	80.2	89.5	2.6	12.4	8.3	18.1	2.7
19-Sep-08	62	46	87	15	45	45	45	0	69.8	68.1	71.7	1.2	80.8	77.9	84.1	2	11.1	8	14.6	2.2
20-Sep-08	62	45	86	15	45	45	45	0	69.4	68.4	70.6	0.6	80.7	77.8	85.1	2.4	11.3	8	15.1	2.4
21-Sep-08	66	46	85	16	45	45	45	0	70	69.1	71.4	0.6	81.1	77.5	85.2	2.6	11.1	8.1	13.8	2.2
22-Sep-08	71	47	85	14	45	45	45	0	70	67.6	71.7	1.2	81.8	78.1	85.5	2.4	11.8	8.1	14.6	2.2
23-Sep-08	77	48	85	11	45	45	45	0	69.4	67.5	72.4	1.7	82.2	76.4	88.1	2.9	12.8	8.3	15.7	2
24-Sep-08	67	45	85	16	45	45	45	0	69.2	67.1	71.9	1.5	80.6	75.5	85.6	3.4	11.3	8	14.5	2.5
25-Sep-08	70	44	87	18	45	45	45	0	69.4	68.4	70.6	0.7	80.9	76.8	84.7	2.9	11.4	7.3	14.4	2.8
26-Sep-08	73	43	89	16	45	45	45	0	69.5	67	71.5	1.6	81.8	75.9	87	3.7	12.3	7.5	17.1	2.8
27-Sep-08	76	46	88	14	45	45	45	0	70	68.8	71.1	0.7	82.6	78	84.6	2.3	12.5	8.3	14.4	2.3
28-Sep-08	63	44	84	17	45	45	45	0	70.4	69.7	71.3	0.5	81.2	77.7	85.7	3	10.9	7.9	15	2.6
29-Sep-08	72	45	86	16	45	45	45	0	69.4	68.3	70.8	0.6	81.8	77.3	86.6	2.6	12.4	8.4	17.6	2.5
30-Sep-08	66	47	85	14	45	45	45	0	67.7	66.8	68.7	0.6	78.8	75.7	82.4	2.1	11.2	8.2	14.1	2.3

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
1-Oct-08	67	46	85	16	45	45	45	0	67.3	66.4	68.7	0.7	78.8	74.5	85.4	3	11.5	7.9	17.4	2.7
2-Oct-08	58	47	84	13	45	45	45	0	66.9	66.1	68.4	0.7	76.5	74.2	80.7	2.2	9.6	7.8	13.4	2
3-Oct-08	52	0	85	21	45	45	45	0	65.6	64.5	66.6	0.5	74.6	64.4	79.5	3.6	9	-0.1	14.1	3.4
4-Oct-08	0	0	0	0	45	45	45	0	63.1	62.3	64.1	0.4	63.1	62.1	63.9	0.5	0	-0.5	0.6	0.3
5-Oct-08	0	0	0	0	45	45	45	0	61.6	61	62.1	0.3	61.5	60.9	62.2	0.4	-0.1	-0.5	0.2	0.2
6-Oct-08	50	0	98	35	45	45	45	0	62.4	60.8	65	1.6	71.1	60.5	80.4	6.9	8.6	-0.4	17.2	6
7-Oct-08	52	46	85	11	45	45	45	0	62.9	60.9	65	1.2	71.3	68.9	77	2	8.5	7.4	13	1.3
8-Oct-08	82	45	101	22	45	45	45	0	62.7	62	63.6	0.5	76.3	71.2	79.4	2.9	13.6	8.1	16.8	3.2
9-Oct-08	79	45	100	22	45	45	45	0	64	62	65.8	1.4	77.1	70.1	82.1	4.5	13.1	8	16.5	3.3
10-Oct-08	62	44	99	20	45	45	45	0	63.3	62.2	64.3	0.7	74.1	70.8	78.9	2.8	10.8	8	16.1	2.9
11-Oct-08	62	45	98	17	45	45	45	0	63.7	61.9	65.8	1.4	74	70	79.4	2.8	10.3	8	15.6	2.3
12-Oct-08	63	46	99	18	45	45	45	0	63.9	62.6	65.1	0.7	74.9	71.3	81.3	2.8	11	8.1	16.5	2.9
13-Oct-08	66	43	100	23	45	45	45	0	64.1	63.1	65.1	0.6	75.6	71.8	81	3.5	11.5	8	16.5	3.3
14-Oct-08	54	45	93	13	45	45	45	0	64.3	62.9	66	1	74.3	72.1	82.3	2.5	10.1	8.4	16.9	2.2
15-Oct-08	77	45	101	23	45	45	45	0	64.6	63.3	66	0.8	77.6	72.4	82.7	3.7	13	8.7	16.9	3.3
16-Oct-08	80	55	102	15	45	45	45	0	65	63.6	66	0.6	78.7	75.1	82.8	2.3	13.8	9.8	17.1	2.2
17-Oct-08	74	47	99	18	45	45	45	0	63.7	62.1	65.7	1.1	76.9	71.1	81	3.2	13.2	8.4	16.6	2.8
18-Oct-08	54	45	92	13	45	45	45	0	61.7	59.9	62.8	0.9	71.8	69.1	77.4	2	10.1	7.9	15.2	2.1
19-Oct-08	65	44	101	23	45	45	45	0	60.3	58.6	61.7	1	71.3	67.5	77.3	3.3	11	8	15.9	3.1
20-Oct-08	66	46	99	22	45	45	45	0	60.3	58.5	62.5	1.4	71.8	67.2	79.1	3.4	11.5	7.9	17.1	3.5
21-Oct-08	76	45	101	21	45	45	45	0	61.2	58.2	62.6	1.1	73.7	67.1	78.4	3.8	12.5	7.7	16.1	3.2
22-Oct-08	80	45	101	22	45	45	45	0	57.1	55.9	58	0.5	70.8	66	75.4	3.3	13.7	8.3	18.5	3.6
23-Oct-08	79	45	101	20	45	45	45	0	58.8	57	60.3	1.1	72.7	66.9	76.1	3.3	13.8	8.1	17.4	2.7
24-Oct-08	70	45	97	17	45	45	45	0	57.4	55.5	59.4	1	69.4	64.9	73.7	2.5	12	8.1	16	2.7
25-Oct-08	48	44	82	8	45	45	45	0	56	54.6	57.9	1.2	64.7	62.8	69.2	1.6	8.8	7.8	13.6	1.4
26-Oct-08	45	45	46	0	45	45	45	0	56.4	54.8	57.6	0.8	64.5	62.9	66	0.8	8.1	7.6	8.5	0.2
27-Oct-08	67	45	97	20	45	45	45	0	58.5	57.4	60.2	0.9	69.9	65.8	75.5	3.4	11.4	8	16	3.1
28-Oct-08	78	46	101	23	45	45	45	0	56.2	54.5	59.4	1.3	70	63.4	73.2	2.6	13.7	8	17.5	3.2
29-Oct-08	81	46	100	22	45	45	45	0	54.2	52.9	55.3	0.8	67.7	61.8	71	3.3	13.5	8.2	16.1	3.1
30-Oct-08	70	42	101	23	45	45	45	0	53.5	51.9	55.4	0.8	65	60.9	70	3	11.5	7.5	16.3	3.3
31-Oct-08	53	42	85	14	45	45	45	0	54.2	53.4	55.4	0.6	63.5	61.5	67.9	2	9.3	7.6	14.4	2.2
1-Nov-08	52	43	76	10	45	45	45	0	54.9	53.9	56.1	0.6	64.1	62.4	67.7	1.6	9.2	7.5	13.2	1.5
2-Nov-08	70	43	103	22	45	45	45	0	54.4	53.5	55.4	0.5	65.9	61.5	70.7	3.2	11.5	7.5	16.5	3.2
3-Nov-08	74	44	99	24	45	45	45	0	53.2	52.4	54.7	0.6	65.6	60.9	69.1	3.3	12.4	7.4	16.3	3.5
4-Nov-08	69	43	101	26	45	45	45	0	53.8	52.9	55	0.6	65.5	61.5	70.1	3.4	11.6	7.8	16.3	3.7
5-Nov-08	77	43	100	23	45	45	45	0	53.6	52.7	55.1	0.7	66.5	60.9	71	3.8	12.9	7.8	16.6	3.4
6-Nov-08	81	43	103	25	45	45	45	0	55	53.5	56.3	0.8	68.4	61.9	72.8	4.3	13.4	8	17.5	3.8

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
7-Nov-08	63	43	100	21	45	45	45	0	55.6	54.8	56.6	0.5	66.4	62.6	71.7	3	10.8	7.5	16.3	3.2
8-Nov-08	77	43	102	27	45	45	45	0	56	54.6	57.4	0.8	68.9	62.5	73.8	4.6	12.9	7.7	16.8	3.9
9-Nov-08	65	42	102	22	45	45	45	0	55.5	54.6	56.3	0.5	66.4	62.9	72.3	3.2	10.9	7.4	16.7	3.3
10-Nov-08	82	42	101	23	45	45	45	0	54.8	53.7	55.4	0.5	67.8	61.8	71.5	3.5	13.1	7.2	16.1	3.4
11-Nov-08	87	48	102	17	45	45	45	0	53.7	51.7	54.8	0.9	67.3	62	70.3	2.6	13.6	7.6	16.4	2.8
12-Nov-08	72	43	101	24	45	45	45	0	53	52.4	53.9	0.4	64.9	61	69.2	3.2	11.8	7.4	16.2	3.4
13-Nov-08	85	59	100	15	45	45	45	0	51.7	50.6	53.3	1	65.3	62.1	67.9	1.8	13.6	9.7	16	2.4
14-Nov-08	83	44	101	21	45	45	45	0	52.4	51.1	53.1	0.6	66.2	60.8	69.1	2.7	13.7	8.1	16.8	3
15-Nov-08	83	43	101	19	45	45	45	0	53.7	52.5	55.1	0.9	67.3	61.5	71.3	3.3	13.6	7.5	16.5	3
16-Nov-08	75	43	99	21	45	45	45	0	52.9	51.5	54.5	0.8	65.1	59.9	68.5	2.9	12.2	7.4	15.7	3.2
17-Nov-08	85	42	101	21	45	45	45	0	51.7	50.5	53.5	0.9	65	59.4	69.1	3	13.4	7.2	16.2	3
18-Nov-08	89	49	101	19	45	45	45	0	49.2	47.9	51.4	1.2	63	59.1	65.2	2	13.9	7.7	16.5	3
19-Nov-08	102	100	105	1	45	45	45	0	48.8	47.2	49.7	0.7	64.4	63.1	65.3	0.6	15.6	14.9	16.1	0.3
20-Nov-08	102	101	104	1	45	45	45	0	48.9	47.6	51.4	1	64.9	63.6	67.5	0.9	16	15.3	16.7	0.4
21-Nov-08	101	100	103	1	45	45	45	0	47.8	46.3	50.7	1	63.4	61.6	65.6	1	15.5	14.9	16.1	0.3
22-Nov-08	100	94	102	2	45	45	45	0	46.9	45.4	49	0.9	62.4	61.1	64.7	0.9	15.6	14.9	15.9	0.2
23-Nov-08	97	74	102	9	45	45	45	0	46.2	44.1	47.7	1.3	61.5	56.3	63.1	2.2	15.3	12.1	16.9	1.3
24-Nov-08	100	92	102	2	45	45	45	0	43.4	42.1	46.1	1.1	59.4	58.1	62.1	1.1	15.9	15.5	16.4	0.2
25-Nov-08	83	45	101	21	45	45	45	0	45.1	43.6	47.3	1.2	58.4	51.5	62.9	4	13.4	7.4	16.2	3.2
26-Nov-08	80	42	102	24	45	45	45	0	45.9	44.1	48	1.4	59	51.5	64	4.8	13.1	7.2	16.4	3.7
27-Nov-08	74	42	102	23	45	45	45	0	46.4	45.3	47.4	0.7	58.8	55.2	63.4	3.1	12.4	7.8	17.2	3.6
28-Nov-08	73	42	101	18	45	45	45	0	45.9	44	47.8	1.4	57.9	52.7	63.3	3.1	12	7.8	16.2	2.8
29-Nov-08	84	48	104	19	45	45	45	0	48.1	47.2	49	0.5	61.8	55.5	65.1	3.1	13.7	8.1	16.7	3
30-Nov-08	82	47	101	20	45	45	45	0	45.7	43.3	47.9	1.8	59.1	55.7	62.6	2.1	13.4	8.4	16.7	2.9
1-Dec-08	87	43	102	23	45	45	45	0	44.3	43.2	45.5	0.7	58.1	51	61.2	3.7	13.8	7.4	16.4	3.2
2-Dec-08	88	46	101	19	45	45	45	0	46.3	44.7	48.1	1.2	60.2	52.9	63.7	3.7	13.9	7.3	16.1	2.8
3-Dec-08	101	99	103	1	45	45	45	0	44.6	42.6	47.6	1.7	60.5	58.4	63.4	1.6	15.9	15.3	16.6	0.4
4-Dec-08	98	85	102	4	45	45	45	0	46.2	44.2	48.4	1.5	61.6	57.1	64.4	2.2	15.4	12.6	16.3	1.1
5-Dec-08	98	75	101	5	45	45	45	0	47.8	47	48.5	0.4	63.5	61.9	64.5	0.6	15.6	14.8	16.2	0.4
6-Dec-08	83	46	98	20	45	45	45	0	43.6	40.5	46.5	2.2	57.7	53.5	61.8	2.2	14.2	9	16.1	2.2
7-Dec-08	73	42	92	18	45	45	45	0	43.1	41.4	44.8	1.1	55.2	49.8	59.4	3.3	12.1	7.9	15.1	2.5
8-Dec-08	47	0	90	39	45	45	45	0	43.3	39.5	45.2	1.5	51.2	39.8	58.8	7.2	7.8	0	14.2	6
9-Dec-08	0	0	0	0	45	45	45	0	38.9	37.2	40.4	1	39	37.3	40.5	1	0.1	-0.3	0.5	0.2
10-Dec-08	0	0	0	0	45	45	45	0	40.1	38.4	42	1.2	40.3	38.8	42.1	1.1	0.1	-0.3	0.4	0.2
11-Dec-08	63	0	101	33	45	45	45	0	42.7	40.8	44.4	1.3	53	40.9	60	6.3	10.4	0	16.3	5.4
12-Dec-08	74	42	99	19	45	45	45	0	43.9	42.7	45.4	0.9	56.3	52.5	59.9	2.4	12.5	8	15.9	2.5
13-Dec-08	74	50	96	17	45	45	45	0	43.4	41.1	44.5	0.8	55.7	52.3	58.9	2.1	12.3	7.8	15.6	2.4

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
14-Dec-08	66	43	94	20	45	45	45	0	40.8	39.6	42.5	0.9	52.1	47.8	57.5	3.3	11.2	7.6	15.5	3
15-Dec-08	70	43	99	22	45	45	45	0	43.5	41.5	46.4	1.6	54.8	49.5	61.9	4.4	11.4	7.4	16.5	3.3
16-Dec-08	81	43	101	24	45	45	45	0	43.6	41.8	47.8	1.5	56.6	51.5	61.5	3.2	13.1	7.5	15.9	3.3
17-Dec-08	95	80	99	4	45	45	45	0	42.8	41.1	45.9	1.6	57.9	54.8	61	1.7	15	13.6	16	0.7
18-Dec-08	79	43	107	21	62	45	79	17	45	42.9	47	1.2	57.5	51.7	61.1	3.2	12.4	7.8	15.3	2.7
19-Dec-08	123	90	144	14	79	79	79	0	44.4	42.2	47.2	1.6	59.4	55.1	63.1	2	15	9.6	17.1	1.7
20-Dec-08	128	121	132	4	79	79	79	0	42.3	40.2	46.6	1.8	57.6	55.2	61.6	1.7	15.4	13.5	17.7	1
21-Dec-08	134	128	143	6	79	79	79	0	41.4	40.1	45.5	1.4	57	55.3	62.4	1.9	15.6	14.4	16.9	0.7
22-Dec-08	124	70	135	19	79	79	79	0	42	40.5	44.4	0.9	56.3	50.6	59.7	2.1	14.3	8	16	1.9
23-Dec-08	125	89	135	14	79	79	79	0	41.7	38.2	44.4	1.7	55.3	51.1	58.5	2	13.6	8.2	14.9	1.7
24-Dec-08	104	66	133	27	79	79	79	0	40.3	38.2	43	1.2	52.1	48.9	55.4	2.3	11.8	7.9	15	2.7
25-Dec-08	91	66	125	23	79	79	79	0	42.8	41.4	44.9	1	53.6	49.8	58.9	3.1	10.8	7.9	14.1	2.3
26-Dec-08	104	79	127	15	79	79	79	0	42.7	39.9	45.7	2.2	55.2	51.7	59.7	2.3	12.6	9.6	15.1	1.4
27-Dec-08	74	66	104	10	79	79	79	0	42.1	40.9	43	0.5	51.1	49.8	55.6	1.5	9	7.7	13.4	1.7
28-Dec-08	81	64	128	21	79	79	79	0	44.4	42.4	46.5	1.3	54.3	50.1	60	3.4	9.9	7.5	14.7	2.6
29-Dec-08	98	65	126	26	79	79	79	0	45.7	44.7	47.1	0.6	56.7	53	61.3	3	11.1	7.6	14.5	2.8
30-Dec-08	91	65	138	26	79	79	79	0	42.9	41.7	45.6	0.9	53.2	49.8	59.1	2.9	10.3	7.5	16	2.8
31-Dec-08	100	67	138	27	79	79	79	0	41.3	39.6	43.2	1	53.7	48.8	62.9	4	12.4	7.4	22.6	4
1-Jan-09	99	88	118	8	58	45	79	16	40	38.7	43.5	1	55.5	53.2	60	1.2	15.6	13	16.6	0.7
2-Jan-09	85	43	100	20	45	45	45	0	38.5	37.5	41.1	1	51.9	45.7	55.2	2.9	13.4	6.9	16	3
3-Jan-09	89	78	92	3	45	45	45	0	40.6	39.2	41.7	0.8	54.7	53.3	56.1	0.9	14.1	12.1	15	0.5
4-Jan-09	68	62	73	2	45	45	45	0	41.4	40.5	43.7	0.8	52.8	51.1	55.1	1	11.4	10.5	12.9	0.6
5-Jan-09	83	47	93	15	45	45	45	0	41.6	40.5	43	0.7	54.7	48.8	57.3	2.5	13.1	7.6	15.1	2.3
6-Jan-09	80	44	93	19	45	45	45	0	41.6	39.8	43.8	1	54.4	48.7	58.5	2.9	12.9	7.6	15.4	2.7
7-Jan-09	86	50	96	14	45	45	45	0	41	39.5	44.2	1.4	54.7	48.7	58.9	2.5	13.7	8.9	16.1	2
8-Jan-09	82	46	93	14	45	45	45	0	41.8	39.9	44	0.9	54.9	50	58.8	2.1	13.2	8.5	15.1	2.2
9-Jan-09	92	80	94	3	45	45	45	0	40.2	39.1	43.2	1	54.9	52.4	57.5	1.2	14.6	12.6	16.1	0.9
10-Jan-09	71	64	93	11	45	45	45	0	41.9	38.9	43.8	1.5	53.7	50.3	57.8	2.5	11.8	10.6	14.4	1.3
11-Jan-09	67	61	85	6	45	45	45	0	38.7	37.5	40.4	0.7	50	49	53.4	1	11.4	10.4	14.3	0.8
12-Jan-09	94	73	100	7	45	45	45	0	42.4	40.6	44.5	1	57	51.9	59.3	1.8	14.6	9.5	16.1	1.5
13-Jan-09	96	77	111	7	58	45	79	16	40.2	38	42.8	1.3	54.7	52.1	57.9	1.5	14.5	11.9	15.8	1.3
14-Jan-09	116	67	144	25	79	79	79	0	40.9	39.1	44.3	1.3	54.1	47.8	58.1	3.3	13.2	7.9	15.2	2.7
15-Jan-09	124	71	143	19	79	79	79	0	41.5	39	44.5	1.6	55.2	49.6	58.8	2.3	13.7	8.2	16	1.7
16-Jan-09	123	89	138	13	77	45	79	7	40	38.3	42.5	1	53.4	50.2	56	1.5	13.4	9.3	15.2	1.2
17-Jan-09	92	85	96	4	45	45	45	0	37.6	35.5	41.2	2	52.5	49.6	56.4	2.1	14.9	13.6	16.1	0.6
18-Jan-09	84	49	95	11	45	45	45	0	37.9	37	38.5	0.5	51.8	47	53.4	1.5	13.9	8.6	15.3	1.6
19-Jan-09	91	83	95	4	45	45	45	0	42.5	38.7	44.7	1.4	57.1	51.5	59.9	2	14.6	12.8	15.5	0.7

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
20-Jan-09	72	46	89	17	45	45	45	0	41.1	38.9	43.7	2	53.2	47.8	57.9	3.3	12.1	8.6	14.8	2.4
21-Jan-09	79	47	91	16	45	45	45	0	41.1	38.4	44	1.9	54	46.9	58.5	3.8	12.9	8.3	14.8	2.4
22-Jan-09	73	44	88	12	45	45	45	0	41.7	39.4	43.3	1.2	53.9	49.9	57.3	2.3	12.2	7.6	14.6	2.1
23-Jan-09	75	54	89	10	45	45	45	0	41.5	39.3	44.3	1.7	53.8	48.7	58.4	2.9	12.3	8.4	14.7	1.7
24-Jan-09	67	46	90	16	45	45	45	0	39.3	38.3	40.4	0.6	51.4	48	54.8	2.2	12.1	8.3	16.2	2.5
25-Jan-09	80	57	91	12	45	45	45	0	39.6	36.1	42.7	2.2	52.6	47.9	56.6	2.6	13	9.9	15.1	1.8
26-Jan-09	91	84	97	4	45	45	45	0	42.9	40.5	45	1.3	57.4	55.4	59.8	1.4	14.5	13.5	15.5	0.7
27-Jan-09	91	73	98	7	45	45	45	0	42.4	39.6	44.8	1.5	57.1	52.8	59.8	1.7	14.7	12.6	15.9	0.8
28-Jan-09	85	50	96	13	45	45	45	0	38.6	37.7	42.5	1	52.6	47.1	57.8	2	14	8.6	15.9	1.9
29-Jan-09	80	51	87	9	45	45	45	0	41.2	39.4	44.5	1.7	54.2	48	58.9	2.8	13.1	8.4	14.6	1.6
30-Jan-09	78	57	86	9	45	45	45	0	41.1	37.9	44.4	2	53.8	49.5	58.5	2.4	12.7	9	14.9	1.5
31-Jan-09	77	45	94	15	45	45	45	0	41.1	39.1	43.4	1.2	54	47.4	57.3	2.9	12.9	8.3	15.4	2.2
1-Feb-09	72	48	95	17	45	45	45	0	40.2	37.5	44	2	52.4	46.3	58.2	3.5	12.2	7.9	15.8	2.5
2-Feb-09	74	45	96	20	45	45	45	0	42.5	41.2	44.2	0.7	54.7	50.6	58.4	2.7	12.3	7.8	16.7	3.1
3-Feb-09	87	60	96	10	45	45	45	0	40.3	38.5	44.3	1.6	54.6	51.8	58.3	1.4	14.3	9.7	16.7	1.6
4-Feb-09	91	84	98	4	45	45	45	0	37	36.2	38.3	0.6	52	48.7	54.8	1.1	14.9	12.5	16.9	1.1
5-Feb-09	93	82	98	4	45	45	45	0	36.3	35.3	37.6	0.8	51.4	48.6	53	1.1	15.1	13.2	16.2	0.7
6-Feb-09	93	82	97	3	45	45	45	0	38.4	36.5	41.2	1.2	53.4	51.8	56.6	1.2	15	14.2	15.9	0.5
7-Feb-09	70	47	94	15	45	45	45	0	39.7	38	42.6	1.4	51.8	47.4	57	2.9	12	8.4	15.3	2.5
8-Feb-09	51	45	74	8	45	45	45	0	40.1	39.5	41.2	0.4	49.2	47.7	52.7	1.2	9.1	8	12.7	1.1
9-Feb-09	85	59	98	12	45	45	45	0	42.1	40.5	44.7	1.4	56.1	49.9	59.4	2.5	14	8.8	16.2	2
10-Feb-09	71	45	98	20	45	45	45	0	42.4	41.1	43.8	0.7	54.7	49.5	59	3.2	12.3	7.9	16.7	3.1
11-Feb-09	71	48	100	16	45	45	45	0	42.5	41.3	44.4	0.9	54.5	50.3	58.8	2.9	12	8.5	16.3	2.6
12-Feb-09	76	45	98	21	45	45	45	0	42.5	40.4	45	1.6	55.2	50.4	58.8	2.6	12.7	8.1	16.5	3.2
13-Feb-09	74	45	97	20	45	45	45	0	40.7	40	43.2	0.6	52.9	48.2	56.5	2.9	12.3	7.8	16.5	3
14-Feb-09	69	46	97	14	45	45	45	0	40.6	39.5	43.4	1	52.2	48.1	58.3	2.6	11.6	8.2	15.7	2
15-Feb-09	70	45	98	17	45	45	45	0	40.1	38.6	41.9	1	51.8	47.6	56.1	2.5	11.7	7.8	15.6	2.5
16-Feb-09	82	62	97	10	45	45	45	0	39.9	38.6	42.5	1.2	53.2	49.1	56.1	1.7	13.3	8.9	15.7	1.7
17-Feb-09	81	60	90	6	45	45	45	0	39.4	39	39.9	0.3	52.7	50	53.6	1	13.3	10.5	14.1	0.9
18-Feb-09	73	47	89	13	45	45	45	0	39.2	38.7	39.7	0.3	51.3	47.9	54.8	2	12	8.2	15.5	2.1
19-Feb-09	61	44	89	14	45	45	45	0	40.6	38.7	42.5	1.3	51.2	47.2	56.3	3.4	10.6	8.1	15.2	2.4
20-Feb-09	78	48	90	12	45	45	45	0	40.5	39	41.9	0.8	53.4	48.6	56.2	2	13	8.1	15.4	2
21-Feb-09	64	46	85	14	45	45	45	0	40	38.5	42.5	1.1	51.2	47.4	55.9	2.1	11.2	8.5	15	2.2
22-Feb-09	59	45	83	11	45	45	45	0	40.7	38.6	43.4	1.6	51.1	47.3	57.1	2.5	10.5	8.3	13.7	1.8
23-Feb-09	73	47	89	13	45	45	45	0	38.6	37.7	40.9	0.7	51.1	47.3	54.1	2.1	12.5	8.5	15.6	2.3
24-Feb-09	86	61	97	7	45	45	45	0	38	36.8	39.2	0.7	52.3	49.6	54.7	1.3	14.3	11.8	16.3	1.1
25-Feb-09	82	60	98	15	45	45	45	0	40.3	38.8	42.4	1.1	53.7	48.5	57.7	2.9	13.4	8.5	15.7	2.4

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
26-Feb-09	76	45	98	19	45	45	45	0	40.9	38.6	44.9	2	53.6	47.6	59.1	3.2	12.7	8	16.7	3.1
27-Feb-09	54	45	81	11	45	45	45	0	42	40.4	45.8	1.4	51.5	48.9	57.7	2.1	9.6	8.3	16	1.7
28-Feb-09	79	49	97	16	45	45	45	0	39.4	38.5	40.3	0.4	52.9	48.7	55.9	2.3	13.5	8.9	16.3	2.4
1-Mar-09	83	51	99	10	45	45	45	0	38.5	37.3	41	0.8	52.8	48.6	55.6	1.8	14.3	10.4	16.8	1.8
2-Mar-09	77	44	97	19	45	45	45	0	36.7	35.9	37.6	0.5	52	46.5	57.2	3.1	15.3	9	20.4	3.4
3-Mar-09	91	64	99	8	45	45	45	0	36.3	34.6	38.6	0.9	51.6	46.8	53.4	1.5	15.3	10.1	17.5	1.5
4-Mar-09	74	45	100	21	45	45	45	0	38	36.6	40.6	1.1	51.1	45.7	55.2	3.1	13.1	8.6	17.2	3.1
5-Mar-09	70	43	99	20	45	45	45	0	40.3	39.1	43.4	1	52.9	48.1	58	2.8	12.6	8.2	17	3.1
6-Mar-09	49	46	58	3	45	45	45	0	41.7	39.4	44.2	1.8	51.1	48.5	54.2	1.9	9.4	8.5	11.8	0.6
7-Mar-09	71	48	102	22	45	45	45	0	42.5	41.1	44.4	0.9	55	49.9	61.4	4.1	12.5	8.5	17.5	3.4
8-Mar-09	73	47	101	21	45	45	45	0	41.5	40.4	42.6	0.6	54.2	49.6	59.4	3.4	12.7	8.5	17.7	3.5
9-Mar-09	76	47	97	17	45	45	45	0	42	40.1	44.1	1.4	55.1	51.2	60.8	2.7	13.1	8.5	16.7	2.7
10-Mar-09	65	46	95	15	45	45	45	0	41.8	39.7	45.1	1.6	53.7	49.3	60.9	3.4	11.9	9	16	2.6
11-Mar-09	62	47	88	13	45	45	45	0	42.1	40.4	45.5	1.7	53.2	49.4	59.5	3.5	11.1	8.3	15	2.2
12-Mar-09	70	47	97	17	45	45	45	0	39.5	39	40	0.3	51.9	48.6	56.1	2.6	12.4	9.1	17	2.6
13-Mar-09	66	47	95	16	45	45	45	0	40.4	37.9	43.3	1.4	52.1	49.3	56.3	2	11.8	8.3	16.1	2.4
14-Mar-09	50	45	65	5	45	45	45	0	42.1	39.3	45.5	1.8	51.6	49.6	54.9	1.6	9.5	8.4	13	1.1
15-Mar-09	52	46	75	9	45	45	45	0	41.4	40.3	42.9	0.7	51.2	48.8	56.5	1.8	9.8	8.5	14.9	1.6
16-Mar-09	59	48	78	11	45	45	45	0	42.3	40.7	43.9	0.9	53	49.6	56.8	2.2	10.7	8.2	14.1	2
17-Mar-09	66	47	106	23	45	45	45	0	43.4	40.6	46.2	1.9	55.4	50.2	62.7	3.7	12	8.6	18	3.6
18-Mar-09	53	47	85	8	45	45	45	0	44	42.4	44.9	0.7	54	52.1	58.5	1.5	10	8.9	14.3	1.3
19-Mar-09	53	44	77	8	45	45	45	0	42.8	41.7	45.2	0.8	52.6	51	55.9	1.4	9.8	8.2	13.2	1.4
20-Mar-09	56	43	93	16	45	45	45	0	41.3	40.5	43.5	0.6	51.5	48.8	57.4	2.5	10.2	8.2	16.7	2.6
21-Mar-09	52	42	81	11	45	45	45	0	41.7	40.8	42.6	0.6	51.3	49	56.3	2.2	9.6	7.9	13.9	1.9
22-Mar-09	51	42	77	10	45	45	45	0	41.5	40.3	42.9	0.8	50.8	48.8	54.2	1.4	9.3	7.9	13.6	1.5
23-Mar-09	56	42	91	16	45	45	45	0	39.7	38.3	42.3	1	50.1	47.5	54.9	2.4	10.3	8	15.8	2.7
24-Mar-09	68	43	96	20	45	45	45	0	41.8	40.1	43.9	1.3	53.9	48.5	59.5	3.5	12.1	8.1	16.4	3.2
25-Mar-09	66	45	95	20	45	45	45	0	41.7	40.7	42.7	0.5	53.7	49.6	58.6	3.1	11.9	8.1	16.4	3.1
26-Mar-09	81	44	100	22	45	45	45	0	41.4	40.4	44.3	1	55.5	49.7	58.9	3.2	14.1	8.3	17.3	3.4
27-Mar-09	64	21	89	19	45	45	45	0	43	41.9	44.5	0.8	54.3	46.5	59.3	3.2	11.3	4.1	15.5	2.9
28-Mar-09	60	43	93	14	45	45	45	0	42.8	41.2	44.2	0.8	53.7	50	59.5	2.9	10.9	7.8	16.1	2.6
29-Mar-09	64	42	99	21	45	45	45	0	45.4	42.3	47.6	1.5	57	50.9	64.3	4.7	11.6	7.8	17.7	3.6
30-Mar-09	63	44	90	15	45	45	45	0	43.1	41.2	45	1.2	54.3	50.2	59.5	3.3	11.2	7.9	15.3	2.7
31-Mar-09	61	44	88	13	45	45	45	0	43.1	40.7	45.8	1.7	54.2	49.7	58.6	2.5	11.1	8.5	15.8	2.3
1-Apr-09	72	45	101	19	45	45	45	0	42.8	41.2	44.4	1.1	55.7	50.2	60.3	3	12.8	7.7	17.9	3.4
2-Apr-09	72	43	98	20	45	45	45	0	43.4	41.4	45.4	1.3	56.2	49.4	62.6	3.9	12.7	8	17.6	3.3
3-Apr-09	59	42	87	15	45	45	45	0	44.1	43.2	46.8	0.9	54.9	51.8	60.3	2.7	10.8	8.4	15.2	2.3

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
4-Apr-09	44	0	95	33	45	45	45	0	42.5	40.3	46.3	2	50.7	41.5	58.9	6.1	8.2	-0.1	16.9	5.8
5-Apr-09	49	43	81	8	45	45	45	0	42.3	40	44.8	1.6	51.6	49	57.8	2.2	9.3	7.7	13.9	1.4
6-Apr-09	13	0	47	20	45	45	45	0	43.9	42.7	44.9	0.6	46.8	43.4	52.8	3.7	2.9	0	9	3.7
7-Apr-09	0	0	0	0	45	45	45	0	40.8	39.2	43.6	1.1	41.1	39.5	43.7	1	0.3	-0.2	0.8	0.3
8-Apr-09	0	0	0	0	45	45	45	0	39.9	39.2	41.3	0.6	40.2	39.5	41.4	0.5	0.3	-0.2	0.7	0.2
9-Apr-09	0	0	0	0	30	0	45	22	41.3	39.1	45.8	2.3	41.6	39	46.8	2.7	0.2	-0.3	1.1	0.5
10-Apr-09	0	0	0	0	0	0	0	0	47	45.9	47.9	0.5	48.3	46.8	49.3	0.8	1.3	0.2	2.1	0.6
11-Apr-09	0	0	0	0	0	0	0	0	47.5	46.8	47.9	0.3	49.7	49.2	50.2	0.2	2.2	1.9	2.7	0.2
12-Apr-09	0	0	0	0	0	0	0	0	46.4	45.4	47.4	0.5	48.2	47	49.6	0.7	1.8	1.3	2.5	0.3
13-Apr-09	0	0	0	0	0	0	0	0	45.8	43.7	46.7	0.9	49.4	44.8	55.8	3	3.7	1.1	10	2.5
14-Apr-09	0	0	0	0	0	0	0	0	46.4	45.6	47.2	0.5	52.5	48.5	57.4	3.2	6.1	2.4	11	3.2
15-Apr-09	0	0	0	0	0	0	0	0	46.2	45.4	47.3	0.6	53.5	50.1	58.7	2.7	7.3	3.6	12.2	2.8
16-Apr-09	0	0	0	0	0	0	0	0	45.6	45.2	46	0.2	52.8	49.8	57.3	2.2	7.3	4.3	11.5	2.2
17-Apr-09	0	0	0	0	0	0	0	0	50.5	45.4	58.2	5.7	58.8	47.2	71.5	8.6	8.3	1.7	13.7	4
18-Apr-09	0	0	0	0	0	0	0	0	58.4	57.6	59.1	0.4	63.2	62	66	0.9	4.8	3.3	7.9	1.2
19-Apr-09	0	0	0	0	0	0	0	0	58.8	58.1	59.4	0.4	61.6	61.1	62.4	0.3	2.8	2.1	3.7	0.5
20-Apr-09	0	0	0	0	0	0	0	0	59	58.7	59.2	0.1	67	61.6	71.8	3.8	8	2.5	12.9	3.8
21-Apr-09	0	0	0	0	0	0	0	0	59.4	58.8	60.2	0.4	66.8	62.8	72.3	3	7.4	3.5	12.1	2.7
22-Apr-09	0	0	0	0	0	0	0	0	59.2	58.8	59.6	0.2	66	62.8	70.3	2.1	6.8	3.9	10.9	2.1
23-Apr-09	0	0	0	0	0	0	0	0	58.7	51.7	60.2	1.8	62.4	58	67.4	2.1	3.7	1.4	7.9	1.8
24-Apr-09	0	0	0	0	0	0	0	0	57.3	51.8	61.3	3.7	57.8	51.3	62.2	4.4	0.5	-1.2	2.4	1.1
25-Apr-09	0	0	0	0	26	0	45	23	48.6	43.9	53.4	3.8	48.2	43.8	52.4	3.4	-0.4	-1.1	0.3	0.5
26-Apr-09	0	0	0	0	45	45	45	0	44.1	42.8	46	1	44.2	43.1	46	1	0.1	-0.3	0.5	0.2
27-Apr-09	0	0	0	0	45	45	45	0	45.1	43.7	46.8	0.9	45.3	43.6	47.1	1.1	0.1	-0.5	1	0.3
28-Apr-09	0	0	0	0	45	45	45	0	46.6	45.2	48.5	1	46.6	45.3	49	1	0	-0.4	0.6	0.3
29-Apr-09	0	0	0	0	35	23	45	12	45.8	44	47.6	1.1	45.9	44.4	47.2	0.9	0.1	-0.5	0.6	0.3
30-Apr-09	0	0	0	0	23	23	23	0	46.7	45.6	48.4	0.7	46.8	45.9	48.6	0.6	0.1	-0.5	0.5	0.3
1-May-09	0	0	0	0	23	23	23	0	45.2	43.9	47.1	0.9	45.6	44.1	47	0.8	0.4	-0.2	1.1	0.3
2-May-09	0	0	0	0	23	23	23	0	43.8	41.5	46.1	1.6	43.9	41.8	46.1	1.5	0.1	-0.5	0.7	0.4
3-May-09	0	0	0	0	23	23	23	0	45.7	44.5	47.4	1	45.8	44.7	47.4	0.9	0.1	-0.5	0.7	0.3
4-May-09	0	0	0	0	23	23	23	0	46	45	47.6	0.8	46	45.2	47	0.6	0	-0.7	0.7	0.4
5-May-09	0	0	0	0	23	23	23	0	46.8	45.7	48.2	0.9	46.8	45.7	47.8	0.7	0	-0.5	0.5	0.3
6-May-09	0	0	0	0	23	23	23	0	48.2	45.9	49.3	0.8	48.3	46.2	49.3	0.8	0.1	-0.5	1	0.4
7-May-09	0	0	0	0	23	23	23	0	46.6	44.6	48.7	1	47	44.9	48.5	0.9	0.4	-0.5	0.7	0.3
8-May-09	0	0	0	0	23	23	23	0	47.9	46.1	50.8	1.5	48.1	46.2	50.5	1.4	0.2	-0.4	0.6	0.3
9-May-09	0	0	0	0	39	23	45	10	47.9	45.7	51.2	1.5	48.2	45.9	51.7	1.5	0.3	-0.2	0.8	0.2
10-May-09	0	0	0	0	45	45	45	0	44.1	43	45	0.6	44.2	42.9	45.2	0.6	0	-0.6	0.7	0.3

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
11-May-09	2	0	25	6	19	0	45	22	50	44.5	60.7	4	48.5	44.6	54.2	2.2	-1.5	-9	7.3	3.6
12-May-09	55	0	96	29	45	45	45	0	51.3	49.3	53.3	1.4	60.4	49.4	69	6	9.1	-0.1	16	4.7
13-May-09	68	43	84	15	45	45	45	0	51.8	49.3	53.3	1.1	63.6	58.8	67.2	2.6	11.8	7.6	16	2.4
14-May-09	52	0	80	14	45	45	45	0	45.6	44	49.1	1.2	54.6	45	63.1	3	9	1	14	2.4
15-May-09	0	0	0	0	45	45	45	0	46.6	42.1	50.4	2.7	46.7	42.7	50.7	2.7	0.1	-0.4	0.8	0.3
16-May-09	0	0	0	0	45	45	45	0	49.2	46.1	52.1	1.7	49.3	46.2	52.3	1.7	0	-0.4	0.5	0.2
17-May-09	0	0	0	0	45	45	45	0	47.2	45.9	48.6	0.9	47.2	45.8	49.2	1	0	-0.6	0.6	0.3
18-May-09	0	0	0	0	21	0	45	23	49.1	47.1	51.4	1.8	49	47.1	51.2	1.6	-0.1	-0.7	0.4	0.3
19-May-09	0	0	0	0	0	0	0	0	51.9	50	53.7	1.1	51.6	49.7	53.2	1	-0.4	-0.9	0.4	0.3
20-May-09	0	0	0	0	20	0	23	8	49.2	46.4	53.7	2.1	49.3	46.8	52.9	1.8	0.1	-1	1.1	0.5
21-May-09	0	0	0	0	23	23	23	0	47.1	45.7	50	1.1	47.4	45.9	50.1	1	0.2	-0.4	0.8	0.2
22-May-09	0	0	0	0	23	23	23	0	49.8	47.2	53.3	2.3	50	47.5	53.1	2.3	0.2	-0.4	0.8	0.3
23-May-09	0	0	0	0	23	23	23	0	54.1	52.4	56.1	1.4	54.1	52.2	56.3	1.5	0	-0.4	0.5	0.2
24-May-09	0	0	0	0	23	23	23	0	56.6	54.6	59.5	1.5	56.7	54.9	59.4	1.5	0.2	-0.3	0.7	0.3
25-May-09	0	0	0	0	39	23	45	10	57.8	54.6	60.3	1.6	57.9	54.7	60.2	1.6	0.1	-0.2	0.4	0.2
26-May-09	53	0	71	15	45	45	45	0	56	52.5	59	1.8	65	57.6	68.8	3	9	0	11.8	2.7
27-May-09	64	48	97	15	45	45	45	0	50.5	48.5	53.2	1.4	61.7	58.6	66.8	2.5	11.2	8.5	15.7	2.5
28-May-09	70	49	100	19	45	45	45	0	49.2	45.6	51.7	2.1	61.6	54.7	66.4	2.8	12.4	8.5	17.1	2.9
29-May-09	60	48	80	10	45	45	45	0	51.8	50.3	53.2	1	63.6	58.9	74.7	3.6	11.8	8.6	21.9	3
30-May-09	53	50	65	4	45	45	45	0	54.3	52.4	56.2	1.3	63.5	61.4	65.8	1.5	9.2	8.6	11.7	0.6
31-May-09	58	50	87	10	45	45	45	0	55.2	53.8	57.1	0.9	65.1	62.4	70.6	2.1	9.9	8.5	14.8	1.6
1-Jun-09	59	52	78	6	45	45	45	0	54.3	52.9	56.1	1	64.2	62.4	67.5	1.2	9.9	8.1	13.5	1.1
2-Jun-09	62	43	85	12	45	45	45	0	55.2	53.3	57.4	1.1	65.9	62	69.8	2.5	10.7	8.6	14.1	1.9
3-Jun-09	64	50	89	13	45	45	45	0	55.2	54.5	56	0.4	65.9	63.1	70.3	2	10.7	7.9	15.4	2.1
4-Jun-09	59	43	83	11	45	45	45	0	56.6	54.4	59.1	1.7	66.5	62.2	70.6	2.5	9.9	7.6	13.3	1.6
5-Jun-09	54	36	72	9	45	45	45	0	58.5	55.1	60.6	1.4	68.1	63	71	2.1	9.6	7.5	12.2	1.2
6-Jun-09	0	0	1	0	45	45	45	0	55.4	54.2	56.6	0.6	55.8	55	60.4	1.1	0.4	-0.3	5.3	1.1
7-Jun-09	0	0	0	0	45	45	45	0	55.8	54.1	57.2	1	55.8	54.1	57.2	1	0	-0.5	0.5	0.3
8-Jun-09	59	0	85	23	45	45	45	0	59.6	56.5	62.1	1.8	69.6	57.6	75.8	5	10.1	1.1	14	3.5
9-Jun-09	54	49	71	6	45	45	45	0	60.4	59.3	61.9	0.8	69.8	68.4	71.9	1.1	9.4	8.4	11.5	0.9
10-Jun-09	57	50	70	8	45	45	45	0	61.5	59.6	63.9	1.7	71.4	68.6	74.6	2.1	9.9	8.5	11.9	1.1
11-Jun-09	51	48	64	3	45	45	45	0	63.2	60.9	65.2	1.2	72.2	69.9	73.8	1.2	9	8.3	9.8	0.5
12-Jun-09	65	33	100	18	45	45	45	0	64	62.5	65.4	0.9	74.9	71.3	80.9	3.1	11	8.2	15.8	2.6
13-Jun-09	0	0	0	0	45	45	45	0	64.7	63.5	65.8	0.6	65	64	66.1	0.6	0.3	-0.2	0.9	0.3
14-Jun-09	0	0	0	0	45	45	45	0	65.1	62.8	67.8	1.5	65.6	63.7	68.4	1.4	0.5	0	0.9	0.2
15-Jun-09	53	0	85	23	45	45	45	0	68	64.5	70.5	2.3	77.2	66.2	83.5	5.1	9.1	0.4	14.1	3.9
16-Jun-09	61	50	84	10	45	45	45	0	69.8	64.6	72.6	1.8	80.2	74.2	85	2.7	10.3	8.6	13.6	1.6

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
17-Jun-09	64	51	98	16	45	45	45	0	58.1	53.3	64	2.9	69.1	61.9	74.8	3.8	11	8.6	15.7	2.6
18-Jun-09	74	50	99	21	45	45	45	0	61.2	59.8	63	1	73.3	68.8	77.7	3	12.2	8.5	15.9	3
19-Jun-09	77	50	99	18	45	45	45	0	64.5	62.1	66	0.9	77.1	71.6	81.8	3.5	12.6	8.5	15.9	2.8
20-Jun-09	2	0	42	9	45	45	45	0	64.1	63.7	64.7	0.2	65.1	63.9	74.7	2.5	1	-0.1	10.5	2.5
21-Jun-09	0	0	0	0	45	45	45	0	64.7	63.3	66.4	1	65.1	63.8	66.5	0.9	0.4	-0.1	0.9	0.3
22-Jun-09	0	0	0	0	45	45	45	0	66.9	65.5	69	1.2	67.2	65.8	69.1	1.1	0.3	-0.1	0.7	0.2
23-Jun-09	0	0	0	0	45	45	45	0	66.9	63.9	68.6	1.1	67.1	64.2	68.8	1.2	0.3	-0.3	0.8	0.3
24-Jun-09	0	0	4	1	45	45	45	0	64.4	62	66.9	1.6	64.8	62.8	66.8	1.4	0.4	-0.3	1.2	0.4
25-Jun-09	67	20	100	24	45	45	45	0	65.3	63.2	67.4	1.1	76.6	70.2	83.6	4.4	11.3	5.1	16.3	3.6
26-Jun-09	66	50	100	20	45	45	45	0	64	62.4	65.1	0.8	75.2	71.3	80.7	3.3	11.2	8.5	16.2	3
27-Jun-09	74	46	95	19	45	45	45	0	65.2	63.4	67.2	1.4	77.6	72	82.8	3.9	12.4	8.3	15.7	2.7
28-Jun-09	67	46	94	17	45	45	45	0	66.9	65.7	68.4	0.8	78.5	74.6	83.3	3.2	11.7	8.2	15.8	2.7
29-Jun-09	68	45	95	19	45	45	45	0	67	66.1	68.4	0.8	78.7	74.9	83.4	2.8	11.7	8.2	15.7	2.7
30-Jun-09	62	0	97	24	45	45	45	0	65.8	65	66.5	0.4	76.6	66.1	81.3	3.6	10.8	0.4	15.4	3.5
1-Jul-09	0	0	0	0	45	45	45	0	64.8	64.3	65.4	0.3	65.1	64	65.8	0.5	0.3	-0.3	0.8	0.3
2-Jul-09	0	0	0	0	13	0	45	21	67.5	65.1	69.1	1.5	67.4	65.6	68.8	1.2	-0.1	-0.7	0.5	0.4
3-Jul-09	0	0	0	0	0	0	0	0	69	68.1	69.8	0.6	68.5	68	69.1	0.3	-0.5	-1	0.3	0.3
4-Jul-09	0	0	0	0	0	0	0	0	68.6	67.7	69.5	0.5	68.1	67.3	68.7	0.3	-0.5	-1.2	0.1	0.3
5-Jul-09	0	0	0	0	0	0	0	0	67.1	65.1	68.6	1	66.4	63.9	67.9	1.3	-0.8	-1.5	-0.1	0.4
6-Jul-09	0	0	0	0	0	0	0	0	68.1	66.8	69	0.7	67.5	66.4	68.2	0.5	-0.7	-1.1	-0.2	0.2
7-Jul-09	0	0	0	0	0	0	0	0	68.6	68	69.2	0.4	67.7	67.1	68.2	0.3	-0.9	-1.2	-0.5	0.2
8-Jul-09	0	0	0	0	0	0	0	0	68.2	67.3	69.1	0.6	67.1	65.3	69.1	1.1	-1.1	-2	0.2	0.6
9-Jul-09	0	0	0	0	0	0	0	0	68.2	66.6	69.1	0.9	68	66.1	69.3	1.2	-0.2	-1.2	0.6	0.4
10-Jul-09	0	0	0	0	0	0	0	0	69.2	67.8	70.5	0.9	69.1	67.4	70.4	1	-0.1	-0.4	0.4	0.2
11-Jul-09	0	0	0	0	0	0	0	0	71.2	70.6	71.6	0.3	70.8	70.5	71.2	0.2	-0.3	-0.9	0.1	0.3
12-Jul-09	0	0	0	0	0	0	0	0	69.9	68.7	71	0.6	69.3	67.9	70.8	0.8	-0.6	-1.3	0	0.3
13-Jul-09	0	0	0	0	0	0	0	0	69	67.4	70.3	0.8	68.8	67.3	70.2	0.9	-0.2	-0.8	0.5	0.4
14-Jul-09	0	0	0	0	0	0	0	0	68.3	66.6	69.5	0.9	68	66.3	69.5	1.1	-0.2	-0.6	0.4	0.3
15-Jul-09	0	0	0	0	0	0	0	0	68.6	67	69.8	1	68.3	66.7	69.5	0.9	-0.3	-1	0.5	0.4
16-Jul-09	0	0	0	0	0	0	0	0	70.4	69.5	71.2	0.5	69.1	68.6	69.5	0.3	-1.3	-1.9	-0.7	0.3
17-Jul-09	0	0	0	0	0	0	0	0	70.9	70.3	71.3	0.3	69.2	68.8	69.5	0.2	-1.7	-2	-1.2	0.2
18-Jul-09	0	0	0	0	0	0	0	0	70.1	69.2	70.9	0.5	68.7	67.9	69.2	0.4	-1.4	-1.9	-0.9	0.3
19-Jul-09	0	0	0	0	28	0	45	22	70	68.7	72.2	1	69.6	66.6	74.1	2.1	-0.3	-2.1	1.9	1.2
20-Jul-09	57	0	99	35	45	45	45	0	72	69.5	74.5	2	82.4	70.9	92.3	7.4	10.4	1.2	18.4	5.7
21-Jul-09	82	48	101	20	45	45	45	0	74.7	73.2	76.5	1.1	89.5	83.7	93.5	3	14.9	10.1	18.3	2.5
22-Jul-09	72	44	105	26	55	45	68	11	75.2	73.6	77.2	1.1	87.9	82.8	96.5	4.2	12.7	7.8	20.3	4
23-Jul-09	66	42	107	26	68	68	68	0	73.8	71.1	76.1	1.7	84.2	78.2	91.8	4.5	10.5	6.8	15.7	3.4

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
24-Jul-09	64	42	97	20	68	68	68	0	70.1	67.9	71.4	1.2	80	76.7	86.2	3	9.9	6.8	15.4	3
25-Jul-09	9	0	47	18	66	45	68	6	71.4	70.2	72.7	0.9	72.7	69.7	78.2	2.8	1.3	-0.6	7.5	3
26-Jul-09	0	0	0	0	45	45	45	0	72.4	71.3	74.1	1	72.3	71	74.1	1.1	-0.1	-0.8	0.2	0.3
27-Jul-09	0	0	0	0	45	45	45	0	72.8	72	74.1	0.7	72.7	71.7	74.1	0.8	-0.1	-0.6	0.2	0.2
28-Jul-09	65	0	90	33	45	45	45	0	73.9	72.4	75.6	1	84.5	72.8	91.1	6.3	10.7	-0.3	15.8	5.7
29-Jul-09	53	42	94	15	45	45	45	0	73.8	73.1	74.6	0.5	83.2	81	88.3	2.4	9.4	7.3	14.5	2.6
30-Jul-09	60	50	84	7	45	45	45	0	74.8	72.9	77.4	1.4	85.2	81.8	91.2	2.7	10.4	8.7	15.1	1.7
31-Jul-09	64	51	89	12	45	45	45	0	75.5	75	75.9	0.2	86.9	84.3	89.9	1.6	11.5	9	14.6	1.6
1-Aug-09	66	51	91	13	45	45	45	0	75.2	73.7	76.9	1	86.6	83.4	91.1	2.6	11.4	9.2	14.9	2
2-Aug-09	56	50	68	5	45	45	45	0	74.9	74.1	75.9	0.5	84.7	82.6	86.9	1.1	9.9	8.3	12.6	1
3-Aug-09	69	50	99	17	45	45	45	0	74.6	72.8	76.3	1.2	87	82	96	3.3	12.4	8.6	20.6	3
4-Aug-09	80	50	102	18	45	45	45	0	75.2	74.1	76.9	0.9	88.3	83.1	95	3.6	13.1	8.5	18.6	3
5-Aug-09	59	42	94	18	45	45	45	0	75.7	74.5	77.3	0.9	86.7	82.7	92.8	2.9	11	7.4	18.2	3.3
6-Aug-09	69	49	97	15	45	45	45	0	76.1	74.2	78.6	1.4	88	83.7	93.3	2.8	11.8	8.5	15.1	2.1
7-Aug-09	72	43	101	20	45	45	45	0	76.1	74.8	77.9	1	88.7	83.4	95.2	3.9	12.6	7.7	17.7	3.3
8-Aug-09	49	43	60	4	45	45	45	0	75.5	73.9	76.8	0.9	84.8	82.3	87.9	1.5	9.4	8	12.3	1.2
9-Aug-09	61	43	97	18	45	45	45	0	75.1	74	76.2	0.5	86	83.5	90.1	2.2	11	8	15.5	2.4
10-Aug-09	80	42	100	21	57	45	68	12	74.6	73.2	76.1	1	86.8	81.6	91.9	3.5	12.2	7.3	16.4	3
11-Aug-09	96	90	102	3	68	68	68	0	76.5	74	78.6	1.7	89.9	86.1	93.3	1.8	13.4	11.6	15.6	0.9
12-Aug-09	83	56	97	14	68	68	68	0	78.1	76.8	79.6	0.9	90.5	85	94.5	3.1	12.4	8	15.5	2.4
13-Aug-09	67	44	92	15	68	68	68	0	78.8	76.9	81.1	1.4	89.6	85.2	96.7	3	10.7	7.7	16.8	2.2
14-Aug-09	86	49	102	18	68	68	68	0	79.2	77.3	81.3	1.4	91.5	85.7	96.9	3.4	12.3	8.1	15.9	2.4
15-Aug-09	87	55	102	16	68	68	68	0	78	76.7	79.4	0.6	90.2	86.5	92.8	1.9	12.2	8.7	14.9	1.9
16-Aug-09	80	47	100	22	68	68	68	0	77.6	75.8	79.3	1.1	88.5	83.8	92.6	3.5	10.9	6.5	14.2	2.8
17-Aug-09	88	48	101	17	68	68	68	0	78.9	76.9	80.8	1.3	91.1	84.7	96.4	3.2	12.2	7.1	15.9	2.2
18-Aug-09	77	46	97	18	68	68	68	0	78.1	77.5	78.8	0.3	88.6	85	90.8	2	10.5	6.9	12.9	1.9
19-Aug-09	76	49	100	18	68	68	68	0	78.4	76.4	80.5	1.4	88.7	84.1	93.1	3.1	10.3	6.5	13.7	2.3
20-Aug-09	81	47	101	19	68	68	68	0	79	78.5	79.6	0.4	90.6	85.3	94	2.8	11.6	6.8	14.5	2.4
21-Aug-09	83	54	98	15	68	68	68	0	77.7	76.7	78.3	0.4	89.2	85.4	91.1	1.7	11.5	7.8	13	1.7
22-Aug-09	63	45	97	17	68	68	68	0	78.4	76.9	79.9	1.1	87.9	84.4	92.6	2.2	9.5	6.6	14.3	2.2
23-Aug-09	72	49	104	19	68	68	68	0	78.8	78	79.3	0.4	89.6	86.2	93.3	2.4	10.9	7.8	14.3	2.3
24-Aug-09	44	0	92	33	68	68	68	0	78.2	77.4	79.2	0.5	84.6	78.6	90.4	4	6.5	-0.1	13	4.5
25-Aug-09	74	44	102	24	68	68	68	0	78.2	76.9	80	0.9	88.7	84.2	93.7	3.3	10.4	6.8	14.9	3
26-Aug-09	55	43	78	12	68	68	68	0	77.5	77	78.1	0.4	85.6	83.8	91.8	2	8.1	6.5	13.7	1.9
27-Aug-09	83	50	100	14	68	68	68	0	77.2	75.8	79	0.9	88.9	85.1	94.2	2.3	11.7	8.3	15.5	1.8
28-Aug-09	10	0	97	25	59	23	68	19	76.1	75.2	76.8	0.4	77.8	74.9	92	5	1.7	-0.6	15.4	4.8
29-Aug-09	0	0	0	0	23	23	23	0	75.3	74.6	76.3	0.5	74.9	73.9	75.5	0.5	-0.4	-1.5	0.1	0.4

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
30-Aug-09	0	0	0	0	23	23	23	0	73.3	71.9	74.6	0.6	72.1	70.9	73.2	0.6	-1.1	-1.6	-0.2	0.3
31-Aug-09	0	0	0	0	18	0	23	9	71	69.7	72	0.6	70.3	69.4	72.1	0.7	-0.7	-1.5	0.6	0.5
1-Sep-09	0	0	0	0	0	0	0	0	75.5	68	80.8	5								
2-Sep-09	0	0	0	0	0	0	0	0	78.7	76.8	80.3	1.1								
3-Sep-09	0	0	0	0	0	0	0	0	78.8	76.5	81.3	1.6								
4-Sep-09	0	0	0	0	0	0	0	0	79.5	77.6	81.5	1.4								
5-Sep-09	0	0	0	0	0	0	0	0	79.7	77.7	81.8	1.5								
6-Sep-09	0	0	0	0	0	0	0	0	79.8	78.4	81.3	0.9								
7-Sep-09	0	0	0	0	0	0	0	0	80	78.1	81.7	1.3								
8-Sep-09	0	0	0	0	0	0	0	0	81.3	79.7	82.6	0.9								
9-Sep-09	0	0	0	0	0	0	0	0	81.5	80.2	82.8	0.8								
10-Sep-09	0	0	0	0	0	0	0	0	78.5	76.8	80.1	1								
11-Sep-09	0	0	0	0	0	0	0	0	77.5	75.2	79.4	1.5								
12-Sep-09	0	0	0	0	0	0	0	0	80	79.5	80.8	0.5								
13-Sep-09	0	0	0	0	0	0	0	0	80.3	79.3	81.1	0.5								
14-Sep-09	0	0	0	0	0	0	0	0	79.5	78.1	80.6	0.6								
15-Sep-09	0	0	0	0	0	0	0	0	79	77.6	80.5	1								
16-Sep-09	0	0	0	0	0	0	0	0	76.3	74.2	77.9	1.2								
17-Sep-09	0	0	0	0	0	0	0	0	76.7	74.2	78.9	1.6								
18-Sep-09	0	0	0	0	0	0	0	0	76.6	74.5	78.7	1.3								
19-Sep-09	0	0	0	0	25	0	45	23	75.1	72.4	77.7	1.7								
20-Sep-09	0	0	0	0	45	45	45	0	76	74	78.9	1.7								
21-Sep-09	54	0	101	42	45	45	45	0	78.4	76.6	80.5	1.3								
22-Sep-09	75	43	98	18	45	45	45	0	79	77.8	80.4	0.8								
23-Sep-09	80	43	101	20	45	45	45	0	80	78.8	80.9	0.7								
24-Sep-09	82	51	97	16	45	45	45	0	80.8	79.7	81.8	0.6								
25-Sep-09	50	43	73	6	45	45	45	0	78.9	78.1	79.8	0.5								
26-Sep-09	46	43	66	5	45	45	45	0	76.7	75.7	78.3	0.6								
27-Sep-09	48	43	60	5	45	45	45	0	76.7	75.4	77.9	0.6								
28-Sep-09	58	43	92	17	45	45	45	0	75.4	74	77	0.9								
29-Sep-09	50	39	81	11	45	45	45	0	75.4	74.3	76.1	0.5								
30-Sep-09	0	0	7	1	9	0	45	19	74.4	72.8	75.7	0.7								
1-Oct-09	0	0	0	0	0	0	0	0	71.6	70.7	73.1	0.7								
2-Oct-09	0	0	0	0	0	0	0	0	70.4	69.7	71.6	0.5								
3-Oct-09	0	0	0	0	0	0	0	0	72.2	71.4	73.1	0.5								
4-Oct-09	0	0	0	0	0	0	0	0	71.6	70.4	72.8	0.7								
5-Oct-09	0	0	0	0	0	0	0	0	71.5	70.9	72.1	0.4								

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
6-Oct-09	0	0	0	0	0	0	0	0	71	69.8	72.2	0.9								
7-Oct-09	0	0	0	0	0	0	0	0	71.8	70.8	73.2	0.7								
8-Oct-09	0	0	0	0	0	0	0	0	71.1	70	72.1	0.6								
9-Oct-09	0	0	0	0	0	0	0	0	71.9	71.2	72.7	0.5								
10-Oct-09	0	0	0	0	0	0	0	0	71.4	69.5	72.9	0.9								
11-Oct-09	0	0	0	0	3	0	45	10	69.2	67.8	71.7	0.9								
12-Oct-09	20	0	89	33	45	45	45	0	66.7	65.7	67.5	0.6								
13-Oct-09	72	44	95	19	45	45	45	0	69.2	67.4	71.4	1.3								
14-Oct-09	80	43	97	16	45	45	45	0	69.3	67.9	70.6	0.7								
15-Oct-09	83	47	99	18	45	45	45	0	68.3	67.3	69.8	0.8								
16-Oct-09	87	49	97	14	45	45	45	0	68.2	67.4	69.2	0.5								
17-Oct-09	86	52	104	13	45	45	45	0	69.4	68.5	70.6	0.5								
18-Oct-09	93	72	103	8	45	45	45	0	69.6	68.5	70.6	0.5								
19-Oct-09	84	51	101	14	45	45	45	0	67.5	66.6	68.7	0.6								
20-Oct-09	79	43	100	20	45	45	45	0	63.8	59.3	67.9	3.3								
21-Oct-09	82	55	99	14	45	45	45	0	59.1	57.8	60.5	0.8								
22-Oct-09	83	45	102	19	45	45	45	0	61.8	56.9	71.3	5.3								
23-Oct-09	82	50	99	15	45	45	45	0	67.8	66.8	69	0.5								
24-Oct-09	68	46	97	15	45	45	45	0	68	66.5	70.5	1.4								
25-Oct-09	47	43	69	7	45	45	45	0	68.5	67.3	69.5	0.7								
26-Oct-09	72	45	94	19	45	45	45	0	66.1	63.4	68.4	1.5								
27-Oct-09	84	54	102	17	45	45	45	0	66.7	60.2	72.6	3.4								
28-Oct-09	86	58	98	14	45	45	45	0	68	63.9	70.2	2.3								
29-Oct-09	86	50	99	15	45	45	45	0	63.5	57.9	69.4	3.1								
30-Oct-09	73	49	99	15	45	45	45	0	58.7	58.1	59.1	0.3								
31-Oct-09	57	44	92	12	45	45	45	0	57.9	56.8	59.2	0.6								
1-Nov-09	83	48	99	14	45	45	45	0	57.2	56.5	57.8	0.4								
2-Nov-09	83	53	97	14	45	45	45	0	56.7	55.9	60.5	1								
3-Nov-09	90	54	103	13	45	45	45	0	56.5	56	56.9	0.3								
4-Nov-09	73	43	96	19	45	45	45	0	55.9	55	56.4	0.5								
5-Nov-09	83	48	98	16	45	45	45	0	54.8	53.5	55.7	0.6								
6-Nov-09	87	67	102	10	45	45	45	0	54.1	53.1	55.8	0.7								
7-Nov-09	64	44	95	15	45	45	45	0	51.8	50.8	53.2	0.6								
8-Nov-09	73	48	96	17	45	45	45	0	52.7	51.3	54.4	1								
9-Nov-09	66	46	98	17	45	45	45	0	53.1	52.2	53.7	0.5								
10-Nov-09	78	48	98	14	45	45	45	0	54.9	53.3	55.9	0.7								
11-Nov-09	77	51	95	16	45	45	45	0	54.4	53.2	55.7	0.7								

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
12-Nov-09	85	59	98	12	45	45	45	0	53.4	51.6	55.7	1.2								
13-Nov-09	72	54	95	11	45	45	45	0	53.3	52.6	54.3	0.4								
14-Nov-09	57	45	91	13	45	45	45	0	54	53.4	54.9	0.5								
15-Nov-09	47	42	58	4	45	45	45	0	54.2	53	54.9	0.6								
16-Nov-09	55	43	90	14	45	45	45	0	53.7	52.8	54.7	0.5								
17-Nov-09	72	45	102	17	45	45	45	0	52.7	52.2	53.3	0.4								
18-Nov-09	83	49	98	13	45	45	45	0	52.6	51.7	53.4	0.4								
19-Nov-09	77	49	95	14	45	45	45	0	52.7	52.1	54.1	0.4								
20-Nov-09	61	44	86	14	45	45	45	0	53.2	52.4	54.1	0.4								
21-Nov-09	67	45	93	18	45	45	45	0	52.6	51.9	53	0.3								
22-Nov-09	75	48	95	16	45	45	45	0	52.7	52.2	53.4	0.3								
23-Nov-09	78	50	93	17	45	45	45	0	52	51.4	52.8	0.4								
24-Nov-09	73	45	94	17	45	45	45	0	52.3	51.8	53.3	0.4								
25-Nov-09	76	52	94	16	45	45	45	0	52.1	51.2	53.2	0.6								
26-Nov-09	65	44	97	18	45	45	45	0	52.3	51.5	53	0.5								
27-Nov-09	56	44	94	12	45	45	45	0	51.5	50.4	52.4	0.4								
28-Nov-09	54	44	85	12	45	45	45	0	49.8	48.9	50.9	0.5								
29-Nov-09	81	54	97	15	45	45	45	0	49.7	48.9	51	0.5								
30-Nov-09	79	42	99	18	45	45	45	0	50.6	50	51.6	0.5								
1-Dec-09	91	69	99	6	45	45	45	0	50.5	49.1	51.1	0.5								
2-Dec-09	79	49	95	14	45	45	45	0	49.2	47.9	50.8	0.9								
3-Dec-09	79	54	94	10	45	45	45	0	50.6	48.4	51.9	1.1								
4-Dec-09	75	50	96	14	45	45	45	0	50.7	50.3	51.3	0.3								
5-Dec-09	93	74	99	7	45	45	45	0	49.6	49	50.1	0.3								
6-Dec-09	84	50	98	17	45	45	45	0	47.9	46.9	49	0.6								
7-Dec-09	94	89	98	2	45	45	45	0	46.1	45.2	47.6	0.8								
8-Dec-09	89	55	103	13	45	45	45	0	47.5	46.2	48.8	0.5								
9-Dec-09	86	61	97	12	45	45	45	0	47.9	44.1	57.7	4.1								
10-Dec-09	74	45	98	20	45	45	45	0	57.2	55.7	58.3	0.7								
11-Dec-09	91	68	98	8	45	45	45	0	55.5	54.4	56.3	0.5								
12-Dec-09	80	49	103	18	45	45	45	0	54.9	53.2	56.1	0.7								
13-Dec-09	78	47	100	20	45	45	45	0	51.2	48.8	53.9	1.4								
14-Dec-09	87	54	99	15	45	45	45	0	55.2	52.9	56.8	1								
15-Dec-09	71	46	95	16	45	45	45	0	55	52.2	57.2	2								
16-Dec-09	70	47	95	17	45	45	45	0	55.5	54.7	56.3	0.5								
17-Dec-09	77	45	103	19	45	45	45	0	53.9	53.2	54.6	0.4								
18-Dec-09	97	89	103	4	45	45	45	0	52.9	51	54.3	1.1								

date	avg gen MW	min gen MW	max gen MW	sd gen MW	avg kgpm	min kgpm	max kgpm	sd kgpm	avg in temp	min in temp	max in temp	sd in temp	avg dis temp	min dis temp	max dis temp	sd dis temp	avg delta t	min delta t	max delta t	sd delta t
19-Dec-09	97	83	102	4	45	45	45	0	53.6	51.1	55.7	1.2								
20-Dec-09	68	44	97	22	45	45	45	0	52.7	51.2	53.9	0.7								
21-Dec-09	58	45	101	18	45	45	45	0	53.3	51.9	55.6	0.9								
22-Dec-09	78	44	101	21	45	45	45	0	54.2	53.3	55.5	0.7								
23-Dec-09	79	50	99	16	45	45	45	0	53.8	52.5	56	1.1								
24-Dec-09	60	46	85	14	45	45	45	0	53.9	52.2	55.1	0.9								
25-Dec-09	84	45	105	20	45	45	45	0	51.1	50.3	52.2	0.6								
26-Dec-09	74	45	100	19	45	45	45	0	52.8	51.8	54.1	0.7								
27-Dec-09	64	43	100	21	45	45	45	0	55.2	54.7	55.7	0.3								
28-Dec-09	66	43	101	19	45	45	45	0	54.6	53.7	55.5	0.5								
29-Dec-09	78	49	101	20	45	45	45	0	52.2	50.9	54	0.7								
30-Dec-09	94	83	101	5	45	45	45	0	52.9	50.3	54.2	1.1								
31-Dec-09	69	50	97	18	45	45	45	0	49.2	47.3	51.8	1.5								

APPENDIX F

Impingement and Entrainment Characterization Study Addendum

AES GREENIDGE GENERATING STATION

IMPINGEMENT AND ENTRAINMENT CHARACTERIZATION STUDY

ADDENDUM

Prepared for:

AES Greenidge, LLC
590 Plant Road
Dresden, NY 14441

Prepared by:

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August 5, 2010

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1.0 INTRODUCTION

AES Greenidge Generating Station (hereafter AES Greenidge) is a coal-fired facility located on the western shore of Seneca Lake in Yates County, New York. AES Greenidge currently operates under State Pollutant Discharge Elimination System (SPDES) permit number NY0001325, with a 1 February 2010 Effective Date (EDP). Section B of the permit calls for AES to submit a series of reports demonstrating how they will meet the requirements of 6NYCRR §704.5 and Clean Water Act §316(b). These reports are identified in Biological Monitoring Requirements 1 through 6 in the permit. Biological Monitoring Requirement 1, the *Impingement and Entrainment Characterization Study (IECS)*, was submitted to NYS Department of Environmental Conservation (DEC) on 29 April 2010 to meet the EDP plus three-month deadline of the Requirement.

This document is an addendum to the IECS report and provided because additional information has become available about the station's full rated flow and actual operating flows for Unit 4 during 2006. The required changes to the data provided in the April 2010 IECS result from the following:

1) Full rated flow for Unit 4 is being changed from 91.2 kgpm to 68.0 kgpm; as a result the full-rated flow for Units 3 and 4 combined is reduced from 124.5 kgpm to 102.2 kgpm.

   (The 91.2 kgpm value is the plated capacity of the three circulating water pumps at Unit 4; however, pumping rate data collected at the facility confirm that the actual maximum pumping rate is 68.0 kgpm, or 22.67 kgpm per pump. The difference between the plated capacity and the actual pumping rate is expected to be due to the suction withdrawal configuration of Unit 4 which results in considerable pump rate loss (~25%) relative to the plated capacity.)

2) Actual withdrawal rates at Unit 4 were recorded as 60.8 instead of 45.3 kgpm in plant logs during a number of dates between the January 1 through June 27, 2006. The values have now been corrected to 45.3 kgpm where appropriate.

(The 60.8 kgpm values were reported for certain periods of two pump operation at Unit 4. As discussed under item 1, the actual pumping rate at Unit 4 is 22.67 kgpm per pump or 45.3 kgpm for two pump operation.)

The resulting changes to the estimated annual entrainment and impingement for Units 3 and 4 combined are summarized in the following table:

Fish Losses Metric	April 2010 IECS	August 2010 Addendum
Actual Flow Entrainment	591,700	532,600
Full Rated Flow Entrainment	813,200	662,900
Actual Flow Impingement	9,996	9,645
Full Rated Flow Impingement	20,186	16,452

The remainder of this addendum provides Section 5.2 and 5.3 of the IECS updated to reflect the aforementioned changes in actual and full rated flow at Unit 4.

2.0 UPDATED IECS SECTION 5.2 AND 5.3 TEXT AND TABLES

5.2 IMPINGEMENT

5.2.1 Current and Full Flow Annual Impingement (Numbers)

A total of 9,645 (with a 95% confidence interval of 4,059 - 15,529) fish and crayfish were estimated to have been impinged at AES Greenidge during 2006 (Table 12a). This estimate, which accounts for the total cooling water intake volume at Unit 3 and Unit 4, was comprised of 8,477 fish and 1,168 crayfish. Of this total, 3,853 organisms (approximately 40%) were attributable to the Unit 3 intake flow and 5,792 organisms (approximately 60%) were attributable to Unit 4 (Tables 12b and 12c, respectively). Total impingement peaked in January and February with those months contributing 3,325 and 1,358 organisms to the total, respectively (Table 12a). The three lowest monthly impingement estimates occurred in the spring with March, April, and May contributing 32, 250, and 225 organisms to the total, respectively.

Lepomis species were impinged in the greatest number with a total estimate of 3,475 individuals. Pumpkinseed and bluegill, which are of the genus *Lepomis,* contributed an additional 651 and 939 organisms to the total, respectively (Table 12a). When taken together, *Lepomis* accounts for 53% of the total estimated annual impingement. Other taxa contributing to impingement included brown bullhead (1,227), crayfish (1,168), banded killifish (1,010), alewife (542), largemouth bass (226), and bluntnose minnow (107). All other taxa contributed less than 1% to the estimated total impinged (Table 12a).

Under full rated flow of the circulating water pumps (102.2 kgpm), it is estimated that annual impingement at AES Greenidge would be 16,452 individuals, of which 14,911 (91%) are fish and 1,541 (9%) are crayfish (Table 12d). Impingement would be highest during the months of January (5,187) and October (2,893) and lowest during March (48) and April (323). In terms of the fishes, sunfish species would be impinged at the highest annual rate (7,042/year), followed by banded killifish (1,884/year), brown bullhead (1,863/year), bluegill (1,438/year) and pumpkinseed (1,122/year); all other fishes would be impinged at a rate of less than 1,000/year.

5.2.2 Current and Full Flow Annual Impingement (Biomass)

A total of 105.6 kg (with a 95% confidence interval of 19.6 – 218.6) of fish and crayfish were estimated to have been impinged at AES Greenidge during 2006 (Table 13a). This estimate, which accounts for the total cooling water intake at Unit 3 and Unit 4, was comprised of 10.8 kg of decapods (crayfish) and 94.8 kg of fish. Of this total, 35.1 kg (approximately 33%) was attributable to the Unit 3 intake flow and 70.5 kg (approximately 67%) was attributable to Unit 4 (Tables 13b and 13c, respectively). Total biomass impinged peaked in June at 20.3 kg with brown bullhead accounting for 72% of the impinged biomass in that month (Table 13a). The three next highest months for impinged biomass were January (20.2 kg), July (17.4 kg) and May (16.7 kg). Largemouth bass accounted for 76% of the biomass in January, while alewife (43%) and bullheads and catfishes (91%) accounted for the largest percentage of biomass in July and May, respectively. The two lowest monthly biomass estimates occurred in March (0.03 kg) and April (1.4 kg).

The estimated annual biomass impinged consisted primarily of brown bullhead (21.3 kg), Ictaluridae species (15.2 kg), and largemouth bass (15.7 kg), which together accounted for 49% of the estimated total (Table 13a). Other taxa contributing to the impinged biomass totals included crayfish (10.8 kg), Petromyzontidae (11.5 kg), alewife (9.5 kg), pumpkinseed (6.0 kg), yellow perch (5.5 kg), *Lepomis* species (4.6 kg), banded killifish (2.7 kg), and bluegill (2.0 kg). All other taxa combined contributed less than 1% to the estimated total biomass impinged (Table 13a).

Under full rated flow of the circulating water pumps (102.2 kgpm), it is estimated that annual impingement at AES Greenidge would be 162.2 kg, of which 148.5 kg (92%) is fish and 13.7 kg (8%) is crayfish (Table 13d). Impingement would be highest during the months of January (31.5 kg) and May (29.9 kg) and lowest during March (0.05 kg) and April (1.8 kg). In terms of the fishes, brown bullhead contributed the most to the impinged biomass with 29.2 kg per year followed by bullheads and catfishes and largemouth bass with an estimated 27.2 kg and 24.4 kg per year, respectively. All other fishes contributed less than, and more often much less than, 16 kg per year.

5.3 ENTRAINMENT

5.3.1 Current and Full Flow Annual Entrainment

A total of more than 532,000 early lifestage fish (with a 95% confidence interval of 52,100 – 1,189,800) were estimated to have been entrained at AES Greenidge during April through September, 2006 (Table 14a). Of the total, 181,000 (34%) individuals are attributable to the flow from the now retired Unit 3 while 351,600 (66%) are attributable to Unit 4 (Table 14b and 14c). The total combined Units estimate, which accounts for the total cooling water intake flows (i.e., Unit 3 and Unit 4 cooling water intake volumes), is comprised of approximately 208,000 eggs, 23,000 yolk-sac larvae, 143,900 post-yolk-sac larvae, 46,300 unidentified-life stage (YS/PYS) larvae, and 111,400 juveniles. Total entrainment peaked in June (183,000 organisms) and July (205,500). Alewife eggs, banded killifish juveniles and post-yolk-sac white sucker larvae were entrained in the greatest number with a total of 140,300, 81,900, and 80,000 respectively. Other species and life stages contributing to entrainment were post-yolk-sac banded killifish (24,700), unidentified life stage sucker larvae (25,100) and unidentified eggs (57,000). All other species and life stages contributed less than 17,000 individuals to the estimated total entrainment.

Under full rated flow of the circulating water pumps (102.2 kgpm) during April through September, an estimated 662,900 early life stage fish would be entrained at AES Greenidge (Table 14d). Of these months, entrainment would be highest during June (244,900) and July (210,600). June entrainment would include a number of species, but be comprised mostly of alewife eggs (77%) while June entrainment would be distributed primarily among banded killifish juveniles (40%) and post yolk sac larvae (12%) and unidentified eggs (24%). Alewife (eggs only) would be entrained in the largest numbers (187,800) followed by white sucker (141,900) and banded killifish (109,200); all other taxa would be entrained at a rate of approximately 40,000 or less per year.

5.4 TABLES

Table 12a - Estimated Annual Impingement (Expressed as Numbers of Organisms) at AES Greenidge, Units 3 and 4 Combined, 2006

Common Name	Scientific Name	Estimated Annual Impingement, Combined Units 3 and 4*												Total Est. Impinged	Lower 95% C.I.	Upper 95% C.I
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Alewife	*Alosa pseudoharengus*					24	86	432						**542**	**78**	**1,005**
Banded Killifish	*Fundulus diaphanus*	484			89			25	19		29	237	128	**1,010**	**246**	**1,775**
Basses and Sunfishes	Centrarchidae spp.					21								**21**		**50**
Bluegill	*Lepomis macrochirus*	384	160	32							9		353	**939**	**223**	**1,655**
Bluntnose Minnow	*Pimephales notatus*								28	57	4	18		**107**		**220**
Brown Bullhead	*Ameiurus nebulosus*	38	744				35		187	57	35	100	32	**1,227**		**2,546**
Bullheads and Catfishes	Ictaluridae spp.					36								**36**		**86**
Crayfish	Astacidae				107	108	397	373	66	85	12	21		**1,168**	**820**	**1,517**
Lamprey species	Petromyzontidae spp.									28				**28**		**77**
Largemouth Bass	*Micropterus salmoides*	161						23	38		4			**226**	**51**	**401**
Pumpkinseed	*Lepomis gibbosus*		357		36			70	19	23	43	72	32	**651**		**1,336**
Rock Bass	*Ambloplites rupestris*									28	4			**33**		**82**
Smallmouth Bass	*Micropterus dolomieu*	77												**77**		**219**
Spottail Shiner	*Notropis hudsonius*						35	22						**57**		**128**
Sunfish species	*Lepomis* spp.	2,181	97		18	36			47	97	357	224	418	**3,475**	**2,641**	**4,308**
Unidentified	Unidentified								19					**19**		**51**
Yellow Perch	*Perca flavescens*							25			4			**29**		**73**
Total Estimated Number Impinged		**3,325**	**1,358**	**32**	**250**	**225**	**553**	**970**	**423**	**375**	**501**	**672**	**963**	**9,645**	**4,059**	**15,529**

*blank cells have a value of zero

Note: estimates are based on 2006-2007 Unit 3 impingement collections; Unit 4 has no travelling screens such that "impingement" attributable to flow at this unit would actually be entrainment.

Table 12b - Estimated Annual Impingement (Expressed as Numbers of Organisms) at AES Greenidge, Unit 3, 2006

Common Name	**Scientific Name**	**Estimated Annual Impingement, Unit 3***												**Total Est. Impinged**
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
Alewife	*Alosa pseudoharengus*					5	32	143						**180**
Banded Killifish	*Fundulus diaphanus*	151			38			8	6		28	179	52	**461**
Basses and Sunfishes	Centrarchidae spp.	119	63	11							9		143	**345**
Bluegill	*Lepomis macrochirus*								9	11	4	14		**38**
Bluntnose Minnow	*Pimephales notatus*	12	292				13		61	11	34	75	13	**512**
Brown Bullhead	*Ameiurus nebulosus*					4								**4**
Bullheads and Catfishes	Ictaluridae spp.				45	22	148	123	22	16	12	16		**404**
Crayfish	Astacidae					7								**7**
Lamprey species	Petromyzontidae spp.	50						8	12		4			**74**
Largemouth Bass	*Micropterus salmoides*	679	38		8	7			15	19	348	169	170	**1,452**
Pumpkinseed	*Lepomis gibbosus*									5				**5**
Rock Bass	*Ambloplites rupestris*		140		15			23	6	4	42	54	13	**298**
Smallmouth Bass	*Micropterus dolomieu*									5	4			**9**
Spottail Shiner	*Notropis hudsonius*	24												**24**
Sunfish species	*Lepomis* spp.						13	7						**20**
Unidentified	Unidentified								6					**6**
Yellow Perch	*Perca flavescens*							8			4			**12**
Total Estimated Number Impinged		**1,035**	**533**	**11**	**105**	**46**	**206**	**321**	**139**	**72**	**488**	**506**	**391**	**3,853**

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Table 12c - Estimated Annual Impingement (Expressed as Numbers of Organisms) at AES Greenidge, Unit 4, 2006

Common Name	Scientific Name	Estimated Annual Impingement, Unit 4*												Total Est. Impinged
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Alewife	*Alosa pseudoharengus*					19	54	289						**362**
Banded Killifish	*Fundulus diaphanus*	333			51			17	13		1	58	76	**549**
Basses and Sunfishes	Centrarchidae spp.	265	97	21							0		210	**594**
Bluegill	*Lepomis macrochirus*								19	46	0	4		**69**
Bluntnose Minnow	*Pimephales notatus*	26	452				22		126	46	1	25	19	**715**
Brown Bullhead	*Ameiurus nebulosus*					17								**17**
Bullheads and Catfishes	Ictaluridae spp.				62	86	249	250	44	69	0	5		**764**
Crayfish	Astacidae					29								**29**
Lamprey species	Petromyzontidae spp.	111						15	26		0			**152**
Largemouth Bass	*Micropterus salmoides*	1,502	59		10	29			32	78	9	55	248	**2,023**
Pumpkinseed	*Lepomis gibbosus*									23				**23**
Rock Bass	*Ambloplites rupestris*		217		21			47	13	19	1	18	19	**353**
Smallmouth Bass	*Micropterus dolomieu*									23	0			**24**
Spottail Shiner	*Notropis hudsonius*	53												**53**
Sunfish species	*Lepomis* spp.						22	15						**37**
Unidentified	Unidentified								13					**13**
Yellow Perch	*Perca flavescens*							17			0			**17**
Total Estimated Number Impinged		**2,290**	**825**	**21**	**145**	**179**	**347**	**649**	**284**	**303**	**13**	**166**	**572**	**5,792**

*blank cells have a value of zero

Note: estimates are based on 2006-2007 Unit 3 impingement collections; Unit 4 has no travelling screens such that "impingement" attributable to flow at this unit would actually be estimated.

Table 12d - Estimated Annual Impingement (Expressed as Numbers of Organisms) at AES Greenidge at Full Rated Flow (102.2 kgpm)

Common Name	**Scientific Name**	**Estimated Annual Impingement, Full Rated Flow***												**Total Est.**	**Lower**	**Upper**
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Impinged**	**95% C.I.**	**95% C.I.**
Alewife	*Alosa pseudoharengus*					43	115	443						**600**	**114**	**1,087**
Banded Killifish	*Fundulus diaphanus*	754			115			25	19		167	611	191	**1,884**	**390**	**3,378**
Basses and Sunfishes	Centrarchidae spp.					37								**37**		**101**
Bluegill	*Lepomis macrochirus*	599	214	48							51		526	**1,438**	**319**	**2,557**
Bluntnose Minnow	*Pimephales notatus*								28	69	26	47		**170**	**2**	**338**
Brown Bullhead	*Ameiurus nebulosus*	60	993				46		189	69	199	258	48	**1,863**	**42**	**3,683**
Bullheads and Catfishes	Ictaluridae spp.					64								**64**		**175**
Crayfish	Astacidae				139	193	532	382	67	104	71	53		**1,541**	**1,039**	**2,044**
Lamprey species	Petromyzontidae spp.									35				**35**		**97**
Largemouth Bass	*Micropterus salmoides*	252						24	38		24			**337**	**67**	**607**
Pumpkinseed	*Lepomis gibbosus*		476		46			72	19	28	246	186	48	**1,122**	**119**	**2,125**
Rock Bass	*Ambloplites rupestris*									35	26			**60**		**139**
Smallmouth Bass	*Micropterus dolomieu*	120												**120**		**351**
Spottail Shiner	*Notropis hudsonius*						46	23						**69**		**162**
Sunfish species	*Lepomis* spp.	3,402	130		23	64			47	119	2,057	578	622	**7,042**	**3,594**	**10,490**
Unidentified	Unidentified								19					**19**		**52**
Yellow Perch	*Perca flavescens*							25			26			**51**		**117**
Total Estimated Number Impinged		**5,187**	**1,813**	**48**	**323**	**401**	**739**	**994**	**426**	**459**	**2,893**	**1,733**	**1,435**	**16,452**	**5,686**	**27,503**

*blank cells have a value of zero

Note: estimates are based on 2006-2007 Unit 3 impingement collections; Unit 4 has no travelling screens such that "impingement" attributable to flow at this unit would actually be entrainment.

Table 13a - Estimated Annual Impingement (Expressed as Biomass in kg) at AES Greenidge, Units 3 and 4 Combined, 2006

Common Name	Scientific Name	Estimated Annual Impingement Biomass (kg), Combined Units 3 and 4*												Biomass Est.	Lower	Upper
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Impinged	95% C.I.	95% C.I.
Alewife	*Alosa pseudoharengus*					0.577	1.406	7.519						**9.502**	**1.367**	**17.637**
Banded Killifish	*Fundulus diaphanus*	1.175			0.248			0.049	0.038		0.051	0.817	0.321	**2.699**	**0.318**	**5.079**
Basses and Sunfishes	Centrarchidae spp.					0.062								**0.062**		**0.150**
Bluegill	*Lepomis macrochirus*	0.622	0.254	0.032							0.027		1.092	**2.026**	**1.439**	**2.614**
Bluntnose Minnow	*Pimephales notatus*								0.028	0.057	0.004	0.054		**0.143**		**0.286**
Brown Bullhead	*Ameiurus nebulosus*	0.192	2.613				14.702		2.616	0.113	0.168	0.668	0.193	**21.265**	**5.676**	**36.854**
Bullheads and Catfishes	Ictaluridae spp.					15.159								**15.159**		**36.705**
Crayfish	Astacidae				0.943	0.833	3.963	3.455	0.818	0.623	0.037	0.123		**10.795**	**6.665**	**14.926**
Lamprey species	Petromyzontidae spp.									11.485				**11.485**		**31.291**
Largemouth Bass	*Micropterus salmoides*	15.261						0.023	0.415		0.033			**15.732**		**42.717**
Pumpkinseed	*Lepomis gibbosus*		1.848		0.142			2.862	0.565	0.069	0.204	0.235	0.064	**5.990**	**0.944**	**11.036**
Rock Bass	*Ambloplites rupestris*									0.057	0.013			**0.070**		**0.168**
Smallmouth Bass	*Micropterus dolomieu*	0.230												**0.230**		**0.658**
Spottail Shiner	*Notropis hudsonius*						0.242	0.067						**0.309**		**0.736**
Sunfish species	*Lepomis* spp.	2.680	0.097		0.018	0.036			0.243	0.135	0.589	0.273	0.514	**4.584**	**3.201**	**5.966**
Unidentified	Unidentified								0.019					**0.019**		**0.051**
Yellow Perch	*Perca flavescens*							3.442			2.094			**5.536**		**11.704**
Total Estimated Biomass (kg) Impinged		**20.160**	**4.812**	**0.032**	**1.351**	**16.667**	**20.313**	**17.417**	**4.742**	**12.539**	**3.220**	**2.170**	**2.184**	**105.606**	**19.610**	**218.578**

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Note: estimates are based on 2006-2007 Unit 3 impingement collections; Unit 4 has no travelling screens such that "impingement" attributable to flow at this unit would actually be entrainment.

Table 13b - Estimated Annual Impingement (Expressed as Biomass in kg) at AES Greenidge, Unit 3, 2006

Common Name	**Scientific Name**	**Estimated Annual Impingement Biomass (kg), Unit 3***												**Biomass Est.**
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Impinged**
Alewife	*Alosa pseudoharengus*					0.117	0.523	2.489						**3.129**
Banded Killifish	*Fundulus diaphanus*	0.366			0.105			0.016	0.012		0.050	0.616	0.130	**1.295**
Basses and Sunfishes	Centrarchidae spp.					0.013								**0.013**
Bluegill	*Lepomis macrochirus*	0.194	0.100	0.011							0.026		0.443	**0.774**
Bluntnose Minnow	*Pimephales notatus*								0.009	0.011	0.004	0.041		**0.065**
Brown Bullhead	*Ameiurus nebulosus*	0.060	1.026				5.466		0.858	0.022	0.164	0.503	0.078	**8.176**
Bullheads and Catfishes	Ictaluridae spp.					3.080								**3.080**
Crayfish	Astacidae				0.398	0.169	1.473	1.144	0.268	0.120	0.036	0.093		**3.702**
Lamprey species	Petromyzontidae spp.									2.220				**2.220**
Largemouth Bass	*Micropterus salmoides*	4.749						0.008	0.136		0.032			**4.925**
Pumpkinseed	*Lepomis gibbosus*		0.725		0.060			0.947	0.185	0.013	0.199	0.177	0.026	**2.333**
Rock Bass	*Ambloplites rupestris*									0.011	0.013			**0.024**
Smallmouth Bass	*Micropterus dolomieu*	0.072												**0.072**
Spottail Shiner	*Notropis hudsonius*						0.090	0.022						**0.112**
Sunfish species	*Lepomis* spp.	0.834	0.038		0.008	0.007			0.080	0.026	0.574	0.206	0.209	**1.981**
Unidentified	Unidentified								0.006					**0.006**
Yellow Perch	*Perca flavescens*							1.139			2.039			**3.178**
Total Estimated Biomass (kg) Impinged		**6.273**	**1.889**	**0.011**	**0.570**	**3.386**	**7.552**	**5.765**	**1.555**	**2.423**	**3.136**	**1.635**	**0.887**	**35.083**

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Table 13c - Estimated Annual Impingement (Expressed as Biomass in kg) at AES Greenidge, Unit 4, 2006

Common Name	Scientific Name	Estimated Annual Impingement Biomass (kg), Unit 4*												Biomass Est. Impinged
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Alewife	*Alosa pseudoharengus*					0.460	0.883	5.030						**6.373**
Banded Killifish	*Fundulus diaphanus*	0.809			0.143			0.033	0.026		0.001	0.201	0.191	**1.404**
Basses and Sunfishes	Centrarchidae spp.					0.049								**0.049**
Bluegill	*Lepomis macrochirus*	0.428	0.154	0.021							0.001		0.649	**1.253**
Bluntnose Minnow	*Pimephales notatus*								0.019	0.046	0.000	0.013		**0.078**
Brown Bullhead	*Ameiurus nebulosus*	0.132	1.587				9.236		1.758	0.091	0.004	0.165	0.115	**13.089**
Bullheads and Catfishes	Ictaluridae spp.					12.079								**12.079**
Crayfish	Astacidae				0.545	0.664	2.490	2.311	0.550	0.503	0.001	0.030		**7.093**
Lamprey species	Petromyzontidae spp.									9.265				**9.265**
Largemouth Bass	*Micropterus salmoides*	10.512						0.015	0.279		0.001			**10.807**
Pumpkinseed	*Lepomis gibbosus*		1.123		0.082			1.915	0.380	0.056	0.005	0.058	0.038	**3.656**
Rock Bass	*Ambloplites rupestris*									0.046	0.000			**0.046**
Smallmouth Bass	*Micropterus dolomieu*	0.158												**0.158**
Spottail Shiner	*Notropis hudsonius*						0.152	0.045						**0.197**
Sunfish species	*Lepomis* spp.	1.846	0.059		0.010	0.029			0.163	0.109	0.015	0.067	0.305	**2.604**
Unidentified	Unidentified								0.013					**0.013**
Yellow Perch	*Perca flavescens*							2.303			0.055			**2.358**
Total Estimated Biomass (kg) Impinged		**13.887**	**2.923**	**0.021**	**0.781**	**13.281**	**12.761**	**11.652**	**3.187**	**10.116**	**0.084**	**0.535**	**1.297**	**70.523**

*blank cells have a value of zero

Note: estimates are based on 2006-2007 Unit 3 impingement collections; Unit 4 has no travelling screens such that "impingement" attributable to flow at this unit would actually be entrainment.

Table 13d - Estimated Annual Impingement (Expressed as Biomass in kg) at AES Greenidge at Full Rated Flow (102.2 kgpm)

Common Name	**Scientific Name**	**Estimated Annual Impingement Biomass (kg), Full Rated Flow***												**Biomass Est. Impinged**	**Lower 95% C.I.**	**Upper 95% C.I.**
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**			
Alewife	*Alosa pseudoharengus*					1.036	1.882	7.706						**10.624**	**2.092**	**19.157**
Banded Killifish	*Fundulus diaphanus*	1.832			0.323			0.050	0.038		0.291	2.106	0.478	**5.120**	**0.217**	**10.023**
Basses and Sunfishes	Centrarchidae spp.					0.111								**0.111**		**0.303**
Bluegill	*Lepomis macrochirus*	0.970	0.339	0.048							0.154		1.624	**3.135**	**2.165**	**4.105**
Bluntnose Minnow	*Pimephales notatus*								0.028	0.069	0.026	0.140		**0.263**		**0.567**
Brown Bullhead	*Ameiurus nebulosus*	0.299	3.487				19.674		2.649	0.139	0.969	1.721	0.287	**29.225**	**7.391**	**51.060**
Bullheads and Catfishes	Ictaluridae spp.					27.230								**27.230**		**74.325**
Crayfish	Astacidae				1.229	1.497	5.303	3.541	0.829	0.764	0.213	0.318		**13.693**	**7.879**	**19.507**
Lamprey species	Petromyzontidae spp.									14.089				**14.089**		**39.303**
Largemouth Bass	*Micropterus salmoides*	23.806						0.024	0.420		0.189			**24.439**		**68.157**
Pumpkinseed	*Lepomis gibbosus*		2.466		0.186			2.933	0.573	0.084	1.175	0.605	0.096	**8.118**	**1.849**	**14.387**
Rock Bass	*Ambloplites rupestris*									0.069	0.077			**0.146**		**0.336**
Smallmouth Bass	*Micropterus dolomieu*	0.359												**0.359**		**1.052**
Spottail Shiner	*Notropis hudsonius*						0.324	0.069						**0.393**		**0.986**
Sunfish species	*Lepomis* spp.	4.180	0.130		0.023	0.064			0.246	0.165	3.389	0.703	0.765	**9.665**	**3.673**	**15.657**
Unidentified	Unidentified								0.019					**0.019**		**0.052**
Yellow Perch	*Perca flavescens*							3.528			12.053			**15.580**		**38.938**
Total Estimated Biomass (kg) Impinged		**31.446**	**6.422**	**0.048**	**1.761**	**29.938**	**27.183**	**17.851**	**4.802**	**15.379**	**18.536**	**5.593**	**3.250**	**162.209**	**25.266**	**357.915**

*blank cells have a value of zero

Note: estimates are based on 2006-2007 Unit 3 impingement collections; Unit 4 has no travelling screens such that "impingement" attributable to flow at this unit would actually be entrainment.

Table 14a - Estimated Number of Eggs (EGG), Yolk-sac Larvae (YS), Post-yolk-sac Larvae (PYS), and Unidentified-lifestage Larvae (YS/PYS) Entrained at AES Greenidge, Units 3 and 4 Combined, 2006

Common Name	Scientific Name	Life Stage	Estimated Entrainment* (no. in 1,000s)						Total Est.	Lower	Upper
			Apr	May	Jun	Jul	Aug	Sep	Entrained	95% C.I.	95% C.I.
Alewife	*Alosa pseudoharengus*	EGG			140,300				**140,300**	**52,000**	**228,700**
		YS									
		PYS									
		YS/PYS									
		JUV									
Banded Killifish	*Fundulus diaphanus*	EGG									
		YS									
		PYS				24,700			**24,700**		**51,500**
		YS/PYS									
		JUV				81,900			**81,900**		**199,300**
Brook silverside	*Labidesthes sicculus*	EGG			6,100				**6,100**		**18,100**
		YS									
		PYS									
		YS/PYS									
		JUV									
Bullhead Species	*Ameiurus* spp.	EGG									
		YS									
		PYS									
		YS/PYS									
		JUV						13,000	**13,000**		**38,700**
Carp	*Cyprinus carpio*	EGG									
		YS									
		PYS									
		YS/PYS									
		JUV				16,500			**16,500**		**49,200**
Carps and Minnows	Cyprinidae spp.	EGG			6,100				**6,100**		**18,200**
		YS			6,100				**6,100**		**18,200**
		PYS				16,500			**16,500**		**49,200**
		YS/PYS									
		JUV									
Darters	Etheostoma spp.	EGG									
		YS			12,200				**12,200**		**36,400**
		PYS									
		YS/PYS									
		JUV									
Suckers	Catostomidae spp.	EGG									
		YS									
		PYS									
		YS/PYS	25,100						**25,100**		**74,800**
		JUV									
Unidentified	Unidentified	EGG			6,100	49,400			**55,500**		**124,100**
		YS									
		PYS					16,600		**16,600**		**39,400**
		YS/PYS				16,500			**16,500**		**39,000**
		JUV									
White Sucker	*Catostomus commersoni*	EGG									
		YS		4,700					**4,700**		**14,000**
		PYS	37,700	42,300					**80,000**	**1,100**	**158,800**
		YS/PYS		4,700					**4,700**		**14,000**
		JUV									
Yellow Perch	*Perca flavescens*	EGG									
		YS									
		PYS			6,100				**6,100**		**18,200**
		YS/PYS									
		JUV									
Estimated Total Entrainment		**EGG**			**158,600**	**49,400**			**208,000**	**52,000**	**389,100**
		YS		**4,700**	**18,300**				**23,000**		**68,600**
		PYS	**37,700**	**42,300**	**6,100**	**41,200**	**16,600**		**143,900**	**1,100**	**317,100**
		YS/PYS	**25,100**	**4,700**		**16,500**			**46,300**		**127,800**
		JUV				**98,400**		**13,000**	**111,400**		**287,200**
		ALL	**62,800**	**51,700**	**183,000**	**205,500**	**16,600**	**13,000**	**532,600**	**53,100**	**1,189,800**

*blank cells have a value of zero

Table 14b - Estimated Number of Eggs (EGG), Yolk-sac Larvae (YS), Post-yolk-sac Larvae (PYS), Unidentified-lifestage Larvae (YS/PYS), and Juveniles (JUV) Entrained at Greenidge Generating Station Unit 3 during 2006

Common Name	Scientific Name	Life Stage	Estimated Entrainment*						Total Est. Entrained
			Apr	May	Jun	Jul	Aug	Sep	
Alewife	*Alosa pseudoharengus*	EGG			52,200				**52,200**
		YS							
		PYS							
		YS/PYS							
		JUV							
Banded Killifish	*Fundulus diaphanus*	EGG							
		YS							
		PYS				8,200			**8,200**
		YS/PYS							
		JUV				27,100			**27,100**
Brook silverside	*Labidesthes sicculus*	EGG			2,300				**2,300**
		YS							
		PYS							
		YS/PYS							
		JUV							
Bullhead Species	*Ameiurus* spp.	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV						2,500	**2,500**
Carp	*Cyprinus carpio*	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV				5,500			**5,500**
Carps and Minnows	Cyprinidae spp.	EGG			2,300				**2,300**
		YS			2,300				**2,300**
		PYS				5,500			**5,500**
		YS/PYS							
		JUV							
Darters	Etheostoma spp.	EGG							
		YS			4,500				**4,500**
		PYS							
		YS/PYS							
		JUV							
Suckers	Catostomidae spp.	EGG							
		YS							
		PYS							
		YS/PYS	10,600						**10,600**
		JUV							
Unidentified	Unidentified	EGG			2,300	16,400			**18,600**
		YS							
		PYS					5,400		**5,400**
		YS/PYS				5,500			**5,500**
		JUV							
White Sucker	*Catostomus commersoni*	EGG							
		YS		1,000					**1,000**
		PYS	15,900	8,600					**24,500**
		YS/PYS		1,000					**1,000**
		JUV							
Yellow Perch	*Perca flavescens*	EGG							
		YS							
		PYS			2,300				**2,300**
		YS/PYS							
		JUV							
Estimated Total Entrainment		**EGG**			**59,000**	**16,400**			**75,300**
		YS		**1,000**	**6,800**				**7,800**
		PYS	**15,900**	**8,600**	**2,300**	**13,600**	**5,400**		**45,900**
		YS/PYS	**10,600**	**1,000**		**5,500**			**17,000**
		JUV				**32,600**		**2,500**	**35,100**
		ALL	**26,500**	**10,500**	**68,000**	**68,000**	**5,400**	**2,500**	**181,000**

*blank cells have a value of zero

Table 14c - Estimated Number of Eggs (EGG), Yolk-sac Larvae (YS), Post-yolk-sac Larvae (PYS), Unidentified-lifestage Larvae (YS/PYS), and Juveniles (JUV) Entrained at Greenidge Generating Station Unit 4 during 2006

Common Name	Scientific Name	Life Stage	Estimated Entrainment*						Total Est.
			Apr	May	Jun	Jul	Aug	Sep	Entrained
Alewife	*Alosa pseudoharengus*	EGG			88,100				**88,100**
		YS							
		PYS							
		YS/PYS							
		JUV							
Banded Killifish	*Fundulus diaphanus*	EGG							
		YS							
		PYS				16,500			**16,500**
		YS/PYS							
		JUV				54,800			**54,800**
Brook silverside	*Labidesthes sicculus*	EGG			3,800				**3,800**
		YS							
		PYS							
		YS/PYS							
		JUV							
Bullhead Species	*Ameiurus* spp.	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV						10,500	**10,500**
Carp	*Cyprinus carpio*	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV				11,000			**11,000**
Carps and Minnows	Cyprinidae spp.	EGG			3,800				**3,800**
		YS			3,800				**3,800**
		PYS				11,000			**11,000**
		YS/PYS							
		JUV							
Darters	Etheostoma spp.	EGG							
		YS			7,700				**7,700**
		PYS							
		YS/PYS							
		JUV							
Suckers	Catostomidae spp.	EGG							
		YS							
		PYS							
		YS/PYS	14,500						**14,500**
		JUV							
Unidentified	Unidentified	EGG			3,800	33,000			**36,900**
		YS							
		PYS					11,200		**11,200**
		YS/PYS				11,000			**11,000**
		JUV							
White Sucker	*Catostomus commersoni*	EGG							
		YS		3,700					**3,700**
		PYS	21,800	33,700					**55,500**
		YS/PYS		3,700					**3,700**
		JUV							
Yellow Perch	*Perca flavescens*	EGG							
		YS							
		PYS			3,800				**3,800**
		YS/PYS							
		JUV							
Estimated Total Entrainment		**EGG**			**99,600**	**33,000**			**132,700**
		YS		**3,700**	**11,500**				**15,200**
		PYS	**21,800**	**33,700**	**3,800**	**27,600**	**11,200**		**98,000**
		YS/PYS	**14,500**	**3,700**		**11,000**			**29,300**
		JUV				**65,800**		**10,500**	**76,300**
		ALL	**36,300**	**41,200**	**115,000**	**137,500**	**11,200**	**10,500**	**351,600**

*blank cells have a value of zero

Table 14d - Estimated Number of Eggs (EGG), Yolk-sac Larvae (YS), Post-yolk-sac Larvae (PYS), Unidentified-lifestage Larvae (YS/PYS), and Juveniles (JUV) Entrained at Greenidge Generating Station at Full Rated Flow (102.2 kgpm)

Common Name	Scientific Name	Life Stage	Estimated Entrainment*						Total Est. Entrained
			Apr	May	Jun	Jul	Aug	Sep	
Alewife	*Alosa pseudoharengus*	EGG			187,800				**187,800**
		YS							
		PYS							
		YS/PYS							
		JUV							
Banded Killifish	*Fundulus diaphanus*	EGG							
		YS							
		PYS				25,300			**25,300**
		YS/PYS							
		JUV				83,900			**83,900**
Brook silverside	*Labidesthes sicculus*	EGG			8,100				**8,100**
		YS							
		PYS							
		YS/PYS							
		JUV							
Bullhead Species	*Ameiurus* spp.	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV						15,900	**15,900**
Carp	*Cyprinus carpio*	EGG							
		YS							
		PYS							
		YS/PYS							
		JUV				16,900			**16,900**
Carps and Minnows	Cyprinidae spp.	EGG			8,200				**8,200**
		YS			8,200				**8,200**
		PYS				16,900			**16,900**
		YS/PYS							
		JUV							
Darters	Etheostoma spp.	EGG							
		YS			16,300				**16,300**
		PYS							
		YS/PYS							
		JUV							
Suckers	Catostomidae spp.	EGG							
		YS							
		PYS							
		YS/PYS	32,700						**32,700**
		JUV							
Unidentified	Unidentified	EGG			8,100	50,700			**58,800**
		YS							
		PYS					16,900		**16,900**
		YS/PYS				16,900			**16,900**
		JUV							
White Sucker	*Catostomus commersoni*	EGG							
		YS		8,400					**8,400**
		PYS	49,100	76,000					**125,100**
		YS/PYS		8,400					**8,400**
		JUV							
Yellow Perch	*Perca flavescens*	EGG							
		YS							
		PYS			8,200				**8,200**
		YS/PYS							
		JUV							
Estimated Total Entrainment		**EGG**			**212,200**	**50,700**			**262,900**
		YS		**8,400**	**24,500**				**32,900**
		PYS	**49,100**	**76,000**	**8,200**	**42,200**	**16,900**		**192,400**
		YS/PYS	**32,700**	**8,400**		**16,900**			**58,000**
		JUV				**100,800**		**15,900**	**116,700**
		ALL	**81,800**	**92,800**	**244,900**	**210,600**	**16,900**	**15,900**	**662,900**

*blank cells have a value of zero