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COMPANY CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO BUSINESS CONFIDENTIALITY CLAIM

RESPONSE TO UNITED STATES ENVIRONMENTAL PROTECTION AGENCY CWA § 308 LETTER

PSNH MERRIMACK STATION UNITS 1 & 2
BOW, NEW HAMPSHIRE

Prepared and Submitted By

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The Northeast Utilities System

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November 2007

#240

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December 10, 2007

John P. King
U.S. Environmental Protection Agency
One Congress Street
Suite 1100 (Mail Code CIP)
Boston, MA 02114-2023

Re: Release of Confidential Business Information

Dear Mr. King:

In response to your request, and in the spirit of cooperation, Public Service Company of New Hampshire ("PSNH") has determined that the "Confidential Business Information" label may be removed from its recent submittal entitled "Response to United States Environmental Protection Agency CWA Section 308 Letter: PSNH Merrimack Station Units 1 & 2, Bow, New Hampshire."

It is our understanding that the above document cannot receive the appropriate thorough review within the Environmental Protection Agency ("EPA") unless PSNH removes the "Confidential Business Information" classification. We are therefore acquiescing to your request and are hopeful that this action on the part of PSNH not only facilitates your review but also demonstrates our intention to cooperate fully with EPA.

We are looking forward to meeting with you to discuss the Section 308 Response once you have had the opportunity to review it. In the meantime, please let Allan Palmer (603-634-2439) know if we can provide any additional information.

Sincerely,

William H. Smagula

William H. Smagula
Director – PSNH Generation

cc: Allan Palmer, PSNH
Linda T. Landis, Esq., PSNH
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David M. Webster, USEPA

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Summary of Report Conclusions

Public Service Company of New Hampshire's (PSNH's) Merrimack Station electrical generating facility, consisting of two independent units, in Bow, New Hampshire (Station) is seeking a renewal of its existing National Pollutant Discharge Elimination System (NPDES) permit (NPDES Permit NH0001465). This Report has been prepared by Enercon Services, Inc. and Normandeau Associates, Inc., leading experts in the fields of engineering and biological assessment, as PSNH's response, within the United States Environmental Protection Agency's (EPA) allotted timeframe, to EPA's information request under Section 308 of the Clean Water Act (CWA) with respect to CWA § 316(a) and § 316(b).

With respect to § 316(b), and assuming that the requisite adverse environmental impact (AEI) is established (as discussed below), EPA requested that PSNH consider the following technologies and operational measures which EPA assumes may represent the "best technology available for minimizing adverse environmental impact" from the Station's cooling water intake structures (CWISs):

- Mechanical draft cooling towers for use in a closed-cycle cooling configuration for both units combined
- Mechanical draft cooling towers for use in a closed-cycle cooling configuration for each unit individually
- Various CWIS screening and/or fish return technologies
- Technological and operational flow reduction measures

This Report evaluates these technologies, and various other measures.

However, and as a threshold matter, the biological data from Merrimack Station's monitoring programs indicate that no AEI to the aquatic ecosystems of the Merrimack River (River) in the vicinity of the Station has occurred, as measured by any representative important species (RIS) or critical aquatic organism population, as a result of the Station's existing CWIS operation. Additionally, both the entrainment abundance and adult equivalent abundance of fish entrained at Merrimack Station are considered extremely low compared to other stations with comparable intake flows. Similarly, both the impingement abundance and adult equivalent abundance of fish impinged at Merrimack Station are considered extremely low compared to other stations with comparable intake flows. As a result, the costs of certain of the EPA-identified technologies, particularly closed-cycle cooling configuration for one or both units at the Station, would be, by any reasonable measure, wholly disproportionate to any environmental benefit attributable to any such retrofit. Moreover, retrofitting presents substantial negative impacts, including those with respect to regional electric-system reliability and pricing, as well as industry-wide impacts that raise the specter of disruption of the electricity supply in a manner that suggests that such retrofitting may not be cost-effective.

More particularly, the use of mechanical draft cooling towers in a closed-cycle cooling configuration, either for both units combined or for either unit individually, was determined to have both the highest initial cost and the highest ongoing cost of all technologies considered. Furthermore, the conversion to closed-cycle cooling would result in an average annual estimated loss of approximately 10 megawatts power output from the Station, with losses of up to 22 megawatts during peak summer load conditions. These power losses, which are detailed in this Report, result from the additional parasitic losses associated with the cooling tower fans and booster pumps in combination with significant operational efficiency losses due to higher cooling water inlet water temperatures to the condenser.

The Report's consideration of the EPA-identified CWIS screening technologies and their estimated costs and associated biological benefits, indicates that modification of the existing fish return system may be appropriate. An upgrade to a state-of-the-art fish return system, in combination with the operational changes outlined below which PSNH is willing to voluntarily undertake, would significantly reduce impingement mortality. Alternative traveling screen systems could provide some incremental improvement over the existing traveling screen system if coupled with a new fish return system, but again at costs wholly disproportionate to the level of impingement reduction achieved. Moreover, certain fine mesh screening technologies were determined to be infeasible at Merrimack Station due to the configuration of either the source water body or the CWIS. Instead, upgrading the existing fish return and operating the existing traveling screens continuously during impingement-sensitive months would result in significantly reduced annual impingement mortality.

Technological and operational flow reduction measures were also assessed with respect to feasibility, cost and potential for annual impingement and entrainment reduction. Unit 1 was determined to be very intolerant of flow reductions, either technological or operational. Any appreciable reduction in flow on Unit 1 results in significant operational losses or the complete shutdown of that Unit. Unit 2 was found to be capable of reduced flow operation during winter months. Reduction to 50% of actual inlet flow can be achieved by one-pump operation on Unit 2 for three months during the winter, with minimal operational losses and a corresponding presumed impingement/entrainment reduction of 50% for those months. In addition, shifting the Unit 2 maintenance outages (from their usual occurrence in late spring) to the peak early summer entrainment/impingements periods would reduce assumed annual entrainment and impingement.

Based on the engineering evaluation presented in this Report (as summarized in the comparative matrix provided in Section 9.1 and the preceding discussion) and the biological data developed by Normandeau based on the Station's monitoring program, the following combination of technologies and operational measures constitutes the "best technology available" (BTA) for Merrimack Station:

- Upgraded fish return systems for both Unit 1 and Unit 2
- Continuous operation of the Unit 1 and Unit 2 traveling screens from April through December (non-freezing River conditions).
- One-pump reduced flow operation for Unit 2 from December 15th through March15th.
- Scheduling of Unit 2 maintenance outages to coincide with periods of high impingement and entrainment during early summer (ending June 15th).

The cumulative reductions in assumed impingement and entrainment for each unit following implementation of these recommended improvements to Merrimack Station's existing CWIS technologies and operational measures, as compared to the Merrimack Station baseline, are as follows:

For Unit 1 (which has a rated capacity of 120 MW and a design intake capacity of 59,000 gpm), estimated total annual entrainment reduction is 19%, and estimated total annual impingement reduction is 60%

For Unit 2 (which has a rated capacity of 350 MW and a design intake capacity of 140,000 gpm), estimated total annual entrainment reduction is 51%, and estimated total annual impingement reduction is 72%

Without identifying the basis for its request, EPA also asked that PSNH identify and evaluate means by which Merrimack Station could achieve and maintain a maximum ambient temperature differential of 5°F in Hooksett Pool (i.e., between Station N10, which is above the Station's thermal discharge point, and Station S4, which is below that discharge point). As reflected in this Report, Enercon and Normandeau assessed EPA's request, and found the following:

- The temperature differential between Stations N10 and S4 is largely controlled by Merrimack River ("River") flow, which overshadows the potential effect of varying Station effluent temperatures via discharge canal cooling.
- At historical low River flow rates, the Station effluent could not be cooled adequately by evaporative cooling technologies, either via a discharge canal cooling tower or additional power spray modules (PSMs), to achieve a 5°F temperature differential scenario between Stations N10 and S4.
- Based on historical average River flows and ambient temperatures, the Station effluent could be cooled adequately to achieve a 5°F temperature differential between Stations N10 and S4 66% of the time utilizing the existing PSMs for cooling.
- Based on historical average River flows and ambient temperatures, a 10-cell mechanical draft discharge canal cooling tower could achieve a 5°F temperature differential between Stations N10 and S4 91% of the time.

Because of the sensitivity of the discharge canal cooling requirements to low River flow conditions, two options for achieving a maximum ambient temperature differential of 5°F between Stations N10 and S4 are presented: (1) using exclusion hours for periods when extreme low River flow conditions occur, or (2) increasing the temperature differential value. The necessary allowable temperature differentials for evaporative cooling using either the existing PSM configuration or a discharge canal cooling tower are shown below.

- For the existing PSM configuration, the minimum River flow condition for a 5°F differential between Stations N10 and S4 would be 2320 cfs, or the necessary allowable temperature differential between Stations N10 and S4 would need to be 19°F at bounding low River flow conditions.
- For a 10-cell discharge canal cooling tower configuration, the minimum River flow condition for a 5°F differential between Stations N10 and S4 would be 1640 cfs, or the necessary allowable temperature differential between Stations N10 and S4 would need to be 9°F at bounding low River flow conditions.

Each of these options is supported by the thermal and biological monitoring data collected by PSNH in Hooksett Pool and upper Amoskeag Pool since 1967. These data provide no historical evidence that the Station's thermal discharge (1) may reasonably be considered to have caused any prior appreciable harm to the balanced indigenous population or community of shellfish, fish and wildlife that reside within, or are migratory through, the Merrimack River in the sphere of influence of Station's hydrothermal regime (i.e., the "BIP/C"), or (2) in the future, will not assure the protection and propagation of such BIP/C. Most recently (Spring 2007), PSNH provided EPA three (3) scientific studies (References 11.14, 11.15, and 11.16) that were performed by Normandeau Associates, Inc. to assess whether Merrimack Station's thermal discharge into the River continued to satisfy the §316(a) variance-renewal standard. These three studies confirm that the requirements in the Station's existing NPDES permit satisfy that standard, and renewal of the Station's §316(a) variance is again warranted.

1 Background, Introduction, and Scope

1.1 Background and Introduction

Public Service Company of New Hampshire's (PSNH's) Merrimack Station electrical generating facility in Bow, New Hampshire is seeking a renewal of its existing National Pollutant Discharge Elimination System (NPDES) permit (NPDES Permit NH0001465). The following Report has been prepared to provide PSNH's response to an information request letter from the United States Environmental Protection Agency (EPA) under Section 308 of the Clean Water Act (CWA) regarding the Station's compliance with CWA § 316(a) and § 316(b), 33 § 1326(a) and 1326(b) (§ 308 Letter). In the § 308 Letter, EPA requested certain technology and fisheries information from PSNH to support EPA's development of the new permit for Merrimack Station.

1.2 Scope

The content of this Report reflects the information requested by EPA in the § 308 Letter. As a result, the following information is contained in this Report:

- All fisheries data collected during entrainment and impingement sampling conducted from 2005 to 2007.
- A detailed description of Merrimack Station's cooling system
- Response regarding projected retirement date for Merrimack Station's existing coal-fired operation
- A description of the processes employed at Merrimack Station with regard to the operation of the boiler, condenser, cooling water intake structure (CWIS), and effluent treatment
- A description of the engineering analysis involved with converting the Merrimack Station cooling system from the current once-through cooling to the following cooling scenarios:
    - Mechanical draft cooling towers for use in a recirculating (or "closed-cycle") cooling system for both generating units
    - Mechanical draft cooling towers for use in a recirculating (or "closed-cycle") cooling system for one generating unit
    - Mechanical draft cooling towers for use in a "helper tower" or "chiller" configuration that would be used to reduce thermal discharges by Merrimack Station. Note that this scenario is not intended to result in a "closed-cycle" cooling system.
- An analysis of alternate CWIS screening systems, including a discussion of the major components and major modifications that would be required to retrofit Merrimack Station with this technology

- A discussion of the least expensive, most cost-effective means by which Merrimack Station could meet the evaluated scenario whereby the temperature differential between Stations N10 and S4 in the Hooksett Pool is limited to 5°F

Note that information taken from the PIC (Reference 11.8) and from the Merrimack River thermal regime report (Reference 11.9) prepared for Merrimack Station by Normandeau Associates has been previously provided to the EPA. However, it is included in this Report for completeness, and will be denoted as [1] and [2]. However, all fisheries data collected in support of the PIC has been previously provided to the EPA and is not repeated in this Report.

2 Historical Studies Characterizing Impingement Mortality and Entrainment (IM&E) and Potential Thermal Effects from Station Operations

2.1 Historical IM&E Studies

The biological data from Merrimack Station's monitoring programs confirm no adverse environmental impact (AEI) to the aquatic ecosystems of the Merrimack River in the vicinity of the Station, including to any representative important species (RIS) or critical aquatic organism population, from the Station's CWISs.

EPA's now suspended final regulations implementing CWA § 316(b) for CWISs at existing electricity-generating stations (Phase II Regulations) required submission of a Proposal for Information Collection (PIC) in certain circumstances. In a December 30, 2004 letter to PSNH, EPA requested submission of the PIC for Merrimack Station "as expeditiously as practicable and prior to the start of biological and/or information collection activities, but no later than October 7, 2006." PSNH complied with EPA's request, and submitted a PIC for Merrimack Station in April 2005 (Reference 11.8). After discussions with EPA, PSNH's PIC for Merrimack Station was supplemented in November 2005 (Reference 11.18) to add an entrainment abundance and survival sampling program to complement the already proposed two-year (July 2005 through June 2007) impingement abundance and survival sampling program. Seasonal entrainment studies at Merrimack Station began in late May 2006 and continued through September 2006, and then resumed in April 2007. They were planned to continue for a second year through September 2007; however, the second year of entrainment data collection was truncated at the end of June 2007 to allow sufficient time to analyze both the impingement and entrainment data and prepare the data in the format requested in Section 7 and Section 8 of the § 308 Letter.

Section 7 and Section 8 of the § 308 Letter requests that PSNH provide all fisheries data collected during entrainment and impingement sampling conducted from 2005 to 2007, including all data collected as specified in Merrimack Station's PIC. A separate report is incorporated by this reference into PSNH's response to the 308 Letter to address the requirements of Section 7 and Section 8 of the § 308 Letter (Reference 11.17). This report, entitled "Entrainment and Impingement Studies Performed at Merrimack Generating Station from June 2005 through June 2007" and dated September 2007 (E&I Report), provides all fisheries data collected during the June 2005 through June 2007 entrainment and impingement studies for each sampling event exactly as specified in Section 7 of the § 308 Letter. Furthermore, this E&I Report summarizes the entrainment and impingement data into monthly and annual abundance and equivalent adult abundance for fish species and life stages based on the corresponding actual intake flows for each month of sampling at Merrimack Station Unit 1 and Unit 2 exactly as specified in Section 8 of the § 308 Letter. A brief summary of the methods and results of the E&I Report is presented in Section 2.1.1 for entrainment and Section 2.1.2 for impingement.

2.1.1 Entrainment

Historical data and the life history requirements of the fish species present in Hooksett Pool indicate that fish eggs and larvae of a size subjected to entrainment in the CWIS flow through the 3/8-in. mesh traveling screens at Merrimack Station Unit 1 and Unit 2 have the potential to be present only during the months of April through September of each year. Accordingly, entrainment studies at Merrimack Station began in late May 2006 and continued one day per week through September 2006 for a total of 16 weekly or biweekly (September) sampling events. Entrainment sampling was planned to continue through September 2007; however, the second year of entrainment data collection was truncated at the end of June 2007 to allow sufficient time to analyze both the impingement and entrainment data and prepare the data in the format requested in Section 7 and Section 8 of the § 308 Letter.

On each sampling day, one daytime sample and one nighttime sample were collected. For sampling purposes, daytime was defined as occurring between one hour after local sunrise and one hour before local sunset as observed at the Station site. Nighttime was defined as occurring between one hour after local sunset and one hour before local sunrise as observed at the Station site. Entrainment sampling was not conducted at an individual unit on scheduled days when one or both of the unit's two circulating pumps were not operating. Entrainment samples of approximately 100 m^3 were collected through a 0.300 mm mesh plankton net suspended over a barrel sampler located outside of the Unit 1 and Unit 2 screen houses. Intake water was supplied to each entrainment sampling tank from a 3-inch raw-water tap drawing un-chlorinated ambient cooling water from the pressurized condenser supply line at a point after the discharge pipes from each of the two intake pumps have joined into a common line as the flow exited the CWIS on route to the condenser inlet box.

Preserved entrainment samples were manually sorted and eggs and larvae were identified to the lowest distinguishable taxon and enumerated. Ichthyoplankton was enumerated into the following life stages: eggs, yolk-sac larvae, post-yolk-sac larvae, and juveniles. The total length to the nearest 0.1 mm was measured for up to 30 randomly selected individuals of each ichthyoplankton life stage (except eggs) per sample. Quality control inspections were performed for sorting, identification, life-stage determination and enumeration. Items were inspected using a quality control (QC) procedure derived from MIL-STD (military-standard) 1235 (Single And Multiple Level Continuous Sampling Procedures And Tables For Inspection By Attributes) to achieve a 10 percent or better AOQL (Average Outgoing Quality Limit).

The estimated annual average entrainment abundance expressed as the product of the number of fish per unit volume sampled and the actual monthly intake flows combined among all life stages at Merrimack Station for the two years of study was 1,289,515 fish for Unit 1 and 1,587,018 fish for Unit 2, as shown in the table below. These fish were predominantly the larvae of white sucker (43%), carp and other minnows (29%), sunfishes (13%), and yellow perch (8%), with the remaining 7% comprising seven other fish taxa (Reference 11.17, Table 3-2). Very few eggs (1% of total entrainment abundance) were entrained, which is consistent with the spawning behavior of the fish community present in Hooksett Pool that typically spawns in nests or vegetative areas where the eggs are found adhering to the substrate and would therefore not be subjected to entrainment. Entrainment abundance was highest in June of both years combined (67%).

Sampling Year Abundance	**Unit 1 Entrainment**	**Unit 2 Entrainment**	**Both Units Actual Flow**
May 06-Sep 06	685,638	2,100,645	2,786,283
Apr07-Jun 07	1,559,356	889,912	2,449,268
Average Annual	**1,289,515**	**1,587,018**	**2,876,532**

When the annual average entrainment abundance is expressed as adult equivalents by taking into account the high natural mortality that occurs between the early life stages of fish typically entrained and the nominal age at first reproduction (i.e. adult), the actual number of fish entrained at Merrimack Station reduces to an annual average number of equivalent adults of 5,383 fish at Unit 1 and 8,678 fish at Unit 2 as shown in the table below. The increased entrainment abundance of adult equivalent fish at Unit 2 compared to Unit 1 can be attributed to the differences in design flow between the two units, demonstrating that entrainment abundance is proportional to intake flow at Merrimack Station.

Sampling Year Adult Equivalents	**Unit 1 Entrainment**	**Unit 2 Entrainment**	**Both Units Actual Flow**
May 06-Sep 06	2,791	10,506	13,297
Apr 07-Jun 07	6,901	6,302	13,203
Average Annual	**5,383**	**8,678**	**14,061**

An insufficient sample of test and control organisms precluded analysis of conclusions regarding entrainment survival for the fish species and life stages entrained at Merrimack Station Unit 1 or Unit 2.

For the purpose of evaluating the benefits of various technological or operational measures requested by EPA in the § 308 Letter and evaluated in this Report, Table 2-1 (at end of this section) presents both entrainment abundance and adult equivalent fish abundance data by unit and month based on design flows for Unit 1 and Unit 2 of Merrimack Station. These data were obtained from the E&I report and are consistent with the monthly patterns observed for actual flows. Based on abundance for both units combined, 58.3% of the annual entrainment averaged between the two years of sampling occurred during June. Based on adult equivalent abundance, 67.4% of the annual total entrainment averaged between the two years of sampling was observed during June. Both the entrainment abundance and adult equivalent abundance of fish entrained at Merrimack Station are considered extremely low compared to other stations with comparable intake flows.

2.1.2 Impingement

Impingement sampling at Merrimack Station began in late June 2005 and continued in consecutive months through June 2007 at both Unit 1 and Unit 2. Impingement sampling was conducted on a weekly basis from late-June 2005 through mid-December of 2005 (25 sampling weeks), from mid-March of 2006 through November of 2006 (34 sampling weeks) and from mid-March of 2007 through the end of June 2007 (15 sampling weeks). During the intervening time periods, biweekly 24-hour impingement samples were collected (14 sampling weeks). Weekly impingement sampling consisted of one 24-hour sample followed by one six-day sample, and biweekly sampling consisted of one 24-hour sample followed by one thirteen-day sample. The 24-hour impingement samples are considered the primary sampling units, and "long interval" samples of six or thirteen days are considered secondary sampling units. Merrimack Station 24-hr impingement collections were taken weekly from approximately 0930 on Wednesday to 0930 on Thursday (24 total hours) at both Units 1 and 2. The total number of valid 24-hour impingement samples that were collected during the June 2005 through June 2007 study was 80 at Unit 1 and 76 at Unit 2.

Impingement sampling at Merrimack Station was conducted by placing a basket in the fish and debris return sluice at both Unit 1 and Unit 2, to catch all fish and debris washed off of the operating traveling screens. The basket mesh was constructed from the same mesh as on the traveling screens, standard 3/8-inch (0.375-inch) square. The baskets were placed in sampling position and removed using a davit and chainfall installed and operated by PSNH specifically for impingement sampling. Impingement collections were processed in fresh condition. All fish were identified to species and enumerated. A maximum of 50 individuals per species were measured to the nearest millimeter total length and weighed to the nearest gram. The amount (number of gallons) and general characterization of debris (aquatic, terrestrial, etc.) collected in the impingement baskets over the sample period was also quantified. Impingement collection efficiency was determined during one 24-hour sampling period in each month to adjust each 24-hour sample for fish that are lost between the time they are impinged on the operating intake screens and their collection in the sampling device. These impingement collection efficiency factors were applied to other 24-hour impingement collections from each period centered on the date of the collection efficiency test. Collection efficiency adjustments were not applied to the "long interval" samples.

Impingement survival was determined by collection of released live fish off of continuously rotated and washed screens from each unit at Merrimack Station during a four hour period. All alive or stunned fish were observed for initial (0-hour) survival and then held to determine latent (24-hour) survival. The efficiency of separating fish from debris, as well as all field identifications, counts, weights, and measurements were subject to quality control (QC) inspection. Items were chosen for inspection using a "CSP-1" QC procedure derived from MIL-STD (military-standard) 1235 (Single and Multiple Level Continuous Sampling Procedures and Tables for Inspection by Attributes) to achieve a 10% Average Outgoing Quality Limit (i.e., ≥90% of samples are within specified quality control tolerance limits).

Twenty-one species of fish representing nine families were collected in 24-hour impingement samples from June 2005–June 2007 at Merrimack Station Unit 1 and Unit 2. An additional four species in the carp and minnow family were collected in the long-interval (6-day and 13-day) samples. The estimated annual average impingement abundance expressed as the raw number of fish impinged in the 24-hour samples (679 fish) weighted by the monthly actual flows for Merrimack Station for the two years of study was 1,004 fish for Unit 1 and 3,001 fish for Unit 2 as shown in the table below. Bluegill was the most commonly collected fish species and they accounted for 62.6% of the total number of impinged fish. Spottail shiner was the second most abundant fish taxa and they accounted for 7.4% of the fish impinged. Bluegill, spottail shiner, black crappie (5.3%), largemouth bass (4.6%), and yellow perch (4.1%) combined to represent 84% of the total fish impinged during the two years of sampling. The size distribution of fish impinged at Merrimack Station was representative of young of the year fishes, with majority (91%) of the fish less than 125 mm total length.

Sampling Year Abundance	**Unit 1 Impingement**	**Unit 2 Impingement**	**Both Units Actual Flow**
Jun 05-Jun 06	1,603	5,133	6,736
Jun 06-Jun 07	405	866	1271
Average Annual	**1004**	**3001**	**4005**

When the annual average impingement abundance is expressed as adult equivalents by taking into account the natural mortality that occurs between the predominantly young of the year life stages of fish impinged and the nominal age at first reproduction (i.e. adult), the actual number of fish impinged at Merrimack Station reduced to an annual average number of equivalent adults of 273 fish at Unit 1 and 244 fish at Unit 2, as shown in the table below.

Sampling Year Adult Equivalents	Unit 1 Impingement	Unit 2 Impingement	Both Units Actual Flow
Jun 05-Jun 06	478	321	799
Jul 06-Jun 07	69	167	236
Average Annual	**273**	**244**	**517**

The current fish and debris return sluice at Merrimack Station Unit 1 and Unit 2 does not return fish or debris to Hooksett Pool, resulting in 100% mortality of impinged fish. Impingement survival studies were performed to simulate survival from the existing traveling screens if they were continuously rotated to evaluate the condition of fish taken off of the traveling screens and therefore the potential for increasing their survival if an upgraded fish return system were installed in the future. A total of nine survival tests were conducted at Unit 1 with a range in latent (24-hour) survival rate from 40.4% to 99.7% (mean = 59.6%). A total of seven impingement survival tests were conducted at Unit 2 with a range in survival rate from 20.2% to 100.0% (mean = 78.5%). Therefore, the present traveling screens and spray wash system affords the potential to return more than half of all impinged fish alive back into Hooksett Pool if the fish return system can be configured to return these fish back into the Merrimack River.

For the purpose of evaluating the benefits of various technological or operational measures requested by EPA in the § 308 Letter and evaluated in this Report, Table 2-2, (at end of this section) presents both impingement abundance and adult equivalent fish abundance data by unit and month based on design flows for Unit 1 and Unit 2 of Merrimack Station. These data were obtained from the E&I report (Reference 11.17). Based on abundance for both units combined, 56.4% of the annual impingement averaged between the two years of sampling occurred during June. Based on adult equivalent abundance, 37.9% of the annual total impingement averaged between the two years of sampling was observed during December, and 11.8% of the annual impingement occurred in June. The observed differences in seasonal contribution between impingement abundance and the adult equivalent abundance values for these impinged fish is due to the impingement of predominantly older fish in December compared to June. Both the impingement abundance and adult equivalent abundance of fish impinged at Merrimack Station are considered extremely low compared to other stations with comparable intake flows.

2.1.3 Relative Magnitude of Entrainment and Impingement

Expressing entrainment and impingement for Merrimack Station as adult equivalent fish abundance affords the opportunity to compare the relative magnitude of both on equal terms. The following table compares adult equivalent fish abundance data for entrainment and impingement based on the annual average data presented in Tables 2-1 and 2-2 (which respectively present entrainment and impingement abundance and adult equivalent fish abundance data by unit and month based on design flows). Entrainment was the predominant source of fish mortality due to CWIS operation, contributing 95% of the adult equivalent losses at Unit 1 and 97% of the adult equivalent losses at Unit 2 during the June 2005 through June 2007 study. However, the combined adult equivalent abundance of fish entrained and impinged of 17,553 adult fish at Merrimack Station during the study period is considered extremely low compared to other stations with comparable intake flows.

Average Year Adult Equivalents	**Unit 1**	**Unit 2**	**Both Units Design Flow**
Entrainment	6,992	9,888	16,880
Impingement	371	282	653
Combined	**7,363**	**10,170**	**17,533**

2.2 Historical Studies Characterizing Potential Thermal Effects from Station Operations

PSNH recently provided EPA three (3) new scientific studies (Reference 11.14, 11.15, 11.16) that were performed to evaluate whether Merrimack Station's thermal discharge into Hooksett Pool of the Merrimack River had caused prior appreciable harm to the BIP or would cause appreciable harm to the BIP in the future assuming the continuation of Station operations at their current level. The results of these studies confirm that the existing NPDES permit for Merrimack Station adequately assures the protection and propagation of the BIP, i.e., the balanced indigenous populations of shellfish, fish and wildlife that reside within, or are migratory through, the River in the vicinity of Merrimack Station.

One of these studies, which analyzed the thermal tolerance, life history requirements, and habitat requirements of nine RIS of fish found in Hooksett Pool or in upper Amoskeag Pool, concluded that historic thermal conditions have been protective of the BIP (Reference 11.16). These nine RIS of fish include alewife, American shad, Atlantic salmon, smallmouth bass, largemouth bass, pumpkinseed, yellow perch, fallfish, and white sucker. None of the habitat found in the thermally influenced portions of lower Hooksett Pool or in upper Amoskeag Pool were considered to be limiting or essential for resident and migratory fish to complete their life history in Merrimack River. No unique or rare habitat was observed within Hooksett Pool or upper Amoskeag Pool, and no threatened or endangered species were found in either pool.

There is presently no upstream passage for migratory fish into Hooksett Pool. As a result, any concerns about the thermal plume effecting migratory fishes must relate to the transient use of Hooksett Pool during the spring downstream migration of Atlantic salmon smolts (which are present solely due to fry stocking by state resource agencies in the upper watershed), or during the fall downstream migration of anadromous clupeids (i.e. American shad or alewife) (also present due to agency stocking efforts within or upstream from Hooksett Pool). The effects of the thermal discharge on the downstream migration of Atlantic salmon smolts was assessed in the second of the three recently submitted studies, the results of which demonstrate that Merrimack Station's thermal discharge has neither delayed nor created a barrier to the downstream migration of Atlantic salmon smolts (Reference 11.14). We have also observed high growth rates and effective downstream passage of juvenile clupeids during their fall outmigration period. In summary, analysis of migratory behavior supports a finding of no prior appreciable harm, and a projection of no potential future appreciable harm, to Atlantic salmon or anadromous clupeids in Hooksett Pool and upper Amoskeag Pool due to Merrimack Station's existing thermal discharge.

Lower Hooksett Pool and upper Amoskeag Pool are two segments of the Merrimack River receiving Merrimack Station's thermal discharge that are considered low potential impact areas for phytoplankton because they are in a portion of the Merrimack River continuum where the annual carbon cycle is typically dominated by heterotrophic activities in a detrital food chain. Annual studies of the community composition and standing crop of phytoplankton and periphyton from 1975 through 1978 in the upstream ambient zone and in the thermally influenced portions of lower Hooksett Pool confirm the designation of the study area as a low potential impact area for the phytoplankton community (Reference 11.12). Over the four year study period (1975-1978), no endangered or threatened species were found, no shift towards nuisance species was observed in either the upstream ambient or thermally influenced portions of lower Hooksett Pool, and there were no long-term reductions or increases in autotrophic production of the periphyton or phytoplankton components of the algal community that could be attributed to Merrimack Station's thermal discharge (Reference 11.12).

Lower Hooksett Pool and upper Amoskeag Pool are two segments of the Merrimack River receiving Merrimack Station's thermal discharge that are considered low potential impact areas for net zooplankton and meroplankton, because no endangered or threatened species were found, and no reduction or adverse change was observed in exhaustive annual studies performed from 1975 through 1978 in both the upstream ambient zone and in the thermally influenced portions of lower Hooksett Pool (Reference 11.12). The results of the source water body studies were corroborated by a finding of minimal entrainment mortality of net zooplankton and meroplankton due to passage through the condenser cooling system and cooling canal of Merrimack Station (Reference 11.12), indicating the heated discharge did not alter the standing crop, relative abundance, natural population fluctuations, or the free drift of these components of the BIP.

Aquatic vascular plants (i.e., "macrophytes") are the primary habitat formers in the impounded freshwater riverine ecosystem found in lower Hooksett Pool and upper Amoskeag Pool. These two segments of the Merrimack River receiving Merrimack Station's thermal discharge are considered low potential impact areas for aquatic macrophytes, because no endangered or threatened species were found, and because within year comparison of similar habitats upstream and downstream from the cooling canal discharge indicated that the heated effluent from Merrimack Station has generally had no adverse effect on the distribution and abundance of aquatic macrophytes (Reference 11.12). A total of 14 species of aquatic vascular plants were observed during surveys conducted from 1970 to 1974; these aquatic plants were generally most abundant during August and September of each year (Reference 11.12). Merrimack River currents, substrate, water chemistry, and depth are all factors influencing the distribution of macrophytes in impounded freshwater riverine ecosystems. Within-year variability among stations sampled from 1970 to 1974 in both the upstream ambient and thermally influenced portions of the study area was lower in magnitude than inter-annual variation at each station, supporting classifying the study area as one of low potential impact for habitat formers.

Water velocity and substrate conditions were found to determine the distribution, standing crop, and species composition of the benthic macroinvertebrate community (including shellfish) observed in exhaustive annual studies performed from 1975 through 1978 in both the upstream ambient zone and in the thermally influenced portions of lower Hooksett Pool (Reference 11.12). Lentic taxa inhabited the slow-flowing or ponded areas of the study area near Hooksett Dam with fine sediments and organic debris in the substrate, while lotic taxa inhabited rapid-flowing and turbulent areas of moderate currents with a cobble or boulder substrate found primarily in the Garvin's Falls Dam tailwaters at the upstream end of Hooksett Pool and in the Hooksett Dam tailwaters at the downstream end. No endangered or threatened species of shellfish or benthic macroinvertebrates were found. The preference for lentic or lotic habitats overrides any influence of Merrimack Station's thermal discharge, because the standing crop and structure of benthic macroinvertebrate communities sampled by Ponar grabs and by artificial multiplates were similar within the same habitat types found both upstream and downstream from the cooling canal discharge (Reference 11.12). The relatively high thermal tolerance of organisms found in the benthic macroinvertebrate community and the surface-orientation of the thermal plume were two factors ameliorating any discharge effects, including those on drifting invertebrates sampled by artificial multiplate samplers (Reference 11.12). Therefore, the two segments of the Merrimack River receiving Merrimack Station's thermal discharge are considered low potential impact areas for shellfish and benthic macroinvertebrates.

Lower Hooksett Pool and upper Amoskeag Pool are two segments of the Merrimack River receiving Merrimack Station's thermal discharge that are considered low potential impact areas for other vertebrate wildlife because no endangered or threatened species are found there, and because there are no large or unique populations found in both the upstream ambient zone and in the thermally influenced portions of lower Hooksett Pool. EPA considers most sites within the United States, such as the study area, to be low potential areas of impact for other vertebrate wildlife unless they are found along major flyways in cold areas (i.e., North Central United States), or in southern areas where manatees might be attracted to the discharge.

It is clear from the analysis and results of the three recently submitted studies (Reference 11.14, 11.15, and 11.16), as well as the extensive studies performed over nearly 40 years at Merrimack Station, that the existing thermal limits in Merrimack Station's NPDES permit and the Station's current operating regime satisfy CWA § 316(a) by "assuring the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife" in the receiving water. To the extent that EPA is considering including thermal limits in the Station's renewed NPDES permit that are different from the existing NPDES permit, such alternative limits may only be appropriately derived from in-river monitoring data, rather than effluent monitoring data, due to the complex and dynamic interaction among changes in river flow, diel and seasonal atmospheric conditions, and Station operations (Reference 11.15).

Table 2-1. Merrimack Station Fish Entrainment Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Design Intake Flows[3] by Month, Unit and Year (May 2006 through June 2007).

	Unit 1						Monthly %		Unit 2								Both Units Combined						Monthly %	
	May - Sep 2006		Apr - Jun 2007		Average Year				May - Sep 2006		Apr - Jun 2007		Average Year		Monthly %		May - Sep 2006		Apr - Jun 2007		Average Year			
Month	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Apr	NS[4]	NS	0	0	0	0	0.0%	0.0%	NS	NS	132,851	666	132,851	666	7.4%	6.7%	NS	NS	132,851	666	132,851	666	3.8%	3.9%
May	0	0	683,907	1,289	341,954	645	20.4%	9.2%	800,515	4,847	132,019	724	466,267	2,786	26.1%	28.2%	800,515	4,847	815,926	2,013	808,221	3,430	23.3%	20.3%
Jun	519,081	2,536	1,331,392	7,521	925,237	5,029	55.1%	71.9%	1,281,629	6,200	827,604	6,106	1,054,617	6,153	59.0%	62.2%	1,800,710	8,736	2,158,996	13,627	1,979,853	11,182	57.1%	66.2%
Jul	377,049	1,225	NS	NS	377,049	1,225	22.5%	17.5%	133,273	283	NS	NS	133,273	283	7.5%	2.9%	510,322	1,508	NS	NS	510,322	1,508	14.7%	8.9%
Aug	33,563	94	NS	NS	33,563	94	2.0%	1.3%	0	0	NS	NS	0	0	0.0%	0.0%	33,563	94	NS	NS	33,563	94	1.0%	0.6%
Sep	NS0[5]	NS0	NS0	NS0	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%
Oct	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Nov	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Dec	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Jan	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Feb	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Mar	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Annual	929,693	3,855	2,015,299	8,810	1,677,802	6,992	100.0%	100.0%	2,215,417	11,330	1,092,474	7,496	1,787,008	9,888	100.0%	100.0%	3,145,110	15,185	3,107,773	16,306	3,464,810	16,880	100.0%	100.0%

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated in entrainment samples from Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual entrainment density at Unit 1 and Unit 2 combined.
[3]Design intake pump flows used to extrapolate actual entrainment per unit volume for all life stages of fish sampled up to maximum flows were 131.45 cfs for Unit 1 and 311.92 cfs for Unit 2.
[4]NS = no sampling
[5]NS0 = not sampled and assumed zero abundance

Table 2-1a. Merrimack Station Fish Entrainment Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Actual Intake Flows[3] by Month, Unit and Year (May 2006 through June 2007).

	Unit 1						Monthly %		Unit 2								Both Units Combined						Monthly %	
	May - Sep 2006		Apr - Jun 2007		Average Year				May - Sep 2006		Apr - Jun 2007		Average Year		Monthly %		May - Sep 2006		Apr - Jun 2007		Average Year			
Month	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Apr	NS[4]	NS	0	0	0	0	0.0%	0.0%	NS	NS	59,724	285	59,724	285	3.8%	3.3%	NS	NS	59,724	285	59,724	285	2.1%	2.0%
May	0	0	556,360	1,049	278,180	525	21.6%	9.7%	742,481	4,495	65,726	372	404,104	2,434	25.5%	28.0%	742,481	4,495	622,086	1,421	682,284	2,958	23.7%	21.0%
Jun	351,603	1,717	1,002,996	5,852	677,300	3,785	52.5%	70.3%	1,234,410	5,748	764,462	5,645	999,436	5,697	63.0%	65.6%	1,586,013	7,465	1,767,458	11,497	1,676,736	9,481	58.3%	67.4%
Jul	306,731	997	NS	NS	306,731	997	23.8%	18.5%	123,754	263	NS	NS	123,754	263	7.8%	3.0%	430,485	1,260	NS	NS	430,485	1,260	15.0%	9.0%
Aug	27,304	77	NS	NS	27,304	77	2.1%	1.4%	0	0	NS	NS	0	0	0.0%	0.0%	27,304	77	NS	NS	27,304	77	0.9%	0.5%
Sep	NS0[5]	NS0	NS0	NS0	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%
Oct	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Nov	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Dec	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Jan	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Feb	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Mar	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Annual	685,638	2,791	1,559,356	6,901	1,289,515	5,383	100.0%	100.0%	2,100,645	10,506	889,912	6,302	1,587,018	8,678	100.0%	100.0%	2,786,283	13,297	2,449,268	13,203	2,876,532	14,061	100.0%	100.0%

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated at Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual entrainment density at Unit 1 and Unit 2 combined.
[3]Actual monthly intake pump flows used to extrapolate actual entrainment per unit volume for all life stages of fish sampled up to monthly abundance or adult equivalents for Unit 1 and Unit 2 (May 2006 through June 2007).
[4]NS = no sampling
[5]NS0 = not sampled and assumed zero abundance

Table 2-2. Merrimack Station Fish Impingement Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Design Flows[3] by Month, Unit and Year (June 2005 through June 2007)[4].

Month	Unit 1						Monthly %		Unit 2								Both Units Combined						Monthly %	
	Year 1		Year 2		Average Year				Year 1		Year 2		Average Year		Monthly %		Year 1		Year 2		Average Year			
	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Jul	53	5	44	0	49	3	3.7%	0.7%	119	10	192	3	156	6	4.4%	2.2%	171	15	236	3	204	9	4.2%	1.4%
Aug	0	0	11	11	5	5	0.4%	1.4%	31	20	9	0	20	10	0.6%	3.6%	31	20	20	11	26	15	0.5%	2.4%
Sep	30	0	0	0	15	0	1.1%	0.0%	68	15	16	0	42	8	1.2%	2.7%	98	15	16	0	57	8	1.2%	1.2%
Oct	145	67	22	5	83	36	6.3%	9.7%	390	26	128	25	259	25	7.2%	9.0%	535	93	150	30	343	61	7.0%	9.4%
Nov	146	88	40	13	93	51	7.0%	13.7%	158	6	142	54	150	30	4.2%	10.8%	304	94	182	68	243	81	5.0%	12.4%
Dec	498	359	46	28	272	193	20.5%	52.2%	225	99	84	17	155	58	4.3%	20.6%	723	458	130	45	427	252	8.7%	38.5%
Jan	146	32	42	8	94	20	7.1%	5.4%	109	23	42	18	76	20	2.1%	7.2%	255	55	84	26	170	40	3.5%	6.2%
Feb	28	6	20	2	24	4	1.8%	1.1%	171	85	35	1	103	43	2.9%	15.2%	199	92	55	3	127	47	2.6%	7.2%
Mar	245	39	42	19	144	29	10.8%	7.8%	59	13	41	0	50	6	1.4%	2.3%	304	52	83	19	194	35	3.9%	5.4%
Apr	39	0	50	1	45	0	3.3%	0.1%	191	1	59	4	125	2	3.5%	0.8%	230	1	109	4	170	3	3.5%	0.4%
May	333	47	110	4	222	25	16.7%	6.8%	259	2	225	17	242	10	6.8%	3.4%	591	49	335	21	463	35	9.4%	5.4%
Jun	477	5	91	3	284	4	21.4%	1.0%	4236	66	159	59	2198	62	61.5%	22.2%	4713	71	251	62	2482	66	50.6%	10.1%
Annual	2139	648	519	93	1329	371	100.0%	100.0%	6016	366	1133	197	3574	282	100.0%	100.0%	8155	1015	1651	291	4903	653	100.0%	100.0%

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated in impingement samples at Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual impingement counts at Unit 1 and Unit 2 combined.
[3]Design intake pump flows used to extrapolate actual impingement rates for all life stages of fish sampled up to maximum flows were 131.45 cfs for Unit 1 and 311.92 cfs for Unit 2.
[4]Year 1 = 29 June 2005 through 30 June 2006; Year 2 = 1 July 2006 through 30 June 2007.

Table 2-2a. Merrimack Station Fish Impingement Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Actual Intake Flows[3] by Month, Unit and Year (June 2005 through June 2007)[4].

Month	Unit 1								Unit 2								Both Units Combined							
	Year 1		Year 2		Average Year		Monthly %		Year 1		Year 2		Average Year		Monthly %		Year 1		Year 2		Average Year		Monthly %	
	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Jul	43	4	36	0	40	2	3.9%	0.8%	111	9	179	2	145	6	4.8%	2.4%	154	13	215	3	185	8	4.6%	1.5%
Aug	0	0	9	9	4	4	0.4%	1.6%	29	19	9	0	19	9	0.6%	3.8%	29	19	17	9	23	14	0.6%	2.6%
Sep	25	0	0	0	13	0	1.2%	0.0%	63	14	11	0	37	7	1.2%	2.9%	88	14	11	0	50	7	1.2%	1.4%
Oct	110	51	15	4	62	27	6.2%	10.0%	176	15	119	23	148	19	4.9%	7.8%	286	66	134	27	210	46	5.2%	9.0%
Nov	97	57	29	10	63	34	6.3%	12.4%	147	6	132	51	140	28	4.7%	11.6%	244	63	161	61	203	62	5.1%	12.0%
Dec	371	268	33	19	202	143	20.1%	52.4%	209	92	68	14	139	53	4.6%	21.7%	581	360	102	33	342	196	8.5%	37.9%
Jan	112	25	35	7	74	16	7.3%	5.8%	102	22	32	15	67	18	2.2%	7.5%	214	46	67	22	141	34	3.5%	6.6%
Feb	23	5	16	2	20	3	2.0%	1.2%	141	70	32	1	87	36	2.9%	14.5%	163	75	48	2	106	39	2.6%	7.5%
Mar	200	32	28	12	114	22	11.4%	8.1%	55	12	37	0	46	6	1.5%	2.5%	256	44	66	12	161	28	4.0%	5.4%
Apr	31	0	41	1	36	0	3.6%	0.1%	84	0	16	0	50	0	1.7%	0.1%	115	0	57	1	86	1	2.1%	0.1%
May	231	33	90	3	161	18	16.0%	6.6%	76	1	85	6	81	3	2.7%	1.3%	307	34	174	9	241	21	6.0%	4.1%
Jun	359	4	74	2	217	3	21.6%	1.1%	3941	61	146	55	2044	58	68.1%	23.7%	4300	65	220	57	2260	61	56.4%	11.8%
Annual	1603	478	405	69	1004	273	100.0%	100.0%	5133	321	866	167	3001	244	100.0%	100.0%	6736	799	1271	236	4005	517	100.0%	100.0%

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated in impingement samples at Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual impingement counts at Unit 1 and Unit 2 combined.
[3]Actual monthly intake pump flows used to extrapolate actual fish impingement rates up to monthly abundance or adult equivalents for Unit 1 and Unit 2.
[4]Year 1 = 29 June 2005 through 30 June 2006; Year 2 = 1 July 2006 through 30 June 2007.

3 Merrimack Station and Cooling System Description

3.1 Merrimack Station Overview

The Station is a coal-fired electric generating station owned by PSNH. It is located along the eastern edge of Bow, New Hampshire and on the west bank of the River, across from Suncook Village, a residential area that straddles the towns of Pembroke and Allenstown [1].

The Station has two separate generating units, Unit 1 and Unit 2. Unit 1, which became operational in 1960, generates at a rated capacity of 120 MW, and withdraws once-through cooling water from the River using a CWIS located on the shoreline of Hooksett Pool. Unit 2, which became operational in 1968, generates at a rated capacity of 350 MW, and withdraws once-through cooling water from the River using a separate CWIS located approximately 120 feet downstream from the Unit 1 CWIS [1].

3.2 Source Water Body

Merrimack Station withdraws cooling water from a reach of the Merrimack River called Hooksett Pool (Attachment 5, Figure A). Garvins Falls Dam forms the upstream boundary of Hooksett Pool while Hooksett Dam forms the lower boundary. The Hooksett Dam tailwater is in the upper headpond of the Amoskeag Dam pool. The Station is 2.9 miles downstream from Garvins Falls Dam, 2.9 miles upstream from Hooksett Dam and 10.7 miles upstream from Amoskeag Dam. The River in Hooksett Pool is fresh water [1].

Each Unit operates in a once-through cooling water mode by withdrawing cooling water from and discharging it back into Hooksett Pool. Hooksett Pool averages between 6 and 10 feet deep under most flow conditions, and has a surface area of 350 acres and a volume of 130 million cubic feet at full pond elevation (approximately 190 feet at each Unit) [1].

The hydraulic retention time of Hooksett Pool is approximately eight hours under Mean Annual Flow (MAF) conditions, and about five days under 7Q10 flow conditions (both of which are less than the criterion of seven days for classification as a reservoir under the now suspended Phase II Regulations). Accordingly, for purposes of the Phase II Regulations, the source water body type for each Unit at Merrimack Station is a freshwater river or stream [1].

The watershed area for the River at Merrimack Station is approximately 2,535 square miles. The estimated MAF for the River at Merrimack Station based on the 100-year period of record was 4,551 cfs. It should be noted that according to USGS, the expected error associated with Merrimack Station would conservatively be estimated to be at least ±10%. Consequently, the most scientifically credible estimate of River MAF at Merrimack Station based on the 100-year period of record is 4,551 ±455 cfs, or 4,096 to 5,006 cfs [1].

3.3 Cooling Water Intake Structure Description

3.3.1 Physical Description, Location and Depth of CWIS

A separate CWIS supplies River water to each generating Unit at Merrimack Station. Both CWISs are located on the west bank of Hooksett Pool. The Unit 2 CWIS is approximately 120 feet downstream from the Unit 1 CWIS. The north (Unit 1) CWIS has two intake pumps, and the south (Unit 2) CWIS also has two intake pumps; however, the intake pumps at Unit 2 are larger than the intake pumps at Unit 1. The CWIS bulkhead for each Unit projects outward into the River from a rip-rap stabilized shoreline approximately 25 to 30 feet [1].

Each forebay opening to the River is covered with a bar rack. The bar racks for each unit are located at the outer edge of the CWIS structure, which extends approximately 25 to 30 feet outward into the River, and are inclined inward at an angle of about 9º [1].

A partition wall below the deck inside each CWIS divides the CWIS into two discrete forebays, separating the flow to each pump. Each forebay directs the separated flow through a dedicated traveling screen before it reaches the screenwell containing the circulating water pump. These vertical single entry/exit traveling screens provide a basic debris and fish handling and return system. Water from the screen wash spray system is used to remove debris from the traveling water screens and transport the debris along the sluiceway back into the River. Water from the two circulating water pumps at each unit merges into a common pipe at a Y-junction within the pump house a short distance past the pumps. The design through-screen velocity of the Unit 1 CWIS is 1.5 feet per second ("fps"); for Unit 2, it is 1.82 fps.

3.3.1.1 Unit 1

The floor of the Unit 1 intake forebay is at elevation 177 feet, and the associated bar racks (3.5 inch on-center spacing) rise upward from that point at an inward angle of about 9º to an elevation of 190 feet (which is the full pond elevation of Hooksett Pool). The concrete bulkhead wall extends upward from the top of the bar racks at the same angle to a deck elevation of 207 feet. A concrete debris barrier wall is located five feet outboard from the base of the bar racks and extends the floor upward by five feet to a point that is at elevation 181 feet, or one foot above the river bottom at elevation 180 feet. There is a five-foot wide opening in the barrier wall between elevations 181 feet and 186 feet through which the cooling water intake flow passes. The outer bulkhead wall then extends upward at the same angle to the deck elevation of 207 feet (see Attachment 5, Figure B) [1].

In summary, the Unit 1 CWIS withdraws water from a horizontal slot in the outer bulkhead that is five feet wide and located between elevations 181 feet and 186 feet, which is about three feet to eight feet below the Hooksett Pool full pond elevation.

3.3.1.2 Unit 2

The floor of the Unit 2 intake forebay is at elevation 176 feet, and the associated bar racks (3.5 inch on-center spacing) rise to the full pond elevation for Hooksett Pool of 190 feet at an inward angle of about 9º. The concrete bulkhead wall extends upward from that point to an elevation of 207 feet. A concrete debris barrier wall is located eight feet outboard from the base of the bar racks and extends the floor upward by five feet to a point that is at elevation 181 feet, or one foot above the river bottom at elevation 180 feet. Unlike Unit 1, there is no upper portion of the outer concrete barrier wall at Unit 2 [1].

In summary, the Unit 2 CWIS withdraws water from nearly the entire water column between an elevation of 181 feet (or one foot above the river bottom) and the full pond surface elevation of Hooksett Pool of 190 feet (see Attachment 5, Figure C) [1].

3.3.2 Cooling Water Intake Flow Description

As detailed above, a separate CWIS supplies each generating unit with cooling water. There are two distinct flow values: the design intake capacity and the average actual intake flow rate.

The design intake capacity is the flow rate that is shown on the design documents, including the circulating water pump curves and the traveling water screen drawings. It is considered to be the baseline value. It is also the value used to design all CWIS screening technologies. The average actual flow rate, conversely, is the actual amount of flow entering the CWIS.

3.3.2.1 Design Intake Capacity

<u>Unit 1</u>

The north (Unit 1) CWIS has two circulating water intake pumps.

Each circulating water pump has a design intake capacity of 29,500 gpm (42.5 MGD, 65.7 cfs). The two flows join in a common header resulting in a combined design intake capacity for both pumps at Unit 1 of 59,000 gpm (85.0 MGD, 131.5 cfs). The Unit 1 circulating water pumps supply water to the following:

- 1806 gpm (2.6 MGD, 4.0 cfs) is supplied for the Slag Sluice. This value is an average daily flow rate since this flow is an intermittent demand. Slag sluice is typically run 9 hrs/day from mid-March through mid-December. During the winter, the sluice runs continuously to protect the system from freezing. The slag sluice discharges into the Slag Pond and ultimately into the discharge canal.
- 5556 gpm (8.0 MGD, 12.4 cfs) is supplied for De-Icing Recirculation. This system is only used during periods where the temperature is below freezing. In essence, hot water from either the condenser or equipment cooling water heat exchanger is recirculated back into the intake via 6” spray nozzles at the bar racks. Since 5556 gpm of water is being added to the intake, the demand for water from the River is decreased by the same amount.
- The traveling screen wash system draws suction from the discharge of the circulating water pumps. Each traveling screen has a single-pressure spray header to wash fish and debris off of the traveling screens and then flush them back to the River. The Unit 1 traveling screen spray wash system draws a total of 560 gpm (0.8 MGD, 1.2 cfs).

- Flow also is supplied to equipment cooling.
- The remainder of the flow supplies the condenser.

The fire pump draws water from the Unit 1 screenwell. It has a design intake capacity of 486 gpm (0.7 MGD, 1.1 cfs) and runs intermittently.

Unit 2

The south (Unit 2) CWIS also has two intake pumps, each with a design intake capacity of 70,000 gpm (100.8 MGD, 156 cfs). The two flows are combined in a common header with a combined design intake capacity for both at Unit 2 circulating water pumps of 140,000 gpm (201.6 MGD, 312 cfs). The Unit 2 circulating water pumps supply water to the following:

- 2780 gpm (4.0 MGD, 6.2 cfs) is supplied for Slag Sluice. This flow is a constant demand, which discharges into the Slag Pond and ultimately into the discharge canal.
- 9028 gpm (13.0 MGD, 20.1 cfs) is supplied for De-Icing Recirculation. This system is only used during periods where the temperature is below freezing. In essence, hot water from the condenser or equipment cooling water heat exchanger is recirculated back into the intake via 6” spray nozzles at the bar racks. Since 9028 gpm of water is being added to the intake, the demand for water from the River is decreased by the same amount.
- The Unit 2 traveling screen spray wash system works the same as the Unit 1 system. However, it draws a total of 588 gpm (0.9 MGD, 1.4 cfs).
- Flow also is supplied to equipment cooling.
- The remainder of the flow supplies the condenser.

3.3.2.2 Average Actual Intake Flow Rate

The average river level is 190 ft per NPDES Reapplication No. NH0001465. Table 1 of the same document correlates circulating water pump capacity and river level. The following shows the applicable portion of that table:

	UNIT 1		UNIT 2	
RIVER LEVEL (ft)	1 PUMP CW FLOW GPM/PUMP	2 PUMPS CW FLOW GPM/PUMP	1 PUMP CW FLOW GPM/PUMP	2 PUMPS CW FLOW GPM/PUMP
190	25,800	24,000	67,000	65,000

The actual amount of flow entering the CWIS is further reduced by the intermittent flow reductions associated with periods of reduced power, periodic maintenance outages, Unit 2 one pump operation, as well as de-icing recirculation. This decrease in flow is a reduction in the baseline flow and is therefore considered to be an operational measure to reduce impingement/entrainment. This benefit will be discussed in full in Section 5.4.

3.3.3 Biocide Treatment

Both units are treated daily with sodium hypochlorite. Treatment rates were drastically reduced in 1985 when the reissued permit moved the monitoring location from the end of the cooling canal to the U1/U2 discharge box at the beginning of the canal. Each injection pump is set to run for 1 hour two times a day. The Unit 1 pumping schedule is from 08:00 - 09:00 and 20:00 - 21:00. The Unit 2 pumping schedule is from 14:00 - 15:00 and 02:00 - 03:00. During each pumping period, approximately 15 gallons of sodium hypochlorite is pumped through a distribution header into the circulating water inlet tunnel. Therefore, the combined rate of sodium hypochlorite injection is approximately 60 gallons per day. The Unit 1 injection point is located on Elevation 198' prior to the Elliott Strainer. The Unit 2 injection point is located in a manhole east of the hypo pump building. Both injection points have isolation valves for performing maintenance while the Station is online.

3.4 Discharge System

After passing through the Station, cooling water from each unit is discharged from two 72" discharge pipes through a common bulkhead into the upstream end of a 3,900 ft cooling canal. The cooling water becomes thoroughly mixed between the two units in the upstream portion of the cooling canal, and then flows downstream past 54 banks of four power spray modules PSMs (216 total), which provide cooling prior to discharge into the Merrimack River. The downstream end of the cooling canal where the cooling water discharges into the Merrimack River is located on the west bank of Hooksett Pool about 0.5 miles downstream from the Station (represented by Monitoring Station S-0, Figure A) [2].

The Station's normal operating mode is to operate both units at or near full power. When both units are operating, the maximum operating discharge flow rate is as follows:

Unit 1	**48,000 gpm**	**106.9 cfs**	**69.1 MGD**
Unit 2	**130,000 gpm**	**289.6 cfs**	**187.2MGD**
Both Units	**178,000 gpm**	**396.5 cfs**	**256.3MGD**

This value is shown on the Merrimack Station Water Distribution Diagram (Figure D, Attachment 5) and is also reported on the Discharge Monitoring Reports (DMR) under normal CWIS conditions. It is also the value that will be used to size the thermal discharge canal cooling tower requested to be evaluated by the EPA.

3.4.1 Discharge Piping

The Unit 1 cooling water is discharged from the condenser through a 72" I.D. reinforced concrete pipe (RCP). The RCP travels plant west approximately 135 feet before it turns 90° and travels plant south approximately 640 feet before reaching the entrance to the discharge canal.

The Unit 2 cooling water is discharged from the condenser through a 96" I.D. RCP. It travels approximately 100 feet plant west before it turns 90° and travels approximately 460 feet plant south. At this point, the discharge piping turns 22 ½° toward plant west for 30 feet before turning 22 ½° back toward plant east. The 96" piping is then reduced to 72" in a 10 ft reducer before traveling 40 feet plant south and then entering the discharge canal. At the entrance to the discharge canal, the Unit 1 and Unit 2 discharge pipes are spaced 10 ft apart on center and discharge through a common bulkhead.

3.4.2 Discharge Canal

The original discharge canal began at the common bulkhead and proceeded southeast for approximately 250 feet. From there, it continued plant south with a center line around E3442 for approximately 700 ft before reaching Merrimack River. It was approximately 25 feet wide for its entire length.

In 1971, coincident with the addition of the PSMs, the discharge canal was reconfigured (see Figure E, Attachment 5). It is now 'C' shaped, with the entrance to the canal located at the top right hand portion of the 'C', and the discharge at the bottom right hand portion of the 'C'. The left hand portion of the canal is fairly straight. The bottom of the canal is at an elevation of approximately 180 ft.

The first portion of the canal (from the beginning of the canal down to the base of the 'C') has a bottom width of approximately 130 feet. At normal water levels, the canal is approximately 200 feet wide and has a velocity of approximately 0.3 ft/sec.

The remainder of the canal has a minimum bottom width of approximately 25 feet. At normal water levels, the canal is approximately 73 feet wide and has a velocity of approximately 1.1 ft/sec.

The downstream end of the cooling canal, where the cooling water discharges into the Merrimack River is located on the west bank of Hooksett Pool about 0.5 miles downstream from the Station.

3.4.3 Power Spray Modules

"The power spray module system shall be operated, as necessary, to maintain either a mixing zone (Station S-4) river temperature not in excess of 69°F, or a N-10 to S-4 change in temperature (Delta-T) of not more than 1 °F when the N-10 ambient river temperature exceeds 68°F. All available PSMs shall be operated when the S-4 river temperature exceeds both of the above criteria" (EPA 1992). The cooling water in the discharge canal travels a short distance before it encounters the PSM system. The PSM system is a series of spray nozzles located in the cooling canal that spray a portion of the cooling water discharge flow from the cooling canal up into the air prior to discharge into the Merrimack River.

EPA requested in the § 308 Letter that PSNH identify and evaluate means by which Merrimack Station could achieve and maintain a maximum ambient temperature differential of 5°F in Hooksett Pool (i.e., between Station N10, which is above the Station's thermal discharge point, and Station S4, which is below that discharge point). Therefore, this Report analyzes the PSM system's effectiveness in achieving the requested river water temperature differential.

3.4.3.1 PSM Effectiveness

PSMs operate in a manner similar to evaporative cooling towers, in that their cooling performance is bound by an approach to wet bulb parameter (see further discussion of evaporative cooling in Section 6.1.1.1.2). PSMs operate at a relatively high approach to wet bulb (approx. 18°F approach to wet bulb at a design wet bulb temperature of 76°F) which diminishes in performance as the wet bulb temperature decreases from the design point. Further analysis of the PSM approach to wet bulb temperature is provided in Attachment 3.

Analysis of the PSM system's effectiveness is relatively straightforward, requiring the comparison of two measured variables, N10 and S4 river water temperature, against the evaluated temperature differential; however, these two variables must first undergo several degrees of scrutiny to ensure a complete and valid data set is used.

Five years (2002-2006) of Merrimack River water temperatures in discrete 15 minute intervals were provided by PSNH. All negative temperature (°C) values were considered erroneous and were removed from this raw data, and the remaining values averaged into 1 hour intervals to be consistent with National Weather Service (NWS) data used in further analysis. The resulting hourly average river water temperatures were then reviewed and all erroneous data (i.e., hourly values with a greater than 5°C differential) removed. The table below displays the the number of hours per month, and the percentage of the measured hours per month that the Station achieved the evaluated 5°F Station N10 - Station S4 temperature differential during 2002 through 2006. Note that river water temperatures are not monitored once the river water temperature approaches freezing. Therefore, it is not possible to determine hours outside the evaluated temperature differential. These months are not included in the tables.

Historical Measured Attainment of 5°F Station N10 - Station S4 Temperature Differential Scenario										
	2002		2003		2004		2005		2006	
Month	*Hrs.*	*Perc.*	*Hrs.*	*Perc.*	*Hrs.*	*Perc.*	*Hrs.*	*Perc.*	*Hrs.*	*Perc.*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	24	29.3%	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	33	97.1%
April	386	53.6%	152	47.1%	251	100.0%	350	57.3%	531	78.8%
May	492	100.0%	439	99.8%	744	100.0%	739	99.3%	740	100.0%
June	397	62.2%	483	67.1%	339	47.1%	664	97.9%	719	100.0%
July	179	24.1%	241	32.5%	148	20.1%	406	55.8%	691	93.1%
August	127	17.1%	321	45.7%	110	14.8%	87	11.7%	312	42.0%
September	233	32.6%	179	24.9%	279	38.8%	85	11.8%	163	22.7%
October	497	67.3%	380	54.3%	154	20.7%	491	70.4%	505	67.9%
November	84	64.1%	279	67.6%	196	52.8%	267	67.4%	593	82.4%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	110	31.3%
Measured Attainment[2]	2419	48.3%	2474	52.0%	2221	44.2%	3089	58.1%	4397	71.1%
Annual Attainment[3]	5830	69.3%	6053	72.6%	5631	66.7%	6426	74.3%	6916	79.5%

[1]*N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*
[2]*Measured attainment calculated by dividing the average hours within attainment by the number of hours with recorded data*

[3]*Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario*

Measured values were averaged for each month of each calendar year to yield the typical historical monthly hours that the evaluated temperature differential was achieved as tabulated below. However, as previously discussed, the measured data does not include erroneous values or values at or near freezing temperatures (due primarily to the removal of temperature sensors from the Merrimack River at near freezing conditions, with no data provided within the five-year period for Dec. 15th through March 28th).

Annual Historical Measured Attainment of Evaluated 5°F Station N10-Station S4 Temperature Differential (2002-2006)		
Month	**§308 Δ5°F Evaluated Scenario**	
	Hours	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	34.0	41.5%
April	419.7	58.3%
May	742.6	99.8%
June	544.7	75.7%
July	335.6	45.1%
August	191.7	25.8%
September	188.2	26.1%
October	413.5	55.6%
November	473.6	65.8%
December	110.0	31.3%
Measured Attainment[2]	3453.6	54.9%
Annual Attainment[3]	5924.6	67.6%

[1]*N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

[2]*Measured temperature differential attainment calculated by dividing the average hours meeting the scenario by the number of hours with recorded data*

[3]*Annual temperature differential attainment calculated assuming all N/A values are within 5°F temperature differential scenario*

Based on the five years of Merrimack River water temperature analyzed, the Station would be within the evaluated 5°F Station N10-Station S4 temperature differential 67.6% of the measured historical time using the existing PSM operation.

To this point, the analysis of the PSM system's effectiveness has been based on historical data, which reflect both scheduled and unscheduled unit outages. The PSM system's effectiveness was also evaluated as if the Station were operating in an idealized (i.e., continuous full power operation) condition. By removing measured values of attainment of the 5°F temperature differential occurring in conjunction with Unit 1 and 2 combined net electrical power less than 90% of design value (approx. 375 MWe), a full power river water temperature data set was generated. These full power values were averaged similarly to the annual historical measured attainment calculation above and are tabulated below. This idealized calculation is limited by three years of net electrical power data coincident with the provided river water temperatures (2002-2004). Therefore, the measured attainment values presented below are to be considered relatively conservative in comparison to the non-idealized calculations, which used river water temperatures spanning five years. Note that no data is provided for Nov. 18th through March 28th over the three-year period due to freezing conditions.

Annual Full Power PSM Attainment of Evaluated 5°F Station N10-Station S4 Temperature Differential (2002-2004)		
	Attainment of Evaluated 5°F Station N10-Station S4 Temperature Differential	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	267.5	46.6%
May	743.5	99.9%
June	418.3	58.1%
July	163.3	22.0%
August	180.8	24.3%
September	175.0	24.3%
October	253.7	34.1%
November	230.3	55.2%
December	N/A[1]	N/A[1]
Measured Attainment[2]	2432.5	45.0%
Annual Attainment[3]	5555.5	65.1%

[1]N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)
[2]Measured temperature differential attainment calculated by dividing the average hours meeting the evaluated scenario by the number of hours with recorded data
[3]Annual temperature differential attainment calculated assuming all N/A values are within the 5°F temperature differential scenario

3.5 Cooling Water Process Flow Diagram

Please refer to Figure D of Attachment 5, which shows the flow of cooling water through Merrimack Station.

3.6 Recent and Planned Plant Modifications

3.6.1 Modifications Since January 2001

There have been no major upgrades or repairs to Merrimack Station since January 2001.

3.6.2 Planned Scrubber Installation

The only plan for major upgrades or repairs to Merrimack Station is to install a wet flue gas desulphurization (FGD) system for both units by July 2013 as required by state law.

3.6.2.1 Impact On Heat Rejection

It is not currently anticipated that there will be an impact to heat rejection due to the FGD system.

3.6.2.2 Impact On Water Usage

It is anticipated that the FGD system will consume approximately 1 million gallons per day of water. The water will be drawn from the slag sluice stream, which is approximately 6.6 million gallons per day. There will be no additional water taken from the River for the FGD system.

3.6.2.3 Impact On Available Site Real Estate

Please refer to Sargent and Lundy's General Arrangement prints M-GA-01 Sheets 1 and 2 (Figure F, Attachment 5).

3.6.3 Age of Cooling System Equipment

The following table shows the age of the equipment used in Merrimack Station's cooling system:

Equipment	Originally. Installed	Major Repairs or Modifications
Unit 1 Bar Racks	1960	None
Unit 2 Bar Racks	1968	None
Unit 1 Traveling Screens	1960	2002, Existing frame and screens replaced with steel frame and stainless steel screens
Unit 1 Spray Wash Pump	1960	2004, Existing pump replaced with Weinman model #3L4 pump
Unit 2 Traveling Screens	1968	1988, Existing 2A frame and screens replaced with fiberglass frame with stainless steel screens 1989, Existing 2B frame and screens replaced with fiberglass frame with stainless steel screens
Unit 2 Spray Wash Pump	1968	1998, Existing pump replaced with Worthington model #4LR-11A pump
Circ Water Pump 1A, 1B	1960	1991, New stainless steel impeller installed
Circ Water Pump 1B	1960	Note that the original bronze impellers from 1A and 1B circ pumps have routinely been rebuilt and reused since 1991. Currently 1A has a stainless steel impeller in use and 1B has a bronze impeller in use.
Circ Water Pump 2A	1968	1992, New stainless steel impeller installed 2004, 600 HP motor replaced with 700 HP motor
Circ Water Pump 2B	1968	None
Unit 1 Hypochlorite Injection Pump	1960	1997 (approx.), the Unit 1 hypochlorite injection pump was replaced when injection rates were decreased
Unit 2 Hypochlorite Injection Pump	1968	1997 (approx.), the Unit 2 hypochlorite injection pump was replaced when injection rates were decreased

Equipment	Originally. Installed	Major Repairs or Modifications
Unit 1 and 2 Hypochlorite Injection System	1960 – Unit 1 1968 – Unit 2	1. The Unit 1 hypochlorite injection header, located in the cooling water inlet tunnel, was modified to accommodate the low volume of 15% sodium hypochlorite used. The location of the injection head has not changed, however, it has been modified with 1/8th inch drill holes approximately six inches apart where previously half inch slots were utilized. This adaptation was done in order to better distribute the chlorine. The same modification was made to Unit 2, only a titanium distribution header was required instead of stainless steel. Stainless steel failure is attributed to a combination of corrosion and flow current. 2. Both hypochlorite pump control systems were modified to prevent them from operating when only one CWIS pump is in service or when both are out of service. This was done to prevent an overdose of hypochlorite. 3. Both hypochlorite pump suction lines were equipped with calibration columns to verify pump flows 4. Both hypochlorite pumps were outfitted with pressure relief valves that recirculate back to the hypochlorite storage tank 5. A secondary containment with an alarm system for leak detection was added to the hypochlorite pump pedestal and discharge piping area
PSMs	1971	Each PSM unit is comprised of 1 pump and 4 spray nozzles. There are a total of 54 pumps and 216 nozzles. These are routinely maintained and replaced as necessary.

3.7 Projected Retirement Plans

There are no plans to retire Merrimack Station at this time because it provides critically needed reliable, affordable power to New Hampshire customers. In fact, under state law (RSA 369-B:3-a), PSNH must continue to own and operate Merrimack Station so long as it is in the economic interest of retail customers to do so.

4 Description of Plant Processes

4.1 Boiler Operation

Merrimack Station generates steam power using two Babcock and Wilcox pressurized, cyclone fired boilers. Unit 1 went into commercial operation in 1960. It has a gross generation of 120 MW with a main steam flow of 859,000 lb/hr, an outlet steam temperature of 1000 °F, and a pressure of 1800 psig, a reheat temperature of 1000 °F and a pressure of 477 psig. Unit 2 went into commercial operation in 1968 and has a gross generation of 350 MW with a main steam flow of 2,222,000 lb/hr, an outlet steam temperature of 1000 °F and a pressure of 2400 psig, a reheat temperature of 1000 °F and a pressure of 5577 psig. Condensate makeup to the boilers is provided from two on-site groundwater wells.

4.2 Condenser Operation

River water is primarily used to cool the turbine exhaust steam in the condensers and to provide cooling for the heat exchangers in the closed cooling water systems. As reflected in Figure D of Attachment 5, which shows the flow of cooling water through Merrimack Station, the condensers pass river water through tubes that are used to cool exhaust steam from the turbines. Both the condenser and the heat exchangers are non-contact. The cooling water is discharged directly to the cooling canal via the two NPDES outfalls.

River water is used in the tanks at the bottom of the boilers to quench slag and to transport it to an on-site settling area. The water is routed to the slag pond and eventually discharges via the NPDES outfall to the cooling canal

4.3 CWIS Operation

A detailed description of the CWIS system can be found in Section 3.3.

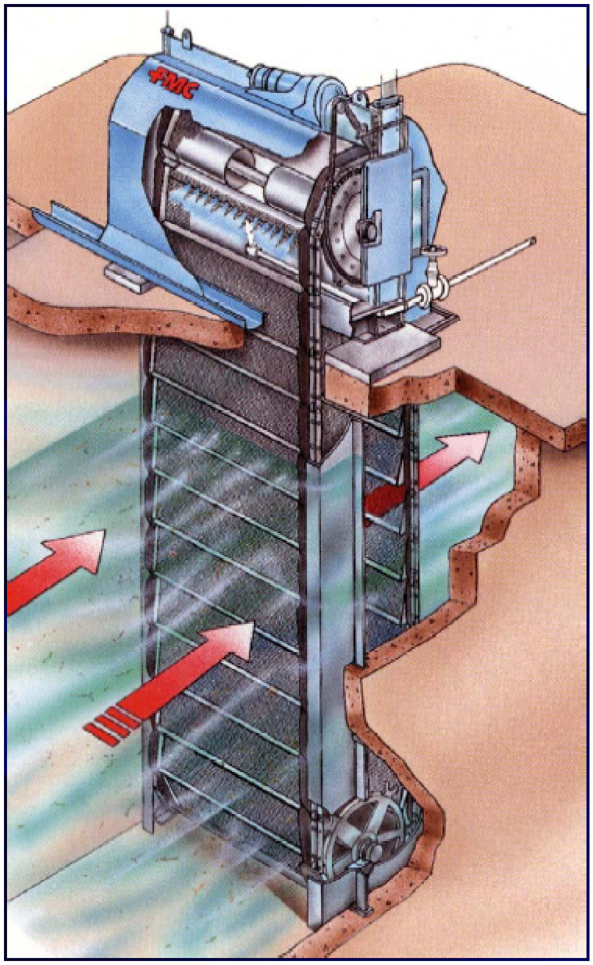
4.4 Effluent Treatment Operations

Both units are treated daily with sodium hypochlorite. Treatment rates were drastically reduced in 1985 when the reissued permit moved the monitoring location from the end of the cooling canal to the U1/U2 discharge box at the beginning of the canal. Each injection pump is set to run for 1 hour two times a day. The Unit 1 pumping schedule is from 08:00 - 09:00 and 20:00 - 21:00. The Unit 2 pumping schedule is from 14:00 - 15:00 and 02:00 - 03:00. During each pumping period, approximately 15 gallons of sodium hypochlorite is pumped through a distribution header into the circulating water inlet tunnel. Therefore, the combined rate of sodium hypochlorite injection is approximately 60 gallons per day. The Unit 1 injection point is located on Elevation 198' prior to the Elliott Strainer. The Unit 2 injection point is located in a manhole east of the hypo pump bldg. Both injection points have isolation valves for performing maintenance while the Station is online.

5 Evaluation of Existing CWIS Technologies and Operational Measures

5.1 Description of Existing Traveling Water Screens and Fish Return System

Traveling water screens are automatically cleaned screening devices that are used to remove fish and/or floating or suspended debris from a channel of flowing water. Merrimack Station's traveling water screens consist of a continuous series of wire mesh panels bolted to frames and attached to two matched strands of roller chains. They are installed in a channel with the screening surface oriented perpendicular to the water flow. The chain operates in a vertical path over head and footsprockets, carrying the panels down into the water, around the footsprockets, back up through the water, and over the headsprockets. Raw water passes first through the ascending and then the descending screen baskets. The ascending basket is located on the upstream portion of the screen and collects fish and/or debris as it passes up through the water. The fish and/or debris is retained on the upstream face of the wire mesh panels. Fish and/or larger particles of debris are collected on a 2 – 3" wide lifting shelf that forms the lower, or trailing, edge of the mesh frame. The basket continues to revolve and descends into the water on the downstream side. Any fish and/or debris that was not originally washed off the screen basket may be washed off in the flow of water. This is considered to be 'carryover' and will travel into the intake screenwell and potentially enter the circulating water pump intake.



Source: http://www.epa.gov/waterscience/presentations/taft.pdf

The Station's traveling screens rotate periodically when the fish and/or debris load is light and continuously when the fish and/or debris load is heavy. The fish and/or debris-laden mesh panels and shelves are lifted out of the flow and above the operating floor where a pressurized water spray is directed outward through the mesh to remove impinged fish and/or debris. The spray wash water and fish and/or debris are collected in a trough for further disposal.

Each of the two traveling screens at Merrimack Station Unit 1 is an FMC Model 45A LinkBelt screen. It is designed to have a capacity for screening 29,000 gpm at a velocity of 1.5 fps. The Unit 2 traveling screens are Rex Chain Belt two-post screens. Each has a design capacity of 70,000 gpm at a velocity of 1.82 fps. The mesh panels for the traveling screens on both units consist of stainless steel screen cloth with standard 3/8-inch (0.375-inch) square openings.

Each screen has a single-pressure spray header to wash fish and/or debris off of the traveling screens.[1] The Unit 1 traveling screen spray wash system supplies approximately 560 gpm at 85 psi. The Unit 2 traveling screen spray wash system supplies a total of approximately 528 gpm at 80 psi or 588 gpm at 100 psi. The spray washes the fish and/or debris into a grate-covered trough in the floor of the CWIS deck for return to the River.

The trough servicing the two Unit 1 traveling screens carries the fish, debris and wash water from the Unit 1 CWIS into an 18-inch-diameter corrugated steel pipe that runs southward for about 175 feet. The trough servicing the two Unit 2 traveling screens carries the fish, debris, and wash water from the Unit 2 CWIS into an 18-inch diameter open top smooth steel pipe that joins the Unit 1 wash water pipe at a point about 25 feet south of the Unit 2 CWIS. The fish, debris and wash water continue downstream in a common 18-inch-diameter corrugated steel pipe that runs southward for about 75 feet. The fish, debris, and wash water discharge from the open end of the corrugated steel pipe onto a grate that leads to a discharge point at the river bank that is about 100 feet south (downstream) of the Unit 2 CWIS. When Hooksett Pool is at a full pond elevation of 190 feet, the discharge location for the common debris and fish sluice is approximately four feet inland from the edge of the river.

5.2 Evaluation of Existing Traveling Water Screens

The purpose of evaluating the existing traveling water screens is to determine how well the screens minimize impingement and entrainment of marine life. The following desirable design features of traveling water screens minimize impingement and entrainment (Reference 11.5):

- Approach and through-flow velocities less than 1 fps
- Open or short intake channels with 'escape routes'
- Small mesh openings
- Provisions to gently handle impinged fish
- Continuous operation
- Low-pressure wash system to gently remove impinged fish

The existing Unit 1 and 2 traveling water screens have some, but not all, of these desirable design features:

- They have an approach velocity of 1.5 fps (Unit 1) and 1.82 fps (Unit 2) which is greater than the desired 1 fps maximum.
- The current Unit 1 and Unit 2 intakes are short but lack 'escape routes'.
- Their screen mesh has square 3/8 inch openings. Therefore, they are considered coarse mesh screens, which minimize impingement, but not entrainment.
- They have no provisions to gently handle impinged fish.
- They rotate periodically when the debris load is light. Therefore, although they run continuously when the fish and/or debris load is heavy, they do not run continuously under all fish and/or debris loading conditions.
- They each have only a high-pressure spray wash system. They have no low-pressure wash system.

5.3 Evaluation of Existing Fish Return System

The main objective of any fish return system is to return any captured fish to the water body with a minimum of stress. A quality fish return system usually consists of a trough designed to maintain a water velocity of 3 to 5 fps (0.9 to 1.5 m/s) and with a minimum water depth of 4" to 6" (102 to 152 mm). The trough should avoid sharp radius turns and should discharge slightly above the water level. The trough should be covered with a removable cover to prevent access by birds or other predators.

The current fish return system is more of a debris return system. The fish, debris, and wash water from the traveling screens are discharged onto a grate which covers the opening of the trough. The trough is normally empty, unless the traveling screens are operating. Therefore, there is no minimum water level. The Unit 1 and common troughs are covered (since the trough is a corrugated steel pipe). However, the Unit 2 trough is uncovered. The bottom of the Unit 1 and common trough is a corrugated surface, which would add significant stress to any living thing descending the trough. The common trough discharges onto another grate before transporting the fish, debris, and wash water to the water body. When the water body level is high, the discharge is 4 ft into the river. When the water body level is low, the impinged fish may not reach the River.

Per an evaluation by Normandeau Associates, the survivability benefit of the existing fish return system is minimal due to the location of the fish return discharge.

5.4 Description of Current Operational Measures

Impingement and entrainment abundance are generally assumed to be based on the amount of cooling water entering the CWIS, reduction in intake flow would also reduce impingement and entrainment. Reduction in flow is considered to be an operational measure. For Merrimack Station, the reduction in flow is based on the % reduction from the design intake capacity of 59,000 gpm (85 MGD, 131.5 cfs) for Unit 1 and 140,000 gpm (201.6 MGD, 312 cfs) for Unit 2. The following operational measures are currently implemented at each Unit of Merrimack Station.

5.4.1 Maintenance Outages

During a maintenance outage, there is no flow entering the CWIS for whichever unit is in the outage. For Unit 1, maintenance outages occur every two years and last approximately four weeks. For Unit 2, maintenance outages occur every year and also last approximately four weeks. The outages are staggered so that both Units are not offline at the same time.

5.4.2 Unit 2 Single Intake Pump Operation

During the winter months, certain weather conditions contribute to the formation of frazil ice at the Unit 2 intake. The frazil ice builds up on the traveling screens. The same weather conditions cause small chunks of ice to build up on the trash racks. In order to remove the frazil ice and small chunks of ice, one of the Unit 2 circulating water pumps is shut off. Therefore, only one traveling water screen is being used, which allows 100% of the screen wash flow to spray on the active Unit 2 traveling water screen. This happens approximately 8.4 days per winter. This practice is not done for Unit 1.

One Unit 2 circulating water pump operates at approximately 70,000 gpm (100.8 MGD, 156 cfs). Therefore the total reduction in flow is 850 million gallons per year, which equates to an annual average decrease of 1611 gpm (2.3 MGD, 3.6 cfs) or approximately 1.0%.

The following chart shows the periods of Unit 2 single pump operation from December of 2000 to January of 2007.

Single Pump Operation Period	Number of Days
12/20/00 – 01/14/01	26
12/03/02 – 12/06/02	4
12/08/03 – 12/19/03	12
12/28/04 – 12/31/04	4
2005	0
2006	0
01/17/07 – 01/29/07	13

5.4.3 De-Icing Recirculation

During the winter months of December through March, when river temperature is below 35°F, hot water from either the condenser or the equipment cooling water heat exchanger is recirculated back into the intake. The addition of hot water prevents ice formation at the CWIS. The de-icing flow is discharged at a location about eight feet outboard from the trash racks at an elevation of about 179 feet via 6" spray nozzles. Since water is being added to the intake, the demand for water from the River is decreased by the same amount.

The Unit 1 recirculation occurs approximately 90 days per year and pumps 5555 gpm (8 MGD, 12.4 cfs). Unit 2 recirculation occurs approximately 90 days per year and pumps 9000 gpm (13 MGD, 20.1 cfs).

5.4.4 Biological Effectiveness of Existing CWIS Technologies and Current Operational Measures

The Phase II Regulations, now suspended, measured impingement mortality and entrainment reductions against a 'calculation baseline' that assumed once-through cooling with 3/8-inch-mesh intake screens oriented parallel to the shoreline and without any structural or operational controls for reducing impingement mortality or entrainment. PSNH continues to object to the Phase II Regulations' definition of 'calculation baseline' and EPA's interpretation and application of the 'calculation baseline' concept. Nonetheless, solely for purposes of this Report, PSNH discusses potential percentage IM&E reductions in this section using the assumption that EPA will require Merrimack Station to attain IM&E reductions from IM&E levels reflecting the above described 'calculation baseline.'

If it can be assumed that (1) there is a direct linear (1:1) relationship between flow reductions and the number of fish impinged or entrained (a fundamental assumption of the Phase II Rule), and (2) there is 100% mortality of impinged or entrained fish at each Unit, then the June 2005 through June 2007 impingement and entrainment abundance data (Reference 11.17) can be used to evaluate the impingement and entrainment reductions that Merrimack Station achieves by employing its existing CWIS technologies and current operational flow reduction measures.

The existing traveling screen and fish return system has 100% impingement mortality due to the location of the debris return sluice, which discharges into a dry sump and does not allow the fish to enter the river except under high pool elevations. When combined with the typically high survival afforded by most quality fish return systems with the features described in Section 5.3 above, continuous rotation of the existing traveling screens may provide survival of more than 50% of the impinged fish at the Station. Entrainment mortality due to the CWIS is undoubtedly less than 100%, but the entrainment survival studies collected insufficient organisms to calculate survival of entrained organisms. Therefore, for the purpose of evaluating the effects of flow reductions from a full flow baseline (based on the design intake flows of each Unit), entrainment mortality will also be assumed to be 100%.

Impingement and entrainment are not uniform throughout the year, so flow-weighted annual impingement and entrainment reductions were calculated based on the results of the impingement studies performed during 2005 through 2007, and the actual or expected pattern of intake flows at each unit in each month throughout the year (Reference 11.17). These calculations were performed based on the actual observed timing of operational flow reductions and the daily, weekly and monthly impingement rates at Unit 1 and Unit 2 presented in the E&I Report (Reference 11.17).

Operational flow reductions at Merrimack Station occurring due to maintenance outages (Section 5.4.1), Unit 2 single pump operation (Section 5.4.2), and de-icing recirculation flow (Section 5.4.3) result in a combined annual flow reduction from a full flow baseline of 6.3% at Unit 1 and 9.0% at Unit 2. Among these three operational flow reductions, the scheduling of maintenance outages contributes most to the cumulative total flow reduction for each unit. However, by far the greatest overall flow reductions for the Unit 1 and Unit 2 CWIS comes from the loss of intake pumping efficiency due to head loss from design full pond elevation as Hooksett Pool water levels change daily due to hydropower operation of the Garvins Falls (upstream) and Hooksett (downstream) hydroelectric stations. An analysis of the observed actual monthly intake flows presented in the Merrimack Station PIC (Reference 11.8) revealed an overall average flow reduction from design capacity of 26.9% for Unit 1 (35.4 cfs; Table 1) and 23.5% for Unit 2 (73.2 cfs; Table 2) during the period 1996 through 2004. These flow reduction values reported in the PIC include the effects of maintenance outages and single pump operation at Unit 2, but not de-icing flows. Therefore, effects of head loss alone on these flow reduction values can be determined by subtracting the contribution of flow reductions due to maintenance outages at Unit 1 (5.3 cfs) and Unit 2 (25.1 cfs), and the effects of one-pump operation at Unit 2 (3 cfs) from the values reported in the PIC. The results reveal that head loss alone accounts for a 22.9% intake flow reduction for Unit 1 and a 14.5% intake flow reduction for Unit 2.

When the actual operational flow reductions during the June 2005 through June 2007 entrainment and impingement studies are weighted by the monthly abundance of impingement and entrainment and compared to the design flows, an overall annual reduction of adult equivalent losses of 17% for entrainment and 21% for impingement is attributable to these operational flow reductions, as shown in the following tables.

Sampling Year Adult Equivalents	**Unit 1 Actual Entrainment**	**Unit 2 Actual Entrainment**	**Both Units Actual Flow**	**Both Units @ Design Flow**
May 06-Sep 06	2,791	10,506	13,297	15,185
Apr 07-Jun 07	6,901	6,302	13,203	16,306
Average Annual	**5,383**	**8,678**	**14,061**	**16,880**
Reduction (%)				**17%**

Sampling Year Adult Equivalents	Unit 1 Actual Impingement	Unit 2 Actual Impingement	Both Units Actual Flow	Both Units @ Design Flow
Jun 05-Jun 06	478	321	799	1,015
Jun 06-Jun 07	69	167	236	291
Average Annual	**273**	**244**	**517**	**653**
Reduction (%)				**21%**

6 Mechanical Draft Towers for Closed-Loop Cooling (both Units)

6.1 Conceptual Design

Conversion of existing operating power stations from once-through to closed-cycle cooling is largely unprecedented. Even without this significant uncertainty, conversion of an existing, operating power plant from once-through condenser cooling to closed-loop condenser cooling represents a massive engineering and construction undertaking in the best of circumstances, even when site conditions are conducive to the required configuration changes. While the total impact of all factors cannot be fully established, certain critical measures play a significant role in determining the feasibility and the appropriate configuration of any evaluated closed-cycle system, as discussed in the following sections.

6.1.1 Major Components

As EPA directed in the §308 Letter, this section evaluates the retrofitting of a mechanical draft cooling tower at Merrimack Station Units 1 and 2. The biological data from Merrimack Station's monitoring programs confirm no AEI to the aquatic ecosystems of the Merrimack River in the vicinity of the Station, including to any RIS or critical aquatic organism population, from the Station's CWISs. As a result, the costs of retrofitting such a cooling tower for use in a closed-cycle cooling configuration for both units at the Station would be wholly disproportionate to any environmental benefits that could be conferred by doing so (and, to the extent it is relevant, closed-loop cooling using a mechanical draft cooling tower would not be the most cost-effective technology available for minimizing AEI, and would raise concerns about negative environmental impacts, energy production and efficiency). Other alternatives for heat rejection with the necessary capacity to support closed-loop cooling, such as evaporative ponds, spray ponds, or cooling canals, all require significantly more real estate to implement than exists at the Merrimack Station site.

6.1.1.1 Cooling Towers

6.1.1.1.1 Dry Cooling Towers

Dry cooling towers, which rely totally on sensible heat transfer, lack the efficiency of wet or hybrid towers using evaporative cooling, and thus require a far greater surface area than is available at the Merrimack Station site. Additionally, due to their lower efficiency, dry towers are not capable of supporting condenser temperatures and associated backpressures necessary to be compatible with either Unit's turbine design and, therefore, their implementation at Merrimack Station is infeasible.

6.1.1.1.2 Evaporative Cooling Towers

Evaporative cooling tower types and configurations are discussed below:

Natural Draft Towers

Of the types of evaporative cooling towers, the natural draft "wet tower" is comparatively efficient, quiet, moderate to high in initial cost, and moderate in footprint (i.e., up to 450 feet in diameter), and under appropriate circumstances, can be less costly to operate than comparably sized mechanical draft cooling towers. Thus, given suitable site conditions, the natural draft tower can be a sound engineering choice.

However, natural draft towers rely on the "chimney effect" of the tower to create the required draft; hence, the tower must be very tall, approximately 450 to 550 feet in height. Local zoning restrictions often preclude the use of natural draft towers. Additionally, natural draft towers require adequate heat load provided by the circulating water system to fuel the thermal differential required to create and sustain the "chimney effect". Because of the relatively small capacity of cooling water (i.e., circulating water) flow at Merrimack Station, particularly Unit 1, implementation of natural draft towers at Merrimack Station is infeasible.

Figure 6.1 illustrates a typical natural draft cooling tower.

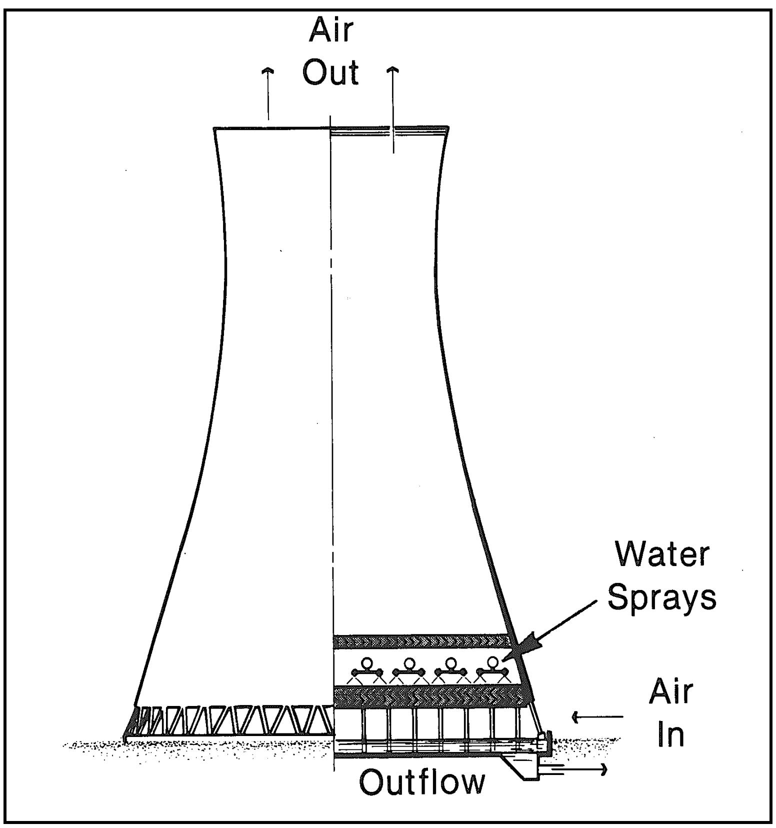


Figure 6.1 – Counterflow Hyperbolic Natural Draft Cooling Tower [Reference 11.3]

Air flow through the tower is produced by the density differential that exists between the heated (less dense) air inside the stack and the relatively cool (more dense) ambient air outside the tower. Since these towers depend on their geometric shape rather than fans for required air flow, they have low operating costs.

Mechanical Draft Towers

Compared to the other types of evaporative cooling towers, a mechanical draft wet cooling tower can be efficient, typically lowest in initial cost, moderate in footprint, and with moderate operating costs. Due to the need for forced draft fans, this type of tower has slightly higher noise levels than a natural draft tower, although attenuation to acceptable levels is possible, at an added cost. As noted previously, EPA has directed PSNH in the § 308 Letter to evaluate a mechanical draft cooling tower for use in a closed-cycle cooling configuration for both units at Merrimack Station.

To support the evaluation required by EPA, SPX Cooling Technologies was consulted relative to optimum tower design approach and tower sizing. To minimize operational losses due to higher intake water temperature, a tower with an 8°F approach (see Figure 6.2 for definition of "Approach") was considered the largest that could be effectively utilized. Since the 84°F condenser inlet water would only occur at maximum ambient conditions, and the fan parasitic losses occur continuously, the 8°F approach tower design point was considered the optimum trade-off between total capacity and performance, and size, initial cost, and operating costs.

Figure 6.2 indicates the relationship between cooling tower design approach to wet bulb and tower size. The 8°F approach to wet bulb tower design point is very close to the theoretical limit in performance, generally acknowledged to be a 7°F approach to wet bulb. Utilizing a tower this large, with this approach to wet bulb, results in the least operational losses for Merrimack Station.

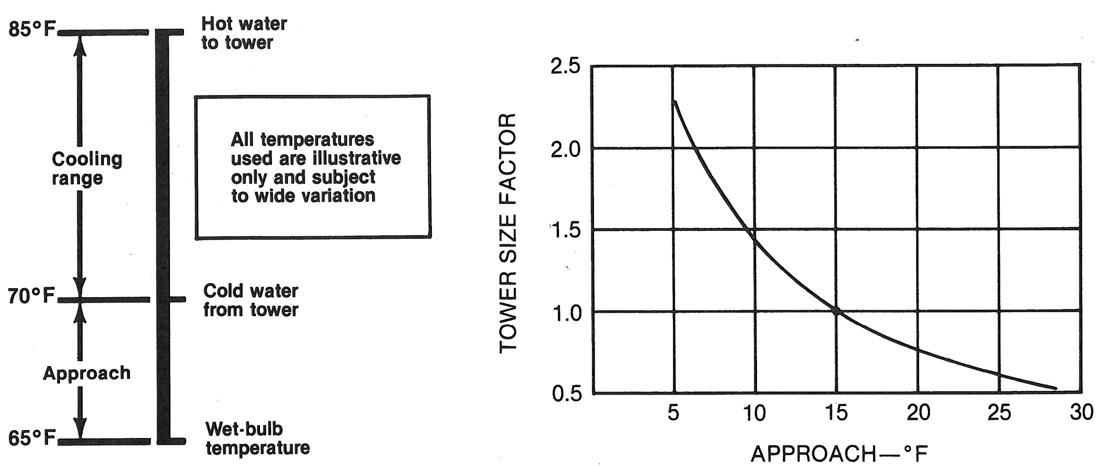


Figure 6.2 – Definition of "Approach," "Cooling Range," and relationship of approach to tower size [Reference 11.3].

The graph on the left shows the relationship of range and approach as the heat load is applied to the tower. Although the combination of range and gpm is fixed by the heat load in accordance with Heat Load = gpm x 8.33 lbs./gal. water x range = Btu/min., approach is fixed by the size and efficiency of the cooling tower.

The graph on the right indicates how given two towers of equal efficiency, with proportionate fill configurations and air rates, the larger tower will produce colder water; i.e. have a closer approach. Important to note, from a tower cost standpoint, is the fact that the base 15°F approach tower would have had to be twice as large to produce a 7°F approach, whereas it could have produced a 25°F approach at only 60% of its size.

Based on a load/capacity assessment provided by SPX Cooling Technologies, the following tower configuration and size was evaluated to support a closed cycle cooling configuration for the Merrimack Station site:

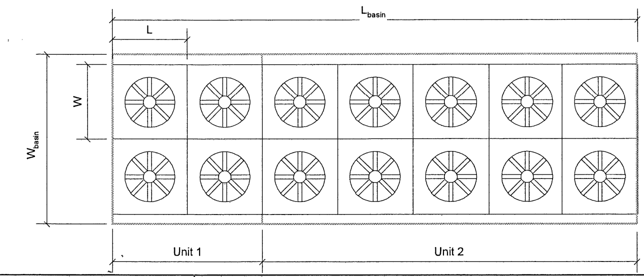
200 HP Selections		
Case 1 **8 °F Approach**	**Design Conditions:** Ambient Wet Bulb = 74 °F Inlet Wet Bulb = 76 °F Unit 1 Flow = 59,000 gpm Unit 1 Range = 19 °F Unit 2 Flow = 140,000 gpm Unit 2 Range = 22.6 °F Unit 1 & Unit 2 CWT = **84.0 °F**	
	No. Cells Unit 1/Unit 2 =	4/10
	W (ft) =	54
	L (ft) =	54
	L basin =	379
	W basin (ft) =	123.67
	Unit 1 Motor Output Power (HP) =	4 x 200
	Unit 1 Pump Head (ft)	36
	Unit 2 Motor Output Power (HP) =	10 x 200
	Unit 2 Pump Head (ft) =	38
	Tower Model No. =	F 499-5.3-14B

Figure 6.3 illustrates the air flow path through a cell of a typical mechanical draft wet cooling tower, and the applicable simplified psychrometric chart.

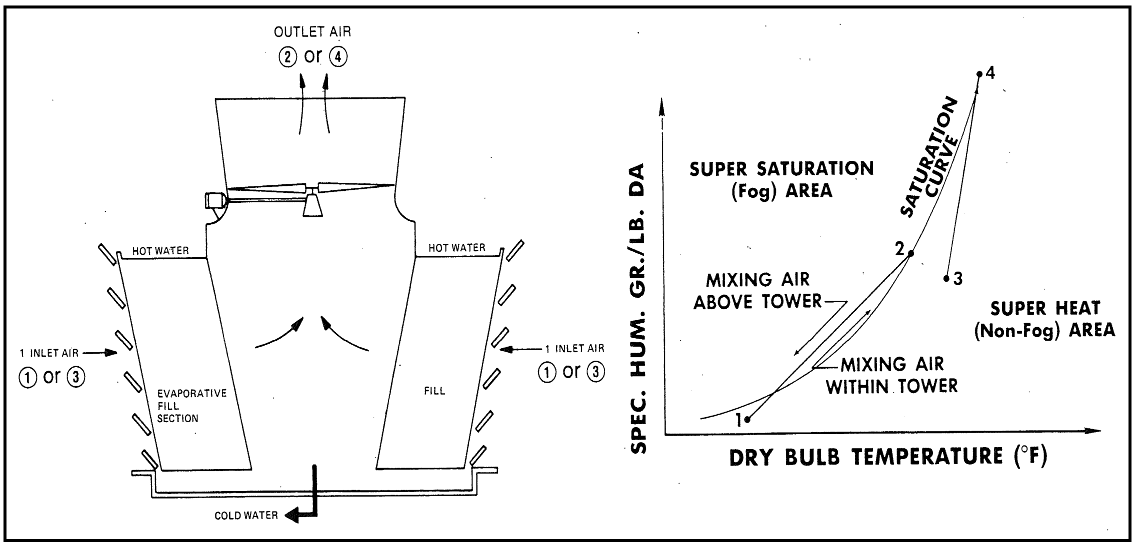


Figure 6.3– Saturation of Air In Typical Mechanical Draft Wet Cooling Tower [Reference 11.3]

Two cases are depicted in the above figure. Case 1 - During summertime, ambient air enters the tower at condition 3 and exits saturated at condition 4. After leaving the tower, this saturated air mixes with the ambient air along line 4-3, such that most of the mixing occurs in the invisible region below the saturation curve of the psychrometric chart. Case 2 - In the winter, ambient air enters the tower at condition 1, exiting saturated at condition 2 and returning to ambient conditions along line 2-1. As can be seen, most of this mixing occurs in the region of super-saturation, which causes a visible plume.

Hybrid Towers

A hybrid cooling tower, also referred to as a "plume abated" cooling tower, addresses plume-related issues associated with the tower types previously evaluated. Basically, a hybrid tower is the combination of the wet tower, with its inherent cooling efficiency, and a dry heat exchanger section used to eliminate visible plumes in the majority of atmospheric conditions. After the plume leaves the lower "wet" section of the tower, it travels upward through a "dry" section where heated, relatively dry air is mixed with the plume in the proportions required to attain a non-visible plume. Hybrid towers are slightly taller than comparable wet towers, typically ~70 feet elevation at the discharge versus 60 feet, due to the addition of the "dry" section, and may require a larger footprint. They are also appreciably more expensive, both in initial costs and in ongoing operating and maintenance costs.

Although much higher in both initial capital cost and ongoing operational costs, a hybrid tower is the most appropriate for the evaluation that EPA has directed Merrimack Station to undertake. Since a cooling tower would operate any time the Station were operating, including during the winter months when visible plumes occur, the plume abated characteristics of a hybrid tower are considered essential. Refer to additional discussions of plume abatement in Section 6.1.3.1.

Hybrid towers are available in different configurations, most often either linear or round. Round towers offer the most concise footprint, but are more expensive. For the Merrimack Station application, available space would be adequate for a linear hybrid tower. Therefore, this Report evaluates a linear hybrid cooling tower design. The "base" mechanical draft tower quoted by SPX (Attachment 1, Section 1) for Merrimack Station is a non-plume abated back-to-back configuration tower. As hybrid towers are not available in a back-to-back configuration (Attachment 1, Section 1), the hybrid tower that this Report evaluates for Merrimack Station is a 14-cell linear mechanical draft cooling tower. Refer to Attachment 2, Sketch PSNH001-SK-001, for a simplified site layout with the 14-cell linear cooling tower.

Figure 6.4 illustrates the air flow path through a cell of a parallel path linear hybrid tower, and the applicable simplified psychrometric chart.

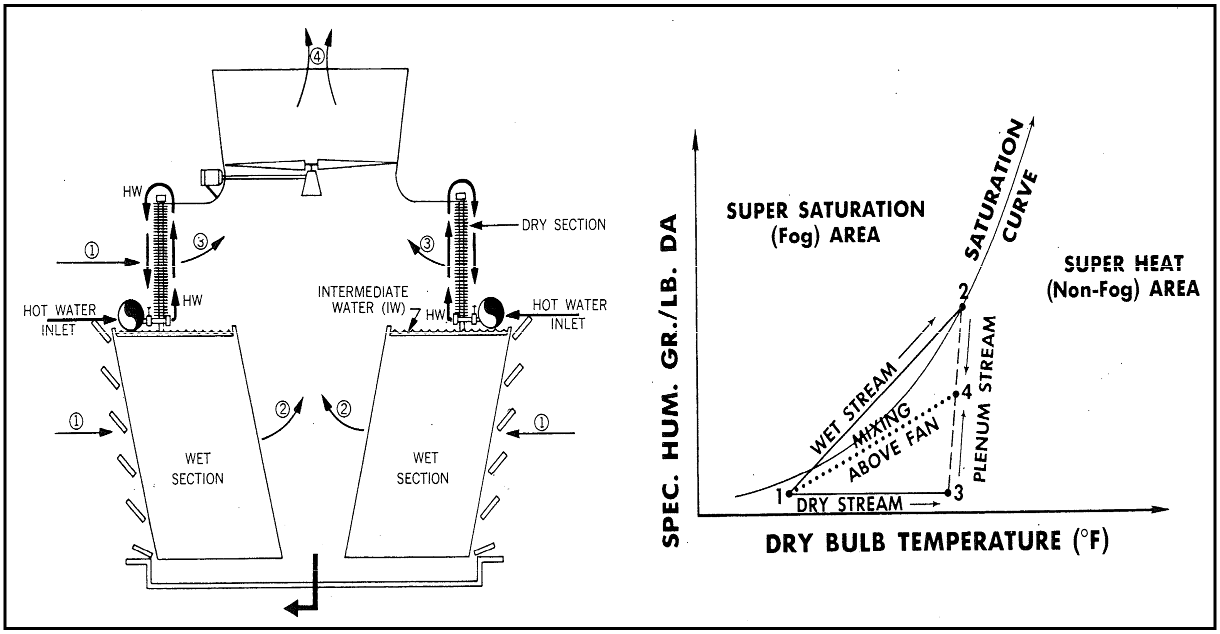


Figure 6.4- Partial Desaturation of Air in a Parallel Path Hybrid Tower [Reference 11.3]

A hybrid cooling tower is designed to drastically reduce both the density and the persistency of the plume. Incoming hot water flows first through the dry heat exchanger (finned coil) sections, then through the wet (evaporative cooling) fill section. Parallel streams of air flow across the coil sections and through the fill sections, leaving the coil sections at dry condition 3, and leaving the fill sections at saturated condition 2. These two separate streams of air then mix together going through the fans, along the lines 3-4 and 2-4 respectively, exiting the fan cylinder at sub-saturated condition 4. This exit air then returns to ambient conditions along line 4-1, avoiding the region of super-saturation (visible plume) altogether in most cases.

6.1.1.2 Pumping Station

Aside from the cooling tower, the most significant components in converting Merrimack Station to a closed-loop condenser cooling configuration would be new circulating water booster pumps and a new 'booster' pumping station. Whereas the existing once-through configuration requires only enough pumping head (pressure) to overcome flow losses in passing water from the River through the condenser and returning to the River, any of the above configurations would require increased pump head to pump the circulating water up to the elevated cooling tower spray headers and overcome the significant internal flow losses of the cooling tower. Whereas the existing Unit 1 and Unit 2 circulating water pumps are designed for 28.5 feet and 24 feet of head respectively, the new booster pumps would be required to produce approximately 36-38 feet of head. Since the condenser inlet water temperature would remain largely constant with the closed-loop arrangement, single speed/flow rate pumps would be adequate and appropriate for the new configuration. Attachment 1, Section 2, contains reference information on the pumps that would be required for a linear hybrid cooling tower at Merrimack Station, as well as the existing pumps.

Preliminary data indicates that (14) 200 HP fans would need to be placed in-service for the cooling tower. Moreover, while the existing Unit 1 circulating water pumps each have a 300

BHP motor, and the Unit 2 circulating water pumps have a 600 BHP motor and a 700 BHP motor, respectively, the new circulating water booster pumps would require an estimated 360 HP motor each (single speed) for Unit 1, and an estimated 1469 HP motor each (single speed) for Unit 2. Because the cooling tower and circulating water booster pumps would represent significant additional electrical loads, a new substation, fed directly from the switchyard, would be required to supply electrical power to the tower and the booster pumping station.

6.1.1.3 Primary Circulating Water Pipe

The new 'booster' pumping station would be located on the discharge side of the condenser to increase the circulating water system pumping head adequately for it to rise up to and pass through the cooling tower. This would require new runs of circulating water piping from the booster pumping station, located where the current discharge piping enters the cooling canal, to the cooling tower located on the island south of the Station, and then returning to the Station intake area where the cooled water would be returned to the existing circulating water pumps suction.

The Unit 1 cooling tower supply would be ~54 inch diameter, AWWA specification, concrete-lined steel piping, and the Unit 2 cooling tower supply piping would be ~84 in. diameter AWWA specification, concrete-lined steel piping. These piping runs would be manifolded at the tower to supply each tower cell individually.

6.1.2 Site Layout for Conversion

Refer to Attachment 2, Sketch PSNH001-SK-001, for a simplified site layout of the evaluated closed-loop cooling configuration.

6.1.2.1 Cooling Tower Location

The cooling tower would be located south of the Station on the island created by the discharge canal. This location would provide adequate space, be relatively close to the Station (minimizing the required length of circulating water piping and associated pumping losses), and requires minimal earthwork to be suitable for the tower erection. The basin elevation of the tower would be dictated by the required head for gravity flow back to the existing circulating water pump intakes, and preliminary analysis indicates a differential elevation of ~5 feet would be required.

Associated electrical power supply modifications are also shown on Sketch PSNH001-SK-001. Due to the appreciable power requirements of the new cooling tower and booster pumping station, a dedicated substation would be required. A pre-fabricated metal building, Attachment 2, Sketches PSNH001-SK-002 through -004, would be required to house the substation transformers, switchgear, and tower control system. The substation for the tower would have to be located as close as practical to the tower to reduce cable runs from the substation to the tower.

6.1.2.2 Intake Pumping Station Location

The location of the existing circulating water pumphouse is expected to remain unchanged on the inlet side of the condenser (intake pumping station). The new booster pumphouse would be located where the circulating water piping discharges to the cooling canal as shown on

Attachment 2, Sketch PSNH001-SK-001. The booster pumps in the new pumphouse would supply circulating water to the new towers via 54 inch diameter, AWWA specification, concrete-lined steel pipes for Unit 1, and 84 inch diameter, AWWA specification, concrete-lined steel pipes for Unit 2. As discussed previously, the necessary head for circulating water return flow to the existing circulating water pump intakes would be provided by the static head achieved from the elevation of the cooling tower basin.

6.1.2.3 Primary Circulating Water Pipe Routing

The new 'booster' pumping station would be located on the discharge side of the condenser near the current circulating water outfall to the discharge canal. There would be new runs of circulating water piping from the booster pumping station to the cooling tower located on the island south of the Station, and then returning to the Station intake area where the cooled water would be returned to the existing circulating water pumps suction.

The large bore AWWA piping would be routed from the booster pumping station along the east side of the discharge canal to where the existing roadway crosses to the island. The circulating water discharge piping from the Station would cross the canal along the roadway built-up area, and then run north-south to supply the manifolds feeding the individual tower cells.

The circulating water return (cold-water) piping from the cooling tower basin would also cross the canal along the roadway built-up area, and then run northeast to supply the existing circulating water pump intakes at the Intake Pumping Station. Refer to Attachment 2, Sketch PSNH001-SK-001, for the evaluated circulating water piping layout.

6.1.3 Operational Features and Schemes

To efficiently utilize a hybrid tower, an automated control system would be required. For the Merrimack Station application, the tower would likely operate at maximum capacity (all fans running) during the summer months to maintain condenser inlet water temperatures as near as possible to current design operating parameters. However, the need to operate all the tower cell fans during the cooler seasons would be totally dependent on ambient conditions. A programmable logic control (PLC) system would be utilized to reduce tower operating cost (parasitic losses) to a minimum, while maintaining condenser inlet water temperatures at the design point for the most efficient Station operation.

6.1.3.1 Plume Abatement

The cooling tower type evaluated, the linear hybrid tower, has specific attributes that minimize the visual impact of the tower's plume. Also termed a plume abated tower, the evaluated model generates no visible plume under the conditions for which it is designed, which correlates to 90% of the projected operating conditions. The evaluated design "plume point" is 27°F @ 90% relative humidity; i.e., the plume would start to become visible when the design plume point is exceeded, although the plume would be much less dense and/or persistent than if generated by a non-plume abated tower.

The cost adder for a plume abated tower of this type is 100-150% of the 'base' tower cost, i.e., a plume abated tower costs approximately double to two and one-half times that of a non-plume abated tower (Attachment 1, Section 1).

6.1.3.2 Noise Abatement

When located in close proximity to residential areas or other noise-sensitive locations, cooling tower noise abatement features are often required. There are two types of noise abatement; water noise abatement and fan noise abatement (low-noise fans). Each can be provided as options for a mechanical draft tower. For the Merrimack Station application, very stringent noise abatement would be required due both to the proximity to the River (and its recreational users) and to a residential area directly across the River from the Station.

The cost adder for the required noise abatement features would be twofold. The water noise abatement would represent a 15% increase in cost over the 'base' tower, and the fan noise abatement would represent an additional 20% increase in cost over the 'base' tower.

6.1.3.3 Make-up and Blowdown

When in a closed-loop cooling configuration with cooling towers providing the heat rejection, the evaporation from the towers tends to concentrate the intake water contaminant levels and total dissolved solids (TDS). A "blowdown" flow is required to maintain a design level of "cycles of concentration" by constantly bleeding off some cooling water back to the River. The "make-up" flow must be adequate to replenish water lost to evaporation and drift (entrained water particles carried out in the tower plume), plus the blowdown flow. The cycles of concentration are predetermined based on intake water quality, and suitability of materials in the cooling tower and the condenser.

Blowdown is calculated as follows [Reference 11.3]:

$$B = \frac{E - [(C-1) \times D]}{(C-1)}$$, where B = blowdown, E = evaporation, D = drift, and C = cycles of concentration

Drift can be approximated as Water Flow $_{Total}$ x 0.00001 gpm.

Evaporation $_{Wet\ Summer}$ can be approximated as Water Flow $_{Total}$ x 0.0167 gpm

For Merrimack Station, since the intake water quality varies based on Merrimack River flow rate, an acceptable cycle of concentration would be dependent on the current intake water quality. For the purpose of this Report, at worst case intake water quality, blowdown and makeup would be based on 5 cycles of concentration. Required makeup flow from the River would thus be:

Makeup = B + E + D [Reference 11.3], where $B = \frac{E - [(C-1) \times D]}{(C-1)}$, and C = 5,

Unit 1 Water Flow = 59,000 gpm

E_{Wet} = 0.0167 x 59,000 gpm = 985.3 gpm

D = Water Flow x 0.00001 gpm = 0.6 gpm

B_{Wet} = 245.7 gpm

M_{Wet} = 1231.6 gpm

Unit 2 Water Flow = 140,000 gpm

E_{Wet} = 0.0167 x 140,000 gpm = 2338.0 gpm

D = Water Flow x 0.00001 gpm = 1.4 gpm

B_{Wet} = 583.1 gpm

M_{Wet} = 2922.5 gpm

Plant makeup from the River, wet mode tower operation would hence equal:

Unit 1 M_{Wet} = 1232 gpm

Unit 2 M_{Wet} = 2923 gpm

6.1.3.4 Condenser Cleaning and Maintenance w/ Closed-Loop Cooling

Current Station design does not incorporate a condenser cleaning system. The installation of a condenser tube cleaning system would provide two advantages:

- Eliminating the need to take a condenser out of service for tube cleaning.
- Allowing maintaining the tubes at a consistently low level of fouling.

Since the presence of fouled tubes would have a greater impact on Station output once converted to closed-loop cooling, due to higher condenser inlet water temperatures, installation of a condenser tube cleaning system would be an imperative part of the Station redesign. The design of the revised circulating water pump house for each unit would thus incorporate the requirements for a permanently installed condenser tube cleaning system.

6.2 Cost Estimates

As EPA directed in the §308 Letter, this section provides estimates of the costs that would be involved in converting Merrimack Station Units 1 and 2 to closed-loop condenser cooling.

- The capital costs of the initial conversions are quantified, including design, procurement, implementation, and startup activities, based on the conceptual design previously identified and discussed.
- The duration of the required unit outages, based on a timeline of critical milestones that would have to be worked with the associated unit off-line, is utilized to determine the resulting lost generating capacity, expressed in $MW_{HOURS\text{-}ELECTRIC}$.
- The new cooling towers and circulating water pumps would require operations and maintenance personnel support, and service, repair, and replacement of components; based on input from potential supplying vendors, these costs are approximated.
- Additionally, the new towers and circulating water pumps would require an appreciable amount of power to operate, herein referred to as "parasitic losses", which effectively would reduce Station output power to the distribution grid. Power consumption of the required new components can be estimated from preliminary vendor data, and hence total $MW_{ELECTRIC}$ parasitic losses determined.

- Finally, the conversion would create less than optimum operating parameters for the existing turbine/condenser, resulting in reduced unit output to the grid under most operating conditions. Based on historical Station operating performance data in the bounding months of July and August for five years (2002 –2006), evaluated cooling tower performance data, and applicable Station heat balance diagrams, in five years of meteorological data, (2002 – 2006) the annual average reduction in unit performance due to operational efficiency losses in generator output averaged over the entire calendar year would not be extremely significant, approximately 0.2 $MW_{ELECTRIC}$ for Unit 1 and 2.8 $MW_{ELECTRIC}$ for Unit 2; however, the reduction in unit performance due to operational efficiency losses occurring during the peak load conditions in July and August would be relatively impactive at approximately 1.0 $MW_{ELECTRIC}$ for Unit 1 and 13.3 $MW_{ELECTRIC}$ for Unit 2.

6.2.1 Initial Capital Costs

An accurate assessment of the capital costs associated with the closed-loop cooling conversion that EPA has directed PSNH to evaluate is a critical goal of this Report. Minimizing assumptions, and relying instead on well-developed, detailed conceptual designs, greatly increases the accuracy of the ensuing estimates. In broad terms, conceptual design engineering outlined system scope definition, evaluated detailed layout and equipment specification/criteria, and assisted in gathering some of the site-specific historical data. Attachment 2 to this Report includes some of the conceptual drawings utilized for subsequent construction estimates. This information was used to develop greater detail regarding associated tasks and logistics that would be required as a minimum to successfully perform the construction for the conversion. The resulting Direct Capital Cost Estimate and Project Schedule represent well thought out approaches with a reasonable level of detail in order to generate an accurate capital cost assessment.

The estimating basis relied less on theoretical national production rates and cost factoring and focused more directly toward soliciting the various assets capable of providing real world solutions. Vendors were contacted for quotations on the major equipment and material components, while established construction cost estimating tools were utilized in developing the labor, equipment, and scheduling requirements.

- RS Means (Factored Construction Cost Data)

  The Means catalogue is one of the nation's most respected guidelines for estimating construction related cost of building. When other resources were unclear or not available, Enercon used the typical factored cost per commodity for the portion of work.

- Construction Industry Institute (CII)

  CII focuses on the industrial construction and maintenance contracting industry as a trade organization devoted to continuous improvement of the means and methods used in construction. Their ideas related to the minimization of field required labor through modularization and prefabrication were considered as the construction strategies were built and as the cost estimates were prepared.

- Engineering News Record (ENR)

  Construction Cost Index, Building Cost Index, Materials Cost Index, which are updated monthly, provided some trending analysis with regard to the industry in general.

Attachment 1 to this Report includes vendor data and budgetary cost estimates for major equipment components. Few allowances were applied and only when time did not permit further task development or reasonable vendor contact and quotation.

Attachment 4 to this Report provides the capital cost assessment for the conversion of Merrimack Station to closed-loop cooling.

From Attachment 4, the total estimated capital cost of the conversion of the two-unit Merrimack Station to closed-loop cooling is $59,215,900.

With lost generating capacity during implementation (Section 6.2.4) added, total cost of conversion is estimated to be $67,980,500.

6.2.2 Costs Due to New Condenser Operating Parameters

As discussed in Section 6.1.1.1.2, cooling towers operate under an approach to wet bulb condition, and are therefore reliant on the ambient wet bulb temperature to effectively cool the condenser inlet temperature. As the current once-through operation of Merrimack Station relies solely on the moderately cold and stable temperatures of the Merrimack River as input for the condenser, modification to a warmer and more variable input temperature derived from ambient weather conditions would pose an operational risk for the Station which must be thoroughly examined. To this extent the following discussion, detailed further in Attachment 3, assesses the operational impacts to Merrimack Station that would be attributable to conversion from once-through to closed-loop cooling.

To quantify the impacts that increased condenser input temperatures would have to Station operation, baseline once-through performance of the Station was modeled using analytical correlations derived from the Station N10 river water temperature and 31 Merrimack Station operating parameters (analysis limited to bounding PSNH data provided for July and August 2002-2006). Per this analysis of the operating parameters, the limiting condition affecting closed-loop operation at both units would be the circulating water condenser pressure (ADH Point #'s 1128 and 2127). Advancing beyond the operational threshold set for these parameters (Unit 1 3 in-Hg, Unit 2 2 in-Hg) would have the potential to result in extensive equipment damage throughout the Station (e.g., boiler tube failure, overheating of turbine/generator bearings, forced draft fan bearings, gas recirculation fan bearings, main boiler feed pump hydraulic coupling oil, etc.)

A five year period of National Weather Services (NWS) meteorological data was used in conjunction with an 8°F approach to wet bulb to input the closed-loop condenser inlet temperature values into these operational performance models. Jointly, the resulting gross electrical power reduction that would be required to maintain the water temperatures from the circulating water condensers below their respective operational thresholds was calculated using a methodology similar to the analytical correlations derived for the operational parameters. The resulting hours in which closed-loop operation of Merrimack Station would operate beyond the limiting operational thresholds without assistance, and the gross electrical power reduction that would be required to lower the circulating water condenser pressure below the operational thresholds, are summarized in the table below.

Merrimack Station Closed-Loop Performance - Units 1 & 2 at Full Power

Description	Yearly	Time Beyond Condenser Operational Threshold					Average
		2002	2003	2004	2005	2006	
Unit 1 (3" Hg)	Hours	904	962	712	997	813	877.6
	Percentage	10.38%	11.07%	8.20%	11.41%	9.28%	10.07%
	Power Loss[1]	0.17	0.19	0.11	0.19	0.14	0.16
Unit 2 (2" Hg)	Hours	2195	2305	2186	2331	2200	2243.4
	Percentage	25.20%	26.52%	25.17%	26.68%	25.12%	25.74%
	Power Loss[1]	2.79	3.00	2.45	3.12	2.72	2.82

[1]*Power loss calculated on an annualized basis (MWe)*

The maximum unaltered circulating water condenser pressure calculated during the time period analyzed (2002-2006) is 4.3 in-Hg and 4.4 in-Hg for Units 1 and 2, respectively. Likewise, the maximum gross electrical power reduction required to maintain the circulating water condensers below their operational thresholds is 6.1 MWe for Unit 1 and 35.1 MWe for Unit 2. Overall, using the empirical analysis for the defined time period Unit 1 would experience an annual average of 878 hours at an annualized 0.2 MWe gross electrical power reduction, and Unit 2 would experience an annual average of 2243 hours at an annualized 2.8 MWe gross electrical power reduction. Note that since the duration and magnitude of power reduction required would be reliant on elevated ambient weather conditions, power reduction occurrences would generally take place during daylight hours of the summer months when power demand is at its peak.

The total estimated average power loss associated with decreased operational efficiency due to the conversion of Merrimack Station to closed-loop cooling is 0.16 MW_{Loss} Unit 1, and 2.82 MW_{Loss} Unit 2.

The corresponding estimated annual cost for the two-unit Station associated with this power loss is $1,879,500 Note: Based on market power value of $72 MW

6.2.3 Parasitic Losses (Costs) Attributable to New Components

An estimate of fan and pump horsepower requirements for the evaluated cooling towers and new circulating water pumphouses was developed in order to estimate additional Station parasitic losses due to conversion to closed-loop cooling.

The existing circulating water pumps and the new circulating water booster pumps would be a constant load; i.e., there would be no operational variations in power consumption, as all pumps for each unit would operate at full capacity at all times. To address the total circulating water pump load due to the conversion to closed-cycle cooling, the power requirements of the existing pumps are simply added to that of the additional booster pumps required for the closed-loop configuration.

Unit	Parasitic Electrical Load, Circ Water Pumps	
	Existing Circ Water Pumps	Additional Closed Loop Pumps
1	0.42 MW	0.96 MW
2	1.46 MW	3.65 MW

Likewise the cooling tower fans would be a constant load; i.e., there would be no operational variations in power consumption, as all fans for each unit would operate at full capacity at all times. This load would represent a corresponding new parasitic loss to the output of each Unit estimated as follows:

Tower Usage $_{\text{Each Tower}}$ = fan MW

Merrimack Station U1 Usage (MW) = (4) 200 HP fans = <u>0.60 MW</u>

Merrimack Station U2 Usage (MW) = (10) 200 HP fans = <u>1.49 MW</u>

Merrimack Station Unit 1 = 0.96 MW $_{\text{New Circ. Water Pumps}}$ + 0.60 MW $_{\text{Tower Fans}}$

Merrimack Station Unit 2 = 3.65 MW $_{\text{New Circ. Water Pumps}}$ +1.49 MW $_{\text{Tower Fans}}$

Based on the estimated power requirements of the new circulating water booster pumps and the cooling tower fans, the estimated total average parasitic losses due to conversion to closed-loop cooling are as follows:

Merrimack Station Unit 1 = 1.56 MW $_{\text{Loss}}$

Merrimack Station Unit 2 = 5.14 MW $_{\text{Loss}}$

The corresponding annual cost for the two-unit Station associated with this power loss is $4,225,800 Note: Based on market power value of $72 MW

6.2.4 Lost Generating Capacity During Implementation

From the construction schedule provided in Attachment 7, the approximate duration that Units 1 and 2 would be in a concurrent forced outage to accommodate the conversion to closed-loop cooling would be 7 weeks. This represents optimum performance during the construction phase, with no contingencies or allowances for emergent activities or overruns, and assumes the maximum possible portion of the work scope being performed either pre-outage or post-outage.

Merrimack Station currently has the following maintenance outage schedule:

- Unit 1; 4 week outage every two years
- Unit 2; 4 week outage every year

A typical maintenance outage for Merrimack Station Unit 1 occurs every two years and has a duration of 4 weeks. Unit 2 maintenance outages occur every year and have a duration of 4 weeks. The outages are performed out of phase, to minimize impact on the power grid as well as plant personnel. For purposes of this Report, it will be assumed that 4 weeks of the forced outage for the conversion would be utilized for required maintenance of both units. The remaining 3 weeks conservatively represent a period of lost generating capacity for the Station.

Estimating the lost generating capacity from a concurrent additional 3 week implementation outage, based on a typical Merrimack Station Unit 1 generator output of 120 MW_E and Merrimack Station Unit 2 generator output of 350 MW_E:

Merrimack Station Unit 1, 60,480 megawatt hours
Merrimack Station Unit 2, 176,400 megawatt hours

Although generating capacity as well as wholesale cost of electricity vary, the approximate dollar cost of the outages, based on $37.00/MWh projected replacement power cost equates to:

Merrimack Station Unit 1, $2,237,800
Merrimack Station Unit 2, $6,526,800

6.2.5 Operational and Maintenance (O&M) Cost

Additional Station O&M costs for the components that would be added due to the conversion to closed-loop cooling can be best estimated by identifying the general tasks for each component, and then based on operational experience and input from vendors, quantifying the estimated required man-hours and associated costs.

The conversion to closed-loop cooling is complex, and significant new/modified Station components include the cooling towers with their fans and booster (vacuum) pumps (for the 'dry' sections), and the new circulating water booster pumps.

The tower selected for Units 1 and 2 is a SPX/Marley linear configuration hybrid FRP (fiberglass reinforced plastic) tower, designed with noise and plume abatement features. This design uses 14 wet section fans with motor output power of 200Hp, with 4 cells dedicated to Unit 1, and 10 cells dedicated to Unit 2. Due to the large number of active components, as well as the size of the towers and their hot water distribution system, appreciable Operations support is anticipated. For purposes of this assessment, chemistry personnel (for water quality maintenance) man-hours are included/encompassed under Operations.

The anticipated manpower required for operational support of the cooling towers is tabulated below:

	Activity Description	Group	Est. Cost
Daily	• Check fans, motors, driveshafts, gear reducers • Check gear reducer oil level • Check electrical substation, transformers, switchgear • Monitor local control panel and alarm displays • Check water level in cold water basin and hot water distribution system • Check booster pumps and associated instrumentation • Sample water quality	Ops	
Cost Basis	4 hrs/day X 12 months		$73,000
Weekly	• Inspect hot water distribution system • Inspect fill for fouling • Check gear reducer for leakage • Adjust water quality	Ops	
Cost Basis	20 hrs/week X 12 months		$52,500
Notes: Cost based on PSNH O&M labor estimates of $50/hour (hourly wage + benefits)			

Based on the above identified anticipated tasks, applied to Merrimack Station Unit 1 and Merrimack Station Unit 2, annual additional Operations support for the evaluated closed-loop configuration is estimated to be $125,500.

Maintenance Cost

The anticipated cost for preventive and corrective maintenance, including both labor and parts, for the evaluated cooling tower is tabulated below:

	Activity Description	Group	Est. Cost
Monthly	• Inspect drift eliminators and fill for clogging • Check gear reducer oil seals, oil level, and oil condition	Maint.	
Periodic (Quarterly estimated)	• Clean and repaint fans and drivers, drift eliminators, fill, hot water distribution system • Rebalance fans and driveshafts • Lighting inspection or replacement	Maint.	
Semi-annual Inspection	• Inspect keys, keyways, set screws & tighten bolts for fans and drivers • Change oil and check vent condition for gear reducers • Check fan blade clearances • Check for leakage in fill, basin and hot water distribution system • Inspect general condition and repair as necessary all tower components including cranes and hoists	Maint.	
Annual Inspection and Corrective Maint.	• Inspect general condition of basin, suction screen and tower casing • Inspect/repair fans and drivers, and tower access components, including stairs, ladders, walkways, doors, handrails • Transformer Inspection • Starting at year 16, replacement of fan blades, fan motors, fan gearbox, fill, drift eliminators	Maint.	
Quarterly	Lighting Inspection or Replacement	Maint.	
	Annual maintenance cost estimate (years 1-5)*		$100,000
	Annual maintenance cost estimate (years 6-15)*		$200,000
	Annual maintenance cost estimate (years 16-20)*		$400,000
Notes: *Based on vendor (SPX Cooling Technologies) estimates/historical data			

Booster pumping station maintenance, long-term rehabilitation, and replacement costs include those costs for replacement of components such as pump impellers, motors, or entire assemblies. Major equipment rehabilitation or replacement is usually estimated to occur between 20 to 40 years after placing the equipment into operation. Rehabilitation costs for major equipment can be estimated to be 35 to 45 percent of replacement costs depending on the condition of the equipment. Other items of equipment may be replaced several times during the Station life, depending on their use, or may require only partial replacement. It is most likely that equipment, except for pump and motor, may not be replaced in kind. Therefore, the replacement cost should include all engineering and structural modification costs as well as the equipment costs [Reference 11.2].

Based on remaining Station life it was assumed that 1/2 of the pumps for each unit (Unit 1 - 1 pump, @ approximately $400,000/pump, Unit 2 - 1 pump, @ approximately $800,000/pump) would require rehabilitation or partial replacement. When including other miscellaneous pumping station components, the estimated rehabilitation and replacement cost for Unit 1 is $500,000 and for Unit 2 is $1,000,000 for an assumed remaining Station life of 30 years. Hence, for both units, on an average annual basis, beginning at year 16, pumping station maintenance costs would increase by $100,000.

Summary of Additional O&M Annual Cost:
Years 1-5, $125,500 +$100,000 +$0 = $225,500
Years 6-15, $125,500 +$200,000 + $0 = $325,500
Years 16-30, $125,500 +$400,000 + $100,000 = $625,500

6.2.6 Water Treatment Costs

When a plant is designed for or converted to closed-loop cooling via the addition of cooling towers, it is cost effective to impose a high level of water treatment to ensure high quality water is supplied to the towers. This allows cooling tower designers to utilize a higher-efficiency film-fill without fear of fill-fouling. Using a higher efficiency fill allows a smaller tower size and appreciably lower associated initial cooling tower capital cost as well as lower cooling tower operating cost.

The existing once-through circulating water cooling system receives a minimum of water treatment. Biocides, specifically sodium hypochlorite, are added in quantities to attain resulting concentrations as allowed by the discharge permit to minimize fouling of the condensers. For Merrimack Station this corresponds to approximately 15,000 gallons of sodium hypochlorite per year. Annual costs of these biocide injections are estimated to be less than $20,000.

With the evaluated closed-loop cooling system, water treatment requirements would be dramatically increased. The cooling tower fill would be subject to fouling without enhanced water treatment. Both the quantities and frequency of biocide injections would have to be increased significantly to maintain the tower fill in proper condition.

Additionally, increased water treatment would be necessary due to the higher concentrations of dissolved solids, chemicals, and biological agents in the system resulting from constant recirculation of the condenser cooling water. The cooling towers would act as air washers as well as distilleries, constantly evaporating large quantities of water and leaving behind the non-volatile residues. The actual concentrations of these agents would be wholly based on the cycles of concentration (cycles of concentration is discussed in Section 6.1.3.3) being used in the circulating water system.

Unlike the simple injections of biocide required for the once-through configuration, a closed-loop configuration typically utilizes a veritable cocktail of chemicals, each with specific attributes. Chemical treatment is broken into three subsections; deposition, corrosion, and biological.

Deposition

There are two forms of deposition, one being sedimentation, which is usually mitigated through piping design, and the second being scaling. Scaling is a complicated condition and requires an educated approach to mitigation. In some cases scaling is necessary and useful in a piping system to prevent corrosion. For example, a thin uniform coating of calcium carbonate provides corrosion protection for internal surfaces of piping, therefore this type of scaling is desirable and should be left intact where possible. The major problems arise when scaling becomes too thick and reduces heat transfer with the condenser or cooling tower. Scaling is kept under control through the use of pH control and dispersants.

Corrosion

Corrosion control is a complex science, requiring considerable knowledge of corrosion chemistry and of the system being evaluated. Corrosion is best mitigated through piping design and an aggressive chemical treatment program using pH control and corrosion inhibitors.

Biological

Biological growth or biofouling is the most difficult chemical challenge to a cooling water system since it involves a dynamic biological process. The biological process also promotes corrosion through the breakdown of chemical components and the creation of localized acids. In a closed-loop where the concentration of nutrients has increased, biofilms tend to increase on the piping internal surfaces and cooling tower fill. Control of the biofilms usually involve combining biocides with surfactant-type biodispersant to disrupt the biomatrix, allowing better penetration of the antimicrobial. Additional chemical treatments such as biodetergents may also be necessary depending on local biologicals and conditions.

Major cooling water chemicals would typically include:

Chemical type	Use/Function
sodium hypochlorite	biocide
surfactant	biocide aid
sulfuric acid	PH control
dispersant	scale prevention
phosphate	corrosion control

Appreciably increased costs are associated with this increased level of water treatment. Local conditions can greatly affect annual costs, but an annual cost for the Station of $175,000 would be extremely conservative. Total Station increased water treatment costs would therefore be estimated at $175,000, and could easily approach $250,000.

6.3 Environmental Considerations

As EPA directed in the §308 Letter, this section identifies, qualifies and quantifies, to the extent possible, the environmental impacts of retrofitting a mechanical draft cooling tower at Merrimack Station Units 1 and 2. Considerations and evaluations will include the long term positive and negative environmental benefits and impacts.

Resulting changes to the River intake flow will be quantified and specifically addressed in detail, and the associated effect on entrainment and impingement of aquatic organisms is addressed subsequently in Section 9.2.

6.3.1 Cooling Tower Plume

Although the cooling tower evaluated for the Merrimack Station is a plume abated tower, a visible plume would still exist during certain environmental conditions. To best identify plume path and trajectory, a computer code can be utilized to model the plume under site typical environmental conditions. The behavior of the plume can be modeled using the SACTI code under environmental conditions typical of Bow, NH. However, reasonable predictions of plume travel can be made based on the local prevailing wind directions and frequency of occurrence (i.e., site wind rose). Based on the Merrimack Station site wind rose (Attachment 2, sketch PSNH001-SK-001), the predominant direction of plume travel would be up or down the Merrimack River (north or south). The potential environmental impacts attributed to a cooling tower plume can be categorized as visual impact and physical impact.

The visual impact of such a cooling tower plume would be both aesthetically displeasing and hazardous. When atmospheric conditions are conducive to a visible plume, typically anytime during the winter months when the ambient air temperature is below the 27°F 'plume point', a dense plume would exit from the tower fan discharge shrouds. Depending upon the wind direction, thermal conditions, and other factors, the plume could extend skywards for hundreds of feet, or become inverted as a ground-level fog. Local residences would either view the plume intruding high into the sky, or be immersed in a dense fog obscuring their view altogether. Driving on nearby roads and highways could be significantly impacted, with the possibility of 'black ice' formation during winter months, and visibility severely compromised.

The potential physical impacts from a tower plume would arise primary from the 1) moisture content, which could cause icing and fogging during winter conditions, 2) the mineral content of the entrained moisture which could damage vegetation, in the vicinity of the Station, and 3) the heat content, which could potentially degrade Station heating, ventilating and air conditioning (HVAC) systems. Additionally, the presence of the warm moist plume over a period of time would cause degradation of plant and switchyard structures and components due to corrosion. It is important to note that a hybrid tower produces an invisible plume under most conditions, however, the plume still exists and creates the above noted physical impacts.

6.3.2 Cooling Tower Noise

Without the benefit of noise attenuation, mechanical draft cooling towers produce relatively high levels of constant noise. The noise emanating from a cooling tower is due both to the cascading water, and to the large mechanical draft fans.

The hybrid cooling towers evaluated for Merrimack Station would be equipped with sound attenuators. The noise level is expected to be <30dB(A) at one-half mile distance from the tower. As a point of comparison, this sound level corresponds to the typical late-night noise levels in a small town. The noise standard for many townships is in the range of 45-50 dB(A), which would be met at approximately 350 feet from the evaluated tower. Although the noise level would increase on the River in close proximity to the Station, adjacent residential areas would be mostly unaffected by the noise generated from the cooling tower assuming a noise-abated tower design is utilized.

6.3.3 Reduced Intake Flow

PSNH assumes that EPA's overall objective in directing PSNH to evaluate the conversion of Merrimack Station Unit 1 and Unit 2 from once-through condenser cooling to closed-loop condenser cooling is to obtain information about the potential reduction of the Station intake flow that could result from such a conversion. Hence, the quantification of the reduction in River intake flow is a significant assessment.

Current once-through River intake flow for Merrimack Station is as follows:

Summer intake flow rate,	
Unit 1 Circulating Water $_{\text{Maximum}}$ Note 1	59,000 gpm
Unit 1 Screen Wash	(+) 560 gpm
Unit 2 Circulating Water $_{\text{Maximum}}$ Note 1	140,000 gpm
Unit 2 Screen Wash	(+) 590 gpm
Total Intake Flow $_{\text{Once Through, Summer Maximum}}$ Note 1	200,150 gpm
Winter intake flow rate,	
Unit 1 Circulating Water $_{\text{Maximum}}$ Note 1	59,000 gpm
Unit 1 Screen Wash	(+) 560 gpm
Unit 1 De-icing recirculation $_{\text{Maximum winter}}$ Note 2	(-) 5,560 gpm
Unit 2 Circulating Water $_{\text{Maximum}}$ Note 1	140,000 gpm
Unit 2 Screen Wash	(+) 590 gpm
Unit 2 De-icing recirculation $_{\text{Maximum Winter}}$ Note 2	(-) 9,030 gpm
Total Intake Flow $_{\text{Once Through, Minimum}}$ Notes 1 & 2	185,560 gpm

Note 1 Flow at maximum pump performance; includes sluice water flow

Note 2 Current Station design utilizes reduced River intake flow in the winter, when cold water temperatures require de-icing recirculation flow operation.

Intake Flow Used for Sluice Water

Approximately 1,810 gpm (4.0 cfs) of the actual intake flow from Unit 1 and 2,780 gpm (6.2 cfs) of the actual intake flow from Unit 2 is used for sluice water flow to carry slag into a settling pond. This flow could not be reduced by the evaluated conversion to closed-loop cooling, as it is not utilized for Station cooling.

Recirculated Condenser Cooling Water

During the winter months, when ambient air conditions are often below freezing, approximately 5560 gpm (12.4 cfs) of heated condenser cooling water from Unit 1 is recirculated back into the intake forebay of Unit 1 for de-icing and tempering. Similarly, for Unit 2, approximately 9030 gpm (20.1 cfs) of heated condenser cooling water is recirculated back into the intake forebay of Unit 2.

Estimated River intake flow for the Station following the evaluated conversion to closed-loop cooling would be as follows:

Summer intake flow rate

Unit 1 Circulating Water/Cooling Tower Makeup	1,230 gpm
Unit 1 Screen Wash	(+) 560 gpm
Unit 1 Sluice Water	(+) 1,810 gpm
Unit 2 Circulating Water/Cooling Tower Makeup	2,920 gpm
Unit 2 Screen Wash	(+) 590 gpm
Unit 2 Sluice Water	2,780 gpm
Total Intake Flow $_{\text{Closed Loop}}$	9,930 gpm
Total Intake Flow $_{\text{Once Through, Maximum}}$	200,150 gpm
Reduction In River Intake Flow $_{\text{Maximum}}$	95.0%

Winter intake flow rate

Following conversion to closed-loop cooling, the existing flow requirements for Station de-icing during winter operation would decrease somewhat due to the significantly decreased overall intake flows. However, the Circulating Water/Cooling Tower Makeup, Screen Wash, and Sluice Water flows would stay the same for each unit.

Hence, the total required intake flow would remain the same, summer or winter, at 9,930 gpm. Compared to the previous winter intake flow rate of 185,560 gpm, the post closed-loop conversion intake flow rate would constitute a 94.7% reduction in River intake flow, approximately the same reduction as for summer operation.

6.3.4 Loss of River Water Due to Evaporation

Cooling towers evaporate large quantities of water which are effectively lost from the source water body. In the case of Merrimack Station, the estimated daily water loss from the Merrimack River due to evaporation by the evaluated cooling tower can be calculated as follows:

Evaporation $_{\text{Wet Summer}}$ can be approximated as Water Flow $_{\text{Total}}$ x 0.0167 gpm [Reference 11.3]

Unit 1 Water Flow = 59,000 gpm

E_{Wet} = 0.0167 x 59,000 gpm = 985 gpm

Unit 2 Water Flow = 140,000 gpm

E_{Wet} = 0.0167 x 140,000 gpm = 2338 gpm

Estimated total loss of river water due to evaporation by evaluated cooling tower = 3323 gpm, or 4.79 million gallons/day.

6.3.5 Site Aesthetics

Aesthetics are an important issue at Merrimack Station since it is located on the Merrimack River, a recreational use area for many boaters. Any closed-loop cooling conversion-related aesthetic degradation of the area must be considered a negative environmental impact.

6.3.5.1 Tower Size

A cooling tower sized for the needs of Merrimack Station would be a significant structure. A hybrid mechanical draft tower would be approximately 350 feet in length, with a discharge elevation of approximately 65 feet.

6.3.5.2 Cooling Tower Plume

Although a hybrid, or plume abated, tower was evaluated to reduce the visible plume most of the time, a visible plume would occur during the colder periods of the year. The plume could potentially extend hundreds of feet into the sky, and travel for up to a few miles horizontally.

6.3.5.3 Construction Would Require Permanent Modification of the Terrain Along the Shore of the Merrimack River

Any evaluated cooling tower would be located approximately 200 feet from the bank of the Merrimack River, and would have a substantial aesthetic impact. An area approximately 500 feet in length and 150 feet in width would be cleared for the tower. Views from the Merrimack River would be impacted. The Station is an industrial facility already visible from these vantage points. However, the addition of the tower would make the entire facility more visible as the clear-cutting of the trees on the discharge canal island that would be required for construction of the tower and to allow maximum airflow to the tower would remove a visual buffer from vantage points both up and down river.

6.3.5.4 Environmental Impact due to Efficiency Losses

In addition to the adverse air quality and aesthetics impacts that would be associated with a cooling tower's visible water vapor plume, operation of a cooling tower at Merrimack Station would increase the amount of combustion-related air emissions and pollutants produced per net unit of electricity generated. The increase in combustion-related air emissions would have three primary causes: (1) the increased Station parasitic load resulting from the tower's electricity demands (which would also decrease the Station's net output electricity generated), (2) the reduction in Station condenser/turbine efficiency due to warmer condenser water input temperatures, and (3) the increased amount of consumables used to operate the Station near the condensers' operational thresholds (i.e., the increase in condenser cooling water temperature associated with cooling tower operation would reduce cycle efficiency, requiring more fuel to be fired to achieve the same gross electrical output of a more efficient cycle). Moreover, other electric generating facilities would have to increase their generation to compensate for any reduction in the Station's net electrical output, in order to satisfy consumer demand, with potential adverse regional air quality impacts. In summary, closed-loop operation of the Station would generate more stack emissions and material waste per net unit of electricity generated than the Station's current cooling water system.

7 Mechanical Draft Towers for Closed-Loop Cooling (One Unit)

Converting either Unit 1 or Unit 2 at Merrimack Station to closed-loop cooling would provide basically the same benefits and impacts as discussed previously in Section 6, but scaled-down and applied to only the one unit. For that reason, and to minimize repetitiveness, this section will largely just address the specific differences from the Section 6 assessments.

7.1 Conceptual Design

The basic conceptual design for converting either Merrimack Unit 1 or Unit 2 to closed-loop cooling is the same as that required for converting both units. As will be discussed in the subsequent subsections, the cooling tower type, configuration and location would be the same, the need for a booster pumping station would remain, the routing of the cooling tower supply and return piping would be the same, the operational schemes would be the same, and the need for an electrical substation would remain.

7.1.1 Major Components

As established in Section 6, in the §308 Letter, EPA directed PSNH to evaluate the retrofitting of a mechanical draft cooling tower at Merrimack Station. Other alternatives for heat rejection with the necessary capacity to support closed-loop cooling, such as evaporative ponds, spray ponds or cooling canals, all require significantly more real estate to implement than exists at the Merrimack Station site.

7.1.1.1 Cooling Tower Assessment

The hybrid, mechanical draft, FRP, linear, noise-abated cooling tower configuration discussed in Section 6 will remain the evaluated technology for converting either unit separately to closed-loop cooling. The tower evaluated in Section 6 was a 14-cell tower, with four cells dedicated to support Unit 1 operation, and ten cells dedicated to support Unit 2 operation.

- To convert Unit 1 only, a 4-cell tower would be required.
- To convert Unit 2 only, a 10-cell tower would be required.

All other design details, including the specified fill, motor horsepower, plume point of 27°F @ 90% relative humidity, and 8°F approach to wet bulb would remain the same.

7.1.1.2 Pumping Station

The booster pumping station would be required and would be sized and configured for the unit being converted to closed-loop cooling.

- If Unit 1 were the unit being converted, the pumping station would house two pumps, each rated at 29,500 gpm @ 36-38 ft. discharge head, and having a 360 HP motor.
- If Unit 2 were the unit being converted, the pumping station would house two pumps, each rated at 70,000 gpm @ 36-38 ft. discharge head, and having a 1469 HP motor.

Since the condenser inlet water temperature would remain largely constant with the closed-loop arrangement, single speed/flow rate pumps would be adequate and appropriate for the new configuration. Attachment 1, Section 2, contains reference information on the evaluated new pumps as well as the existing pumps.

7.1.1.3 Primary Circulating Water Pipe

One unit conversion to closed-cycle cooling would entail similar Station modifications as required for two unit conversion to closed-cycle cooling. As previously discussed in Section 6.1.1.3, this would require new runs of circulating water piping from a) the booster pumping station, which would be located where the current discharge piping enters the cooling canal, to b) the cooling tower, which would be located on the island south of the Station, and then returning to c) the Station intake area where the cooled water would be returned to the existing circulating water pumps suction.

- For the Unit 1 only conversion, the cooling tower supply would be ~54 inch diameter, AWWA specification, concrete-lined steel piping.
- For the Unit 2 only conversion, the cooling tower supply piping would be ~84 in. diameter AWWA specification, concrete-lined steel piping.

These piping runs would be manifolded at the tower to supply each tower cell individually.

7.1.2 Site Layout for Conversion

Refer to Attachment 2, Sketch PSNH001-SK-001, for a simplified site layout of the evaluated closed-loop cooling configuration.

For a one unit conversion, the location of the cooling tower, booster pumping station, electrical substation, and routing of circulating water piping would be as indicated, although only for the unit being converted to closed-cycle cooling.

7.1.2.1 Cooling Tower Location(s)

The cooling tower location discussed in Section 6, and indicated in Attachment 2, Sketch PSNH001-SK-001, would remain the same; only the number of cells would change depending upon the unit being converted to closed-loop cooling.

7.1.2.2 Pumping Station Location

The booster pumping station location would remain the same as discussed in Section 6.

7.1.2.3 Primary Circulating Water Pipe Routing

The primary circulating water pipe routing would remain the same as discussed in Section 6.

7.1.3 Operational Features and Schemes

As previously discussed in Section 6.1.3, a programmable logic control (PLC) system would be utilized to reduce tower operating cost (parasitic losses) to a minimum, while maintaining condenser inlet water temperatures at the design point for the most efficient Station operation.

This same operational control scheme would be utilized if a single unit conversion is implemented.

7.2 Cost Estimates

The same methodology for developing the cost estimates for closed-loop cooling conversion described in Section 6.2 would apply to conversion of a single unit to closed-loop cooling. The various categories addressed below would be largely scaled down to a single unit from those estimates developed and provided under the corresponding Sections of 6.2.

7.2.1 Initial Capital Costs

The same methodology for developing the capital cost estimates for closed-loop cooling conversion described in Section 6.2.1 would apply to conversion of a single unit to closed-loop cooling. When converting a single unit, however, some of the previously quantified shared costs would now apply almost fully to the single unit being converted. Examples are the pumping station structure, the electrical substation, the trenches for the circulating water piping runs, and the clearing of the island for the cooling tower; all these previously shared costs would now be borne largely by the single unit being converted, driving up the per unit cost.

Attachment 1 to this Report includes vendor data and budgetary cost estimates for major equipment components. Few allowances were applied and only when time did not permit further task development or reasonable vendor contact and quotation.

Attachment 4 to this Report provides the detailed capital cost assessment for the conversion of each unit at Merrimack Station to closed-loop cooling.

From Attachment 4, the total estimated capital cost of the conversion of Unit 1 (alone) Merrimack Station to closed-loop cooling is $22,416,700

With lost generating capacity during implementation (Section 6.2.4) added, total cost of conversion is estimated to be $24,654,500

From Attachment 4, the total estimated capital cost of the conversion of Unit 2 (alone) Merrimack Station to closed-loop cooling is $42,458,600

With lost generating capacity during implementation (Section 6.2.4) added, total cost of conversion is estimated to be $48,985,400

7.2.2 Costs Due to New Condenser Operating Parameters

The methodology utilized in Section 6.2.2 to estimate the total annual average costs due to new condenser operating parameters for converting both units at the Station to closed-loop cooling is the same that would apply for determining each unit's cost individually. The costs for each unit are hence extracted from the combined total cost and listed below.

The estimated average power loss associated with decreased operational efficiency due to the conversion of each unit at Merrimack Station to closed-loop cooling is:

- 0.16 MW Loss Unit 1
- 2.82 MW Loss Unit 2

The corresponding estimated costs associated with this power loss from each unit are:

Annual average costs due to new condenser operating parameters, Unit 1 $100,900

Annual average costs due to new condenser operating parameters, Unit 2 $1,778,600

Note: Based on market power of $72 MW

7.2.3 Parasitic Losses (Costs) Attributable to New Components

The parasitic losses assessed in Section 6.2.3 remain valid for converting either unit at Merrimack Station independently to closed cycle cooling. Therefore, as established previously:

Unit	Parasitic Electrical Load, Circ Water Pumps	
	Existing Circ Water Pumps	Additional Closed Loop Pumps
1	0.42 MW	0.96 MW
2	1.46 MW	3.65 MW

Likewise the cooling tower fans would be a constant load; i.e., there would be no operational variations in power consumption, as all fans for each unit would operate at full capacity at all times. This load would represent a corresponding new parasitic loss to the output of each Unit, estimated as follows:

Tower Usage Each Tower = fan MW

Merrimack Station U1 Usage (MW) = (4) 200 HP fans = 0.60 MW

Merrimack Station U2 Usage (MW) = (10) 200 HP fans = 1.49 MW

Merrimack Station Unit 1 = 0.96 MW $_{\text{New Circ. Water Pumps}}$ + 0.60 MW $_{\text{Tower Fans}}$

Merrimack Station Unit 2 = 3.65 MW $_{\text{New Circ. Water Pumps}}$ +1.49 MW $_{\text{Tower Fans}}$

Based on the estimated power requirements of the new circulating water booster pumps and the cooling tower fans, the estimated total average parasitic losses due to conversion to closed-loop cooling are as follows:

Merrimack Station Unit 1 = 1.56 MW_{Loss}

Merrimack Station Unit 2 = 5.14 MW_{Loss}

The corresponding estimated annual cost for each unit associated with this power loss is:

Merrimack Station Unit 1 = $983,900

Merrimack Station Unit 2 = $3,241,900

Note: Based on market power value of $72 MW

7.2.4 Lost Generating Capacity During Implementation

The methodology described and utilized in Section 6.2.4 for estimating lost generating capacity during implementation applies directly for conversion of either unit independently.

Estimating the lost generating capacity from a concurrent additional three week implementation outage, based on a typical Merrimack Station Unit 1 generator output of 120 MWE and Merrimack Station Unit 2 generator output of 350 MWE:

Merrimack Station Unit 1, 60,480 megawatt hours

Merrimack Station Unit 2, 176,400 megawatt hours

Although generating capacity as well as wholesale cost of electricity vary, the approximate dollar cost of the outages, based on $37.00/MWh projected replacement power cost, equates to:

Merrimack Station Unit 1, $2,237,800

Merrimack Station Unit 2, $6,526,800

7.2.5 Operational and Maintenance (O&M) Cost

The methodology for estimating annual operational and maintenance costs for a two unit closed-loop cooling conversion, as described in Section 6.2.5, applies as well for either unit converted independently. However, the corresponding cost for one unit is somewhat higher than if both units were maintained simultaneously, due to savings from commonality of some O&M tasks. For that reason, the proportional cost for one unit being maintained independently of the other will receive a multiplier of 30%.

Summary of Additional O&M Annual Cost (from Section 6.2.5, both units):

Years 1-5, $125,500 + $100,000 + $0 = $225,500

Years 6-15, $125,500 + $200,000 + $0 = $325,500

Years 16-30, $125,500 + $400,000 + $100,000 = $625,500

Increased Merrimack Station Unit 1 O&M Costs

Years 1-5, (combined $) x (4/14) x (1.30) = $83,800

Years 6-15, (combined $) x (4/14) x (1.30) = $120,900

Years 16-30, (combined $) x (4/14) x (1.30) = $232,300

Increased Merrimack Station Unit 2 O&M Costs

Years 1-5, (combined $) x (10/14) x (1.30) = $209,400

Years 6-15, (combined $) x (10/14) x (1.30) = $302,300

Years 16-30, (combined $) x (10/14) x (1.30) = $580,800

7.2.6 Water Treatment Costs

The discussion and assessment of water treatment costs associated with the conversion of Merrimack Station to closed-loop cooling provided in Section 6.2.6 applies directly to converting either unit independently. The costs for each unit would be proportioned directly to the flow of that unit versus the combined Station total flow rate.

Total Station costs would therefore be estimated at $175,000, and could easily approach $250,000. Hence, proportioned for each unit independently:

Increased Water Treatment Cost per Unit:

Merrimack Station Unit 1, (59/199) (total flow costs) = $51,900 to $74,100

Merrimack Station Unit 2, (140/199) (total flow costs) = $123,100 to $175,900

7.3 Environmental Considerations

The environmental considerations associated with converting either unit to closed-loop cooling independent of the other would basically be the same as previously described in Section 6.3 but scaled down proportionately.

7.3.1 Cooling Tower Plume

If either unit is converted to closed-loop cooling independently, there would still be a cooling tower plume with the same environmental impacts as previously discussed in Section 6.3.1. The only difference would be in the volume of plume generated, i.e., if Unit 1 only is converted, the plume volume would be about 30% of that generated if both units were converted, and if Unit 2 only is converted, the plume volume would be about 70% of that generated if both units were converted.

The need for a plume-abated hybrid tower remains unchanged.

7.3.2 Cooling Tower Noise

If either unit is converted to closed-loop cooling independently, there would still be cooling tower noise with the same environmental impacts as previously discussed in Section 6.3.2. The only difference would be in the volume of noise generated.

The need for a noise-abated tower remains unchanged.

7.3.3 Reduced Intake Flow

As previously discussed in Section 6.3.3, PSNH assumes that EPA's overall objective in directing PSNH to evaluate the conversion of Merrimack Station from once-through condenser cooling to closed-loop condenser cooling is to obtain information about the potential reduction of Station intake flow that could result from such a conversion. Hence, the quantification of the reduction in River intake flow is a significant assessment.

Current once-through River intake flow for Merrimack Station is as follows:

Summer intake flow rate

Unit 1 Circulating Water $_{Maximum}$ Note 1	59,000 gpm
Unit 1 Screen Wash	(+) 560 gpm
Unit 2 Circulating Water $_{Maximum}$ Note 1	140,000 gpm
Unit 2 Screen Wash	(+) 590 gpm
Total U1Intake Flow $_{Once\ Through,\ Summer\ Maximum}$ Note 1	59,560 gpm
Total U2 Intake Flow $_{Once\ Through,\ Summer\ Maximum}$ Note 1	140,590 gpm

Winter intake flow rate

Unit 1 Circulating Water $_{Maximum}$ Note 1	59,000 gpm
Unit 1 Screen Wash	(+) 560 gpm
Unit 1 De-icing recirculation $_{Maximum\ winter}$ Note 2	(-) 5,560 gpm
Unit 2 Circulating Water $_{Maximum}$ Note 1	140,000 gpm
Unit 2 Screen Wash	(+) 590 gpm
Unit 2 De-icing recirculation $_{Maximum\ Winter}$ Note 2	(-) 9,030 gpm
Total U1 Intake Flow $_{Once\ Through,\ Minimum}$ Notes 1 & 2	54,000 gpm
Total U2Intake Flow $_{Once\ Through,\ Minimum}$ Notes 1 & 2	131,560 gpm

[Note 1] Flow at maximum pump performance; includes sluice water flow

[Note 2] Current Station design utilizes reduced River intake flow in the winter, when cold water temperatures require de-icing recirculation flow operation.

Intake Flow Used for Sluice Water

Approximately 1,810 gpm (4.0 cfs) of the actual intake flow from Unit 1 and 2,780 gpm (6.2 cfs) of the actual intake flow from Unit 2 is used for sluice water flow to carry slag into a settling pond. This flow could not be reduced by the evaluated conversion to closed-loop cooling, as it is not utilized for Station cooling.

Recirculated Condenser Cooling Water

During the winter months, when ambient air conditions are often below freezing, approximately 5560 gpm (12.4 cfs) of heated condenser cooling water from Unit 1 is recirculated back into the intake forebay of Unit 1 for de-icing and tempering. Similarly, for Unit 2, approximately 9030 gpm (20.1 cfs) of heated condenser cooling water is recirculated back into the intake forebay of Unit 2.

River intake flow for the Station following conversion to closed-loop cooling is as follows:

Summer intake flow rate

Unit 1 Circulating Water/Cooling Tower Makeup	1,230 gpm
Unit 1 Screen Wash	(+) 560 gpm
Unit 1 Sluice Water	(+) 1,810 gpm
Total Unit 1 Intake Flow $_{\text{Closed Loop}}$	3600 gpm
Total Unit 1 Intake Flow $_{\text{Once Through, Maximum}}$	59,560 gpm
Reduction In Unit 1 River Intake Flow $_{\text{Maximum}}$	94.0%
Unit 2 Circulating Water/Cooling Tower Makeup	2,920 gpm
Unit 2 Screen Wash	(+) 590 gpm
Unit 2 Sluice Water	(+) 2,780 gpm
Total Unit 2 Intake Flow $_{\text{Closed Loop}}$	6330 gpm
Total Unit 2 Intake Flow $_{\text{Once Through, Maximum}}$	140,590 gpm
Reduction In Unit 2 River Intake Flow $_{\text{Maximum}}$	95.5 %

Winter intake flow rate

Following conversion to closed-loop cooling, the existing flow requirements for Station de-icing during winter operation would decrease somewhat due to the significantly decreased overall intake flows. However, the Circulating Water/Cooling Tower Makeup, Screen Wash, and Sluice Water flows would stay the same for each unit.

Hence, the total required intake flow would remain the same, summer or winter, at 9,930 gpm. Compared to the previous winter intake flow rate of 185,560 gpm, the post closed-loop conversion intake flow rate would constitute a 94.7% reduction in River intake flow, approximately the same reduction as for summer operation.

7.3.4 Loss of River Water Due to Evaporation

Loss of river water due to evaporation by the evaluated cooling tower is determined as previously described in Section 6.3.4. This section will quantify the River water loss due to such evaporation on a per unit basis.

Evaporation $_{Wet\ Summer}$ can be approximated as Water Flow $_{Total}$ x 0.0167 gpm [Reference 11.3]

Unit 1 Water Flow = 59,000 gpm

E_{Wet} = 0.0167 x 59,000 gpm = 985 gpm

Unit 2 Water Flow = 140,000 gpm

E_{Wet} = 0.0167 x 140,000 gpm = 2338 gpm

Estimated total loss of river water due to evaporation by the evaluated cooling tower,

Unit 1 = 985 gpm, or 1.42 million gallons/day

Unit 2 = 2338 gpm, or 3.37 million gallons/day

7.3.5 Site Aesthetics

The impact to site aesthetics due to the conversion of either unit at Merrimack Station to closed-loop cooling is mostly the same as discussed in Section 6.3.5 relative to the conversion of both units to closed-loop cooling. The same issues are relevant; the imposing tower size, the visible plume encroaching on the skyline, and the changes to the terrain along the Merrimack River would all affect site aesthetics. For a one unit versus two unit conversion, these impacts remain the same, they would just be scaled down depending upon the unit being converted.

8 Alternative Impingement/Entrainment Reduction Technologies

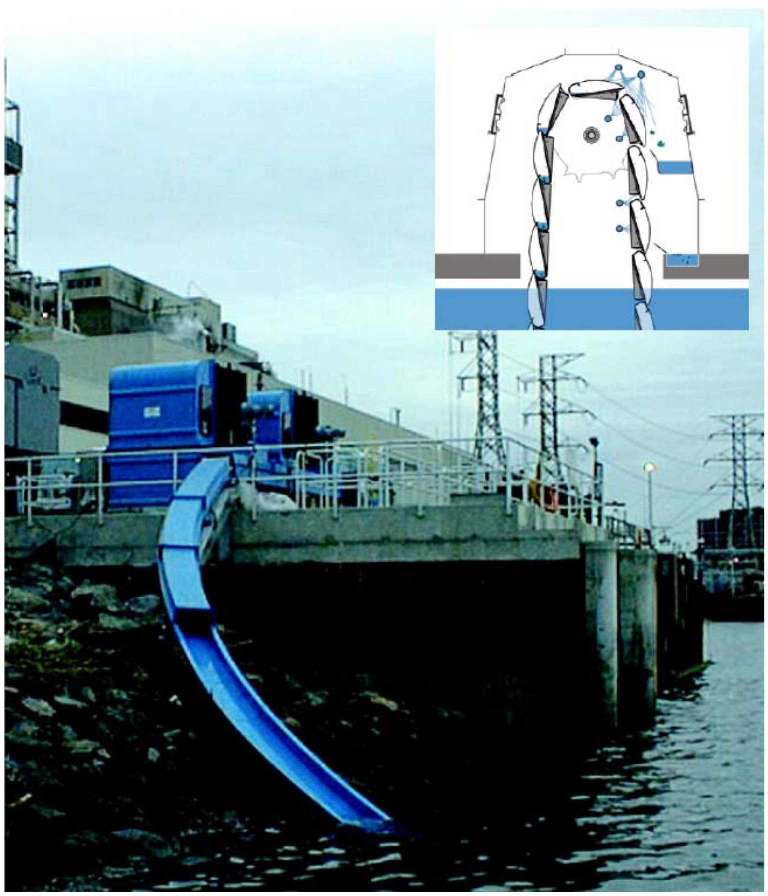
8.1 Alternate Technologies that Reduce Impingement

8.1.1 Modified Traveling Screens and Fish Handling and Return Systems

Conventional traveling water screens can be altered to incorporate modifications that improve survival of impinged fish. These modifications minimize fish mortality associated with screen impingement and spray wash removal.

There are four features that improve the survivability of impinged fish. They are as follows:

- Continuous operation of traveling screens to minimize impingement time.
- A state-of-the-art fish trough which ensures that the fish can be returned to the water body with a minimum of stress.
- Low pressure spray wash systems to gently remove the impinged fish before the high pressure fish spray is used to clean debris off the screens
- Alternative bucket configurations that include provisions to minimize damage to the fish upon entering the fish bucket, while they are in the fish bucket, while they are being transported from the fish bucket, and to keep them from escaping from the safety of the fish bucket



Source: www.glv.com

8.1.1.1 Continuous Operation of Screens with Upgraded Fish Return System

The existing Unit 1 and Unit 2 traveling screens are currently designed to operate intermittently, unless debris levels are high. However, an essential feature of any fish protection system is its ability to operate continuously.

Continuous operation of the traveling screens would reduce impingement and entrainment of fish. This is because the fish and/or debris would be continuously removed, avoiding accumulation of fish and/or debris that reduces available surface area for the flow of water. When such accumulation occurs, the same amount of water must pass through a smaller surface area, increasing both the velocity and the differential head loss. As the head losses and velocities increase, it is more likely that fish cannot escape the screen area and can become impinged.

However, the continuous operation of the screens would not be necessary during periods of low impingement. Per the charts in Section 8.5, January through March is a period of minimal impingement. This is coincident with the time when the River is typically frozen. If the traveling water screens are run continuously during this period, maintenance would be required for the screens as well as the fish return troughs. The troughs are located along the bank of the River. The potential safety hazards associated with maintenance activities performed by plant personnel during this time period are significant due to the freezing conditions. For these reasons, this Report evaluated running the traveling water screens only intermittently from January through March.

<u>Maintenance</u>

By running the existing traveling screens continuously from April through December, Merrimack Station would increase their current maintenance cost by approximately $60,000.

<u>Cost</u>

Currently, there is only one screen wash water pump per unit. Therefore, typically only one traveling screen per unit can be run continuously at a time. In order to run both traveling screens continuously from April through December, one screen wash spray pump would need to be purchased for each unit. It is estimated that the total capital cost to purchase and install 2 additional screen wash spray pumps is approximately $15,000 – $20,000.

<u>Biological Benefit</u>

Without an upgraded fish return system, the continuous operation of the screens will provide minimal biological benefit, since the mortality of the impinged fish is dependent on their safe return to the source water body. Therefore, the biological benefit of continuous operation of the traveling screens will be analyzed in combination with the upgraded fish return trough in the following section.

8.1.1.2 Upgraded Fish Return Trough

The main objective of any fish return system (fish sluice) is to return any captured fish to the water body with a minimum of stress. A quality fish return system usually consists of a trough designed to maintain a water velocity of 3 to 5 fps (0.9 to 1.5 m/s) and a minimum water depth of 4” to 6” (102 to 152 mm). The trough should avoid sharp radius turns and should discharge slightly below the low water level. The trough should be covered with a removable cover to prevent access by birds or other predators. The removable cover should have escape openings along the portion of the trough length that could potentially be submerged. However, during periods of excessive amounts of debris, per EIMCO Water Technologies, the optimal slope for maximum survivability is 1/16 foot drop per linear foot.

At Merrimack Station, the deck elevation of the Unit 1 and 2 screen houses is 207 ft. The river bank elevation is at approximately 193 ft. At a slope of 1/16, upgraded troughs would each need to be approximately 225 ft long between the deck and the river bank. The low water level is 187 ft. Each upgraded trough would need to discharge about one half foot below low water level which would be 187 ft - 0.5 ft = 186.5 ft. So, the slide portion of the troughs would need to flow from the riverbank (elev. 193’) to 186.5 At a slope of ¼ (not optimal, but acceptable due to practical considerations), each slide would be approximately 25 ft. long. Therefore, the total combined lengths of the upgraded troughs and slides would be 500 ft.

<u>Maintenance</u>

There should be no increased operation and maintenance activities for the upgraded fish return trough.

<u>Cost</u>

From Attachment 4, the total estimated capital cost for the modification of Merrimack Station to include an upgraded fish return system is $315,100.

<u>Biological Benefit</u>

Impingement survival at Merrimack Station with the existing sluice is essentially zero, because the end of the screenwash discharge pipe is not above the river’s surface except at extremely high river levels, preventing fish washed from the end of the pipe from returning alive to the River. Table 8-1 estimates the biological benefit of installing a state-of-the-art fish sluice, based on survival rates of golden shiner and white perch at Indian Point (Con Edison 1992) and June 2005-June 2007 impingement rates at Merrimack Station (Reference 11.17), under the assumption of 100% mortality with the existing system. With the existing intake screens, an effective fish return sluice would reduce the numbers of fish killed by impingement at Merrimack Station by an estimated 46% at Unit 1 and 54% at Unit 2. In terms of adult equivalent losses, the mortality rates would be reduced by an estimated 46% at Unit 1 and 50% at Unit 2.

Table 8-1. Estimated mortality reduction associated with a change from the existing fish return sluice for Units 1 and 2 of Merrimack Station to an upgraded return sluice, for impingement at maximum flow with the existing intake screens.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]
UNIT 1						
Total number of fish impinged[a]	1,775	648	365	93	2,141	742
Existing screen survival (#)[b]	1,080	372	226	56	1,306	428
Existing screen survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Existing screens + upgraded sluice survival (#)[c]	821	305	161	34	982	338
Upgraded sluice survival (%)	*76.0*	*81.9*	*71.3*	*60.3*	*75.2*	*79.1*
Sluice mortality reduction (%)[f]	**46.3**	**47.0**	**44.0**	**35.9**	**45.9**	**45.6**
UNIT 2						
Total number of fish impinged[a]	5,460	367	941	197	6,400	564
Existing screen survival (#)[b]	3,521	289	703	145	4,225	434
Existing screen survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Existing screens + upgraded sluice survival (#)[c]	2,893	169	574	114	3,467	282
Upgraded sluice survival (%)	*82.2*	*58.3*	*81.5*	*78.4*	*82.1*	*65.0*
Sluice mortality reduction (%)[f]	**53.0**	**46.0**	**61.0**	**57.6**	**54.2**	**50.0**

[a] Numbers impinged estimated from 24-hour sample collections (June 2005 to June 2007, adjusted for collection efficiency; Normandeau 2007) and based on maximum Merrimack Station intake flow.

[b] Based on average seasonal latent 24-hour screen survival tests using golden shiner (Normandeau 2007).

[c] Based on from return sluice testing at Indian Point (Con Edison 1992), using golden shiner survival for spottail shiner and white perch survival for bluegill, black crappie, pumpkinseed, largemouth bass, and yellow perch.

[d] Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)

[e] Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)

[f] Potential percent reduction in mortality rate for screens and sluice combined after replacing the existing Merrimack Station fish return sluice with an upgraded fish return sluice, based Merrimack Station impingement rates for June 2005 to June 2007.

ASSUMPTIONS

An upgraded fish sluice will be installed for use with the existing intake screens.
All fish that were impinged at Merrimack Station between June 2005 and June 2007 were alive when impinged.
All fish flushed into the current Merrimack Station fish return system do not survive due to location of end of sluice pipe.
An upgraded return sluice will only be operable in the ice-free months of April-December.
Upgraded fish return sluice survival will be comparable to survival rates of white perch and golden shiner tested at Indian Point. Survival rates used in this comparison are the mean corrected survival values of multiple tests.
Average conditions during testing of white perch were a pipe length of 225', discharge depth of 55' and system flow of 1990 gpm. Average conditions during testing of golden shiner were a pipe length of 225', discharge depth of 55' and system flow of 2100 gpm.

Con Edison (Consolidated Edison Company of New York, Inc.). 1992. Indian Point Units 2 and 3 Ristroph Screen Return System Prototype Evaluation and Siting Study. November 1992.

Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

8.1.1.3 Coarse Mesh Ristroph Screens

It is possible to retrofit modified Ristroph screens onto the existing traveling water screens. The replacement screens could be designed to work in conjunction with the debris removal function of the existing traveling water screens.

The coarse mesh Ristroph screen replacement was evaluated as part of an integrated system which would remove fish and fingerlings which are unable to escape from in front of the screen, and safely transport and return them to the source water downstream of the screen intake.

The following features are integral to modified Ristroph screens:

- The screen mesh should minimize harm to the fish
- The basket should maximize the screening area available.
- The fish bucket opening should be designed to encourage fish to enter the bucket.
- The fish bucket should be large enough to safely retain fish in the bucket.
- The bucket should provide a hydraulically stable, "stalled" fluid zone which attracts the fish, prevents damage to the fish while in the bucket and prevents the fish from escaping the bucket.
- The bucket should be shaped to allow gentle and complete removal of impinged fish
- The bucket should maintain a minimum water depth while transporting the fish.

The replacement traveling water screens would match the existing through-screen velocity of the existing traveling water screens.

Note that the screen and bucket portion of the traveling water screen could be replaced without replacing the entire traveling water screen. However, the traveling water screens have not be replaced since they were installed, and upcoming maintenance concerns warrant replacing the entire traveling water screen.

Maintenance

The upgraded Ristroph screens should not have appreciably higher maintenance than the existing traveling screens.

Cost

From Attachment 4, the total estimated capital cost for the replacement of the existing traveling water screens with through-flow traveling water screens incorporating the Ristroph screen design and an upgraded fish return is $1,357,700.

Biological Benefit

Table 8-2 estimates the biological benefit of installing Ristroph screens, based on Ristroph survival testing at Indian Point (Con Edison 1985) and June 2005-June 2007 impingement rates at Merrimack Station (Reference 11.17). Compared to the existing screens, Ristroph screens would reduce the numbers of fish killed by impingement at Merrimack Station by an estimated 14% at Unit 1, although it is estimated that the numbers killed at Unit 2 would increase by 4%. In combination with an upgraded fish handling system, Ristroph screens would reduce the number of fish killed by impingement by an estimated 50% at Unit 1 and 53% at Unit 2. In terms of adult equivalent losses, Ristroph screens in combination with an upgraded fish handling system would reduce mortality rates by an estimated 60% at Unit 1 and 50% at Unit 2, compared to the existing screens and sluice.

Table 8-2. Mortality reduction associated with a change from existing intake screens at Units 1 and 2 of Merrimack Station to Ristroph screens for impingement at maximum flow, with and without adjustment for upgraded return sluice survival.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated [d]	Adult Equivalents [e]	Estimated [d]	Adult Equivalents [e]	Estimated [d]	Adult Equivalents [e]
UNIT 1						
Total number of fish impinged [a]	1,775	648	365	93	2,141	742
Existing survival (#) [b]	1,080	372	226	56	1,306	428
Existing survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Ristroph survival (#) [c]	1,185	482	238	62	1,422	544
Ristroph survival (%)	*66.7*	*74.4*	*65.1*	*66.8*	*66.4*	*73.4*
Ristroph + upgraded sluice survival (#)[f]	914	409	163	36	1,077	445
Ristroph + upgraded sluice survival (%)	*51.5*	*63.1*	*44.5*	*38.4*	*50.3*	*60.0*
Screen mortality reduction (%) [g]	**15.0**	**39.8**	**8.7**	**18.2**	**13.9**	**37.2**
Screen + sluice mortality reduction (%)[h,i]	**51.5**	**63.1**	**44.5**	**38.4**	**50.3**	**60.0**
UNIT 2						
Total number of fish impinged[a]	5,460	367	941	197	6,400	564
Existing survival (#)[b]	3,521	289	703	145	4,225	434
Existing survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Ristroph survival (#)[c]	3,510	292	618	134	4,128	426
Ristroph survival (%)	*64.3*	*79.6*	*65.7*	*67.9*	*64.5*	*75.5*
Ristroph + upgraded sluice survival (#)[f]	2,882	169	514	110	3,397	279
Ristroph + upgraded sluice survival (%)	*52.8*	*46.2*	*54.7*	*55.6*	*53.1*	*49.5*
Screen mortality reduction (%)[g]	**-0.6**	**3.0**	**-35.9**	**-20.7**	**-4.4**	**-6.6**
Screen + sluice mortality reduction (%)[h,i]	**52.8**	**46.2**	**54.7**	**55.6**	**53.1**	**49.5**

[a] Numbers impinged estimated from 24-hour sample collections (June 2005 to June 2007, adjusted for collection efficiency; Reference 11.17) and based on maximum Merrimack Station intake flow.
[b] Based on average seasonal latent 24-hour screen survival tests using golden shiner (Reference 11.17).
[c] Based on Ristroph screen survival test at Indian Point. Latent 96-hour data available for the period from Jan. to Apr. 1985 for 10 species (Con Edison 1985).
[d] Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Reference 11.17)
[e] Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Reference 11.17)
[f] Return sluice counts adjusted for survival based on results of Indian Point sluice survival test (see sluice survival table).
[g] Percent reduction in mortality rate between existing Merrimack Station screens and theoretical application of Ristroph screens based on observed Merrimack impingement rates during June 2005 to June 2007.
[h] Percent mortality reduction between existing Merrimack Station screens and fish return sluice and theoretical application of Ristroph screens and upgraded fish return sluice based on Merrimack Station impingement rates in June 2005 to June 2007.
[i] Assumes an existing sluice survival rate of zero.

ASSUMPTIONS
Assumes that all fish that were impinged at Merrimack Station between June 05 and June 07 were alive when impinged.
Existing estimates assume that golden shiner survival rates are representative of all species.
Ristroph estimates are based on survival rates of like species tested at Indian Point (white perch, pumpkinseed, spottail shiner).
Assumes an existing return sluice survival of zero.

Con Edison (Consolidated Edison Company of New York, Inc.). 1985. Biological Evaluation of a Ristroph Screen at Indian Point Unit 2. June 1985.
Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007

8.1.2 Traveling Water Screens

8.1.2.1 Dual Flow Conversion Traveling Screens

Many existing through-flow traveling screen installations can be retrofit to use a dual flow traveling water screen. A dual flow traveling water screen is mechanically similar to a through flow screen that has been rotated ninety degrees in the channel. The modification consists of the installation of a special wall plate mounted perpendicular to the flow in place of the existing screen. The dual flow is then lowered into the well, with baskets parallel to the flow, on the upstream side of the wall plate. An inlet opening in the wall plate allows screened water to pass to the pumps. An alternative arrangement uses a specially constructed screen mainframe that includes a wall plate made as an integral part of the screen frame with extensions or "wings" that fit into existing embedded guides.

A through flow to dual flow retrofit provides increased flexibility and has the following benefits:

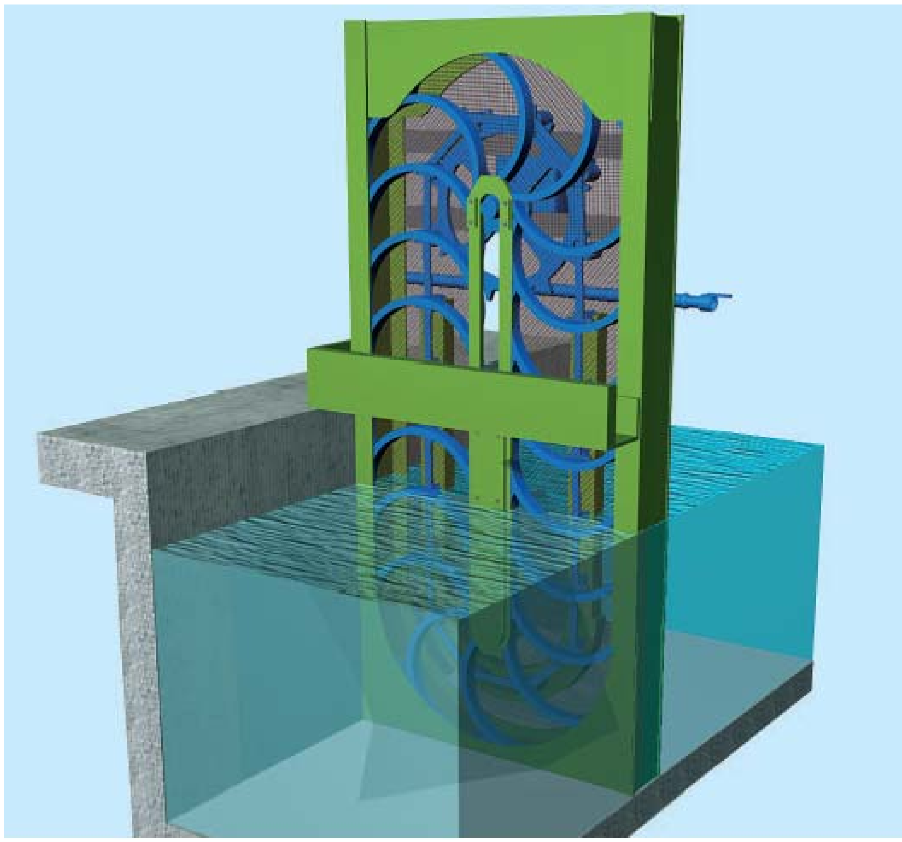
- Potential to decrease the velocity through the screens. The flow pattern of the dual flow screen allows the entire submerged screen surface to be an active screen area. This means that a dual flow screen of a given width would pass almost twice as much water at the same velocity as a through flow screen of the same width. Conversely, the same amount of flow can pass through a dual flow screen at about half the velocity as a through flow screen of the same width.
- Elimination of debris carryover. Since all flow going through a channel installed with a dual flow screen must pass through the screen before entering the screenwell, the potential for debris carryover is eliminated.

At Merrimack Station, the existing penetrations in the CWIS deck for the traveling screens are not of adequate size to accommodate dual-flow traveling screens (Attachment 4). Dual-flow traveling screens are physically larger than the existing units because of the screen configuration. New CWISs or extensive modifications to the existing CWISs would have to be designed for dual-flow traveling screens to be implemented. This cost is estimated to be many times the cost of the traveling screens themselves. As a result, the implementation of dual-flow traveling screens at Merrimack Station is infeasible.

8.1.2.2 Multi-Disc Screens

Traditional traveling water screens are installed in a channel with the screening surface oriented perpendicular to the water flow. Raw water passes first through the ascending and then through the descending screen baskets. The ascending basket is located on the upstream portion of the screen and collects debris as is passes up through the water. When it reaches the top of the traveling screen, the debris is washed off the screen and into a debris trough. The basket continues to revolve and descends into the water on the downstream side. Any debris that was not originally washed off the screen basket may be washed off in the flow of water. This is considered to be 'carryover' and may travel into the intake screenwell and potentially enter the circulating water pump intake.

Multi-disc screens are oriented the same way as traditional through flow screens. However, they have very different designs. Multi-disc screens are comprised of circulating sickle-shaped mesh panels that are connected to a frame via a revolving chain. The linked mesh panels are guided on each side forming a unit together with the support. The forces applied by the flowing water to the center of the mesh panels are transmitted via supporting beams into the civil structure. In the center the mesh panels are supported by rollers. Raw water flows directly through the mesh panels. The debris retained at the face of the ascending mesh panels is transported with debris carriers to floor level. There it is efficiently removed by means of a spray-water device.



Source: Geiger MultiDisc® Screen – Screening Technology Brochure

MultiDisc screens include special provisions for the protection of fish and aquatic species that become impinged. Specifically designed fish buckets attached to the screen panels retain some of the water during its upward travel, thereby allowing any captured fish "to survive within the water" once the fish buckets exit the water level. The fish buckets are surface treated with a special sliding composite material to allow the fish to be easily flushed from the buckets. A low pressure spray header smoothly recovers organisms which are transported upwards on the screen surface into the bucket. Organisms impinged on the screen surface below this bucket are led via an opening in the lower panel frame into the bucket of the following mesh panel. Due to the special turning system of the mesh panels at the drive unit the fish buckets are gently discharged and the retained water and fish are led into a trough.

Due to the installation across the chamber the Geiger MultiDisc® Screens can be retrofit into the existing space of the current traveling water screens, minimizing required civil structure modifications.

Maintenance

The Multi-disc screens should have lower maintenance than the existing traveling screens since each MultiDisc screen can be removed individually.

Cost

From Attachment 4, the total estimated capital cost for the replacement of the existing traveling water screens with MultiDisc traveling water screens with fish protection provisions and incorporating an upgraded fish return is $2,270,800.

Biological Benefit

Table 8-3 estimates the biological benefit of installing Geiger MultiDisc screens, based on survival testing on these screens at Potomac River Generating Station (EPRI 2007) and June 2005-June 2007 impingement rates at Merrimack Station (Reference 11.17). Compared to the existing screens, Geiger MultiDisc screens would reduce the numbers of fish killed by impingement at Merrimack Station by an estimated 83% at Unit 1 and 88% at Unit 2. In combination with an upgraded fish handling system, Geiger MultiDisc screens would reduce the number of fish killed by impingement by an estimated 69% at Unit 1 and 80% at Unit 2. In terms of adult equivalent losses, Geiger MultiDisc screens in combination with an upgraded fish handling system would reduce mortality rates by an estimated 67% at Unit 1 and 60% at Unit 2, compared to the existing screens and sluice.

Table 8-3. Mortality reduction associated with a change from existing intake screens at Units 1 and 2 of Merrimack Station to Geiger multi-disc screens for impingement at maximum flow, with and without adjustment for upgraded return sluice survival.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]
UNIT 1						
Total number of fish impinged [a]	1,775	648	365	93	2,141	742
Existing survival (#) [b]	1,080	372	226	56	1,306	428
Existing survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Geiger multi-disc survival (#) [c]	1,651	559	347	88	1,998	647
Geiger multi-disc survival (%)	*93.0*	*86.3*	*95.1*	*94.0*	*93.4*	*87.3*
Geiger + upgraded sluice survival (#) [f]	1,231	447	245	53	1,475	500
Geiger + upgraded sluice survival (%)	*69.3*	*68.9*	*67.0*	*56.5*	*68.9*	*67.4*
Screen mortality reduction (%) [g]	**82.1**	**67.8**	**87.1**	**85.3**	**82.9**	**69.9**
Screen + sluice mortality reduction (%) [h,i]	**69.3**	**68.9**	**67.0**	**56.5**	**68.9**	**67.4**
UNIT 2						
Total number of fish impinged [a]	5,460	367	941	197	6,400	564
Existing survival (#) [b]	3,521	289	703	145	4,225	434
Existing survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Geiger multi-disc survival (#) [c]	5,256	305	891	182	6,148	488
Geiger multi-disc survival (%)	*96.3*	*83.3*	*94.8*	*92.5*	*96.1*	*86.5*
Geiger + upgraded sluice survival (#) [f]	4,374	194	730	144	5,104	338
Geiger + upgraded sluice survival (%)	*80.1*	*52.9*	*77.6*	*73.1*	*79.7*	*60.0*
Screen mortality reduction (%) [g]	**89.5**	**20.7**	**79.3**	**71.7**	**88.4**	**41.3**
Screen + sluice mortality reduction (%) [h,i]	**80.1**	**52.9**	**77.6**	**73.1**	**79.7**	**60.0**

[a] Numbers impinged estimated from 24-hour sample collections (June 2005-June 2007, adjusted for collection efficiency; Reference 11.17and based on maximum Merrimack Station intake flow.
[b] Based on average seasonal latent 24-hour screen survival tests using golden shiner (Reference 11.17).
[c] Based on Geiger multi-disc screen 48-hr latent survival test at Potomac River Generating Station (EPRI 2007). Survival rates available for bluegill, pumpkinseed, yellow perch, largemouth bass, and spotttail shiner (black crappie estimated from bluegill).
[d] Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Reference 11.17)
[e] Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Reference 11.17)
[f] Return sluice counts adjusted for survival based on results of Indian Point sluice survival test (See sluice survival table).
[g] Percent reduction in mortality rates between existing Merrimack Station screens and theoretical application of Geiger multi-disc screens based on observed Merrimack impingement rates for June 2005 to June 2007.
[h] Percent reduction in mortality rates between existing Merrimack Station screens and fish return sluice and theoretical application of Geiger screens and upgraded fish return sluice, based on Merrimack Station impingement rates in June 2005 to June 2007.
[i] Assumes an existing sluice survival rate of zero.

ASSUMPTIONS
Assumes that all fish that were impinged at Merrimack Station between June 05 and June 07 were alive when impinged.
Existing estimates assume that golden shiner survival rates are representative of all species.
Assumes an existing return sluice survival of zero.

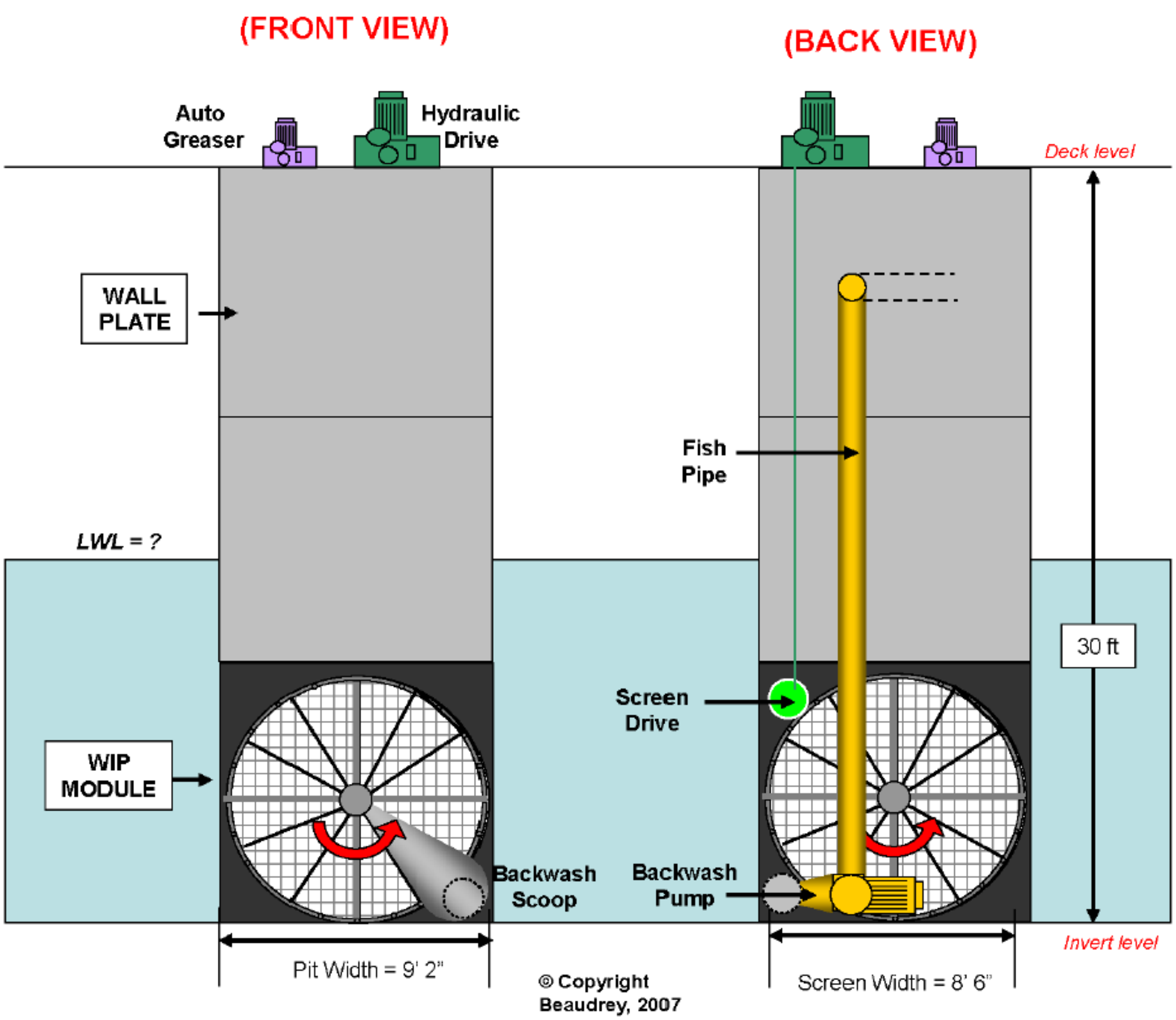
EPRI (Electric Power Research Institute). 2007. Latent impingement mortality assessment of the Geiger MultiDisc screening system at the Potomac River Generating Station.
Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

8.1.2.3 WIP System

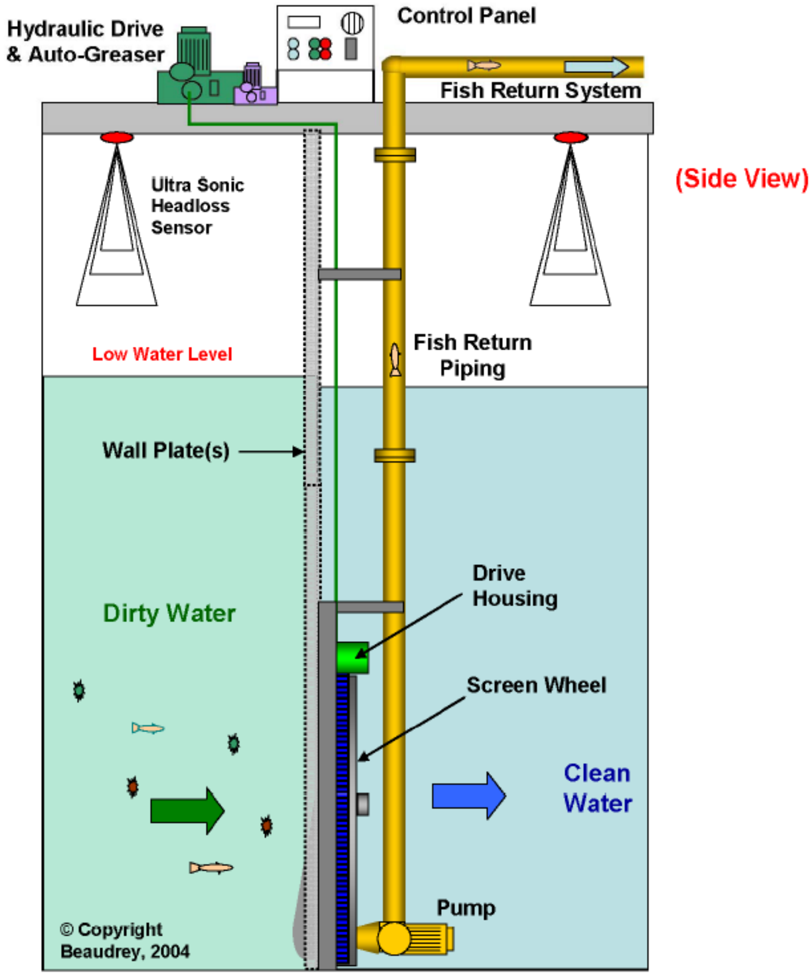
Beaudrey USA supplies a W Intake Protection Screen (WIP) for retrofit into intakes that currently have through flow traveling water screens.

The WIP is a modified revolving disc screen. The traditional revolving disc screen is a simple and compact screening device. It consists of a flat disc covered with screening material that rotates about a horizontal axis, perpendicular to the water flow. As water flows through the submerged portion of the disc, solids are retained on the screening media. On a traditional revolving disc screen, the rotation of the disc lifts the solids above the water surface where they are removed by a series of spray nozzles.

The Beaudrey WIP System uses the technology of traditional revolving disc screens in a new way. The WIP system consists of stacked circular No-Cling screening wheels which rotate within a frame. The screens rotate at 2 revolutions per minute. Both fish and debris are removed from the screen surface below the waterline by a specially engineered fish safe pump and suction scoop. The entire screen is cleaned in 30 seconds. The aquatic life never leave the water and are safely returned downstream of the intake structure.



Source: Beaudrey Proposal 18105-Merrimack1-10071-R01



Source: Beaudrey Proposal 18105-Merrimack1-10071-R01

The WIP System is designed to fit into the existed traveling water screen guides, therefore there are no civil modifications required to the intake.

Maintenance

The W Intake Protection Screen (WIP) should have appreciably easier maintenance than the existing traveling screens, because the WIP screens can be raised out of the water for maintenance activities.

Cost

From Attachment 4, the total estimated capital cost for the replacement of the existing traveling water screens with W Intake Protection Screens with fish protection provisions and incorporating an upgraded fish return is $2,065,300.

Biological Benefit

Table 8-4 estimates the biological benefit of installing an integrated WIP and Beaudrey FPS™ (Fish Protection System), based on survival testing on this type of system at Le Blayais Nuclear Power Station (in France) and June 2005-June 2007 impingement rates at Merrimack Station (Reference 11.17). Compared to the existing screens, the integrated WIP and Beaudrey FPS™ (Fish Protection System) would reduce the numbers of fish killed by impingement at Merrimack Station by an estimated 72% at Unit 1 and 68% at Unit 2. In combination with an upgraded fish handling system, WIP screens the integrated WIP and Beaudrey FPS™ (Fish Protection System) would reduce the number of fish killed by impingement by an estimated 66% at Unit 1 and 74% at Unit 2. In terms of adult equivalent losses, the integrated WIP and Beaudrey FPS™ (Fish Protection System) in combination with an upgraded fish handling system would reduce mortality rates by an estimated 70% at Unit 1 and 60% at Unit 2, compared to the existing screens and sluice.

Table 8-4. Mortality reduction associated with a change from existing intake screens at Units 1 and 2 of Merrimack Station to Beaudrey WIP screens and FPS system for impingement at maximum flow, with and without adjustment for upgraded return sluice survival.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	**Adult Equivalents**[e]	**Estimated**[d]	**Adult Equivalents**[e]	**Estimated**[d]	**Adult Equivalents**[e]
UNIT 1						
Total number of fish impinged [a]	1,775	648	365	93	2,141	742
Existing survival (#) [b]	1,080	372	226	56	1,306	428
Existing survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Beaudrey WIP survival (#) [c]	1,580	577	325	83	1,905	660
Beaudrey WIP survival (%)	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*
Beaudrey WIP + upgraded sluice survival (#) [f]	1,191	472	227	49	1,418	521
Beaudrey WIP + upgraded sluice survival (%)	*67.1*	*72.8*	*62.1*	*52.6*	*66.2*	*70.2*
Screen mortality reduction (%) [g]	**71.9**	**74.1**	**71.2**	**72.9**	**71.8**	**74.0**
Screen + sluice mortality reduction (%) [h,i]	**67.1**	**72.8**	**62.1**	**52.6**	**66.2**	**70.2**
UNIT 2						
Total number of fish impinged [a]	5,460	367	941	197	6,400	564
Existing survival (#) [b]	3,521	289	703	145	4,225	434
Existing survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Beaudrey WIP survival (#) [c]	4,859	326	837	176	5,696	502
Beaudrey WIP survival (%)	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*
Beaudrey WIP + upgraded sluice survival (#) [f]	4,024	199	689	141	4,714	340
Beaudrey WIP + upgraded sluice survival (%)	*73.7*	*54.3*	*73.3*	*71.4*	*73.7*	*60.3*
Screen mortality reduction (%) [g]	**69.0**	**47.8**	**56.4**	**58.7**	**67.6**	**52.2**
Screen + sluice mortality reduction (%) [h,i]	**73.7**	**54.3**	**73.3**	**71.4**	**73.7**	**60.3**

[a] Numbers impinged estimated from 24-hour sample collections (June 2005-June 2007, adjusted for collection efficiency; Reference 11.17) and based on maximum Merrimack Station intake flow.
[b] Based on average seasonal latent 24-hour screen survival tests using golden shiner (Reference 11.17).
[c] Based on Beaudrey FPS system survival testing at Le Blayais Nuclear Power Station in France.
[d] Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Reference 11.17)
[e] Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Reference 11.17)
[f] Return sluice counts adjusted for survival based on results of Indian Point sluice survival test (See sluice survival table).
[g] Percent reduction in mortality rates between existing Merrimack Station screens and theoretical application of Beaudrey WIP screens, based on Merrimack impingement rates for June 2005 to June 2007.
[h] Percent reduction in mortality rates between existing Merrimack Station screens and fish return sluice and theoretical application of Beaudrey WIP screens and upgraded fish return sluice, based on Merrimack Station impingement rates for June 2005 to June 2007.
[i] Assumes an existing sluice survival rate of zero.

ASSUMPTIONS
Assumes that all fish that were impinged at Merrimack Station between June 2005 and June 2007 were alive when impinged.
Existing estimates assume that golden shiner survival rates are representative of all species.
Beaudrey WIP estimates assume that survival rates are similar for fish impinged at Le Blayais and Merrimack stations.
Assumes an existing return sluice survival of zero.

Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

8.1.3 Fish Net Barriers

Fish Net Barriers are wide-mesh nets that are installed in front of intake structures. The water entering the intake must first pass through the openings in the mesh. The size of the mesh openings limits the size of the organism that can pass through the net. In order to be successful, the nets must have a large surface such that the velocity through the net is very small (usually ≤ 0.5 ft/sec). Otherwise, organisms would become impinged on the screen and would be damaged.

Barrier nets have been used/studied at many large power plants. The success of the technology is dependent upon the following site-specific requirements: a) the intake must be located on a source waterbody that allows for the deployment of a large net b) recreation on the waterbody must be limited so as to not interfere with the nets c) the waterbody must have limited debris flows so that the net is not damaged d) if freezing is a possibility, the net can only be deployed seasonally, when ice is not an issue. In addition, biofouling may be a concern unless rigorous maintenance is performed.

Hooksett Pool has a depth of 6-10 feet. It is approximately 700-800 feet wide. Total maximum flow into the intakes is 200,000 gpm. The total combined length of the intakes covers approximately 250 feet of shoreline. Due to the large intake flow and the shallowness of the waterbody, deployment of a barrier net at Merrimack Station is infeasible.

8.1.4 Wide-slot Wedgewire screens

Wedgewire screens are designed to reduce entrainment and impingement in two ways. First, organisms susceptible to entrainment cannot pass through the small slot size in the screen. Screen mesh sizes range from 0.5 to 10 mm, with the most common slot sizes in the 1.0 to 2.0 mm range. Secondly, the cylindrical shape of the screen makes it easier for the fish to swim away before they become impinged. A low through-slot velocity is possible because of the large surface area of the cylindrical screen. Also, because of the screen's cylindrical configuration, the velocity pulling the organisms toward the screen is quickly dissipated. This allows organisms to escape the flow field.

To attain the optimal reduction in impingement mortality and entrainment, certain conditions must be met. First, the slot size must be small enough to physically prevent the entrainment of the organisms identified as warranting protection. Second, a low through-slot velocity must be maintained to minimize the hydraulic zone of influence surrounding the screen assembly. Typically, a lower through-slot velocity, when combined with other optimal factors, will achieve significant reductions in entrainment and impingement mortality. Third, a sufficient ambient current must be present in the source water body to aid organisms in bypassing the structure and to remove other debris from the screen face. A constant current also aids the automated cleaning systems that are now common to cylindrical wedgewire screen assemblies.

Although many wedgewire screen vendors have been contacted, only one has been responsive. However, it has not yet provided a design for a potential system. Therefore, screen sizing for the evaluation directed by EPA is based on publicly available sizing and design information. In order to estimate the required size and number of cylindrical wedgewire screens for each unit, a sizing program available at the following website was used:

http://www.waterintake.com/intakescreenstyles.html. The sizing is based on assuming a 0.5 ft/s through-screen velocity and a .069" wire thickness with .069" (1.75mm) slot width.

Per Reference 11.7, the maximum screen diameter should be half the water depth at the lowest extreme of water level; preferably it should be no more than one-third. Where depth is shallow, the option of using tee-configurations or other multiple arrangements of small-diameter screens could be considered. The recommended minimum submergence depth is half the screen diameter, with the screen being spaced an equivalent distance from the bed and any wall. Submergence to this depth would avoid the risk of excessive entrainment of surface-carried debris into the abstraction flow.

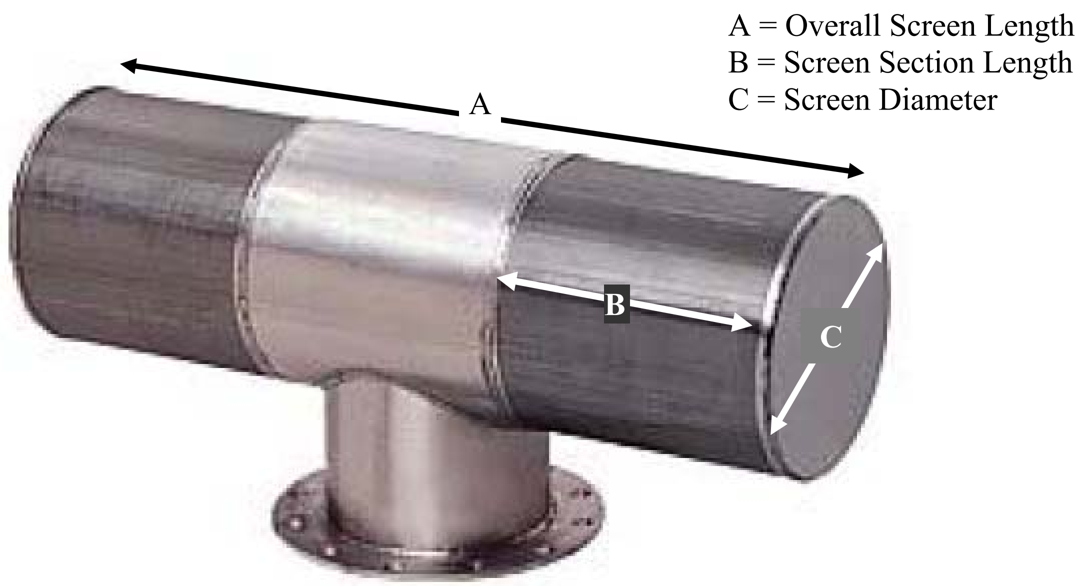
Unit 1 (59,000 gpm)

The sizing calculator indicates that flow could be accommodated with quantity of 7 - 3 ft diameter tee-type screens with 5 ft screen sections for a total length of a little over 13 ft for each screen. It is assumed that the wedgewire screens would begin 66 ft (20m) from the Unit 1 screen house, and be spaced 5 ft apart, and that one header would have 3 screens while the other would have 4. Since the Unit 1 screen house extends 30 ft from the shore, the screens would project approximately 118 ft into the River.

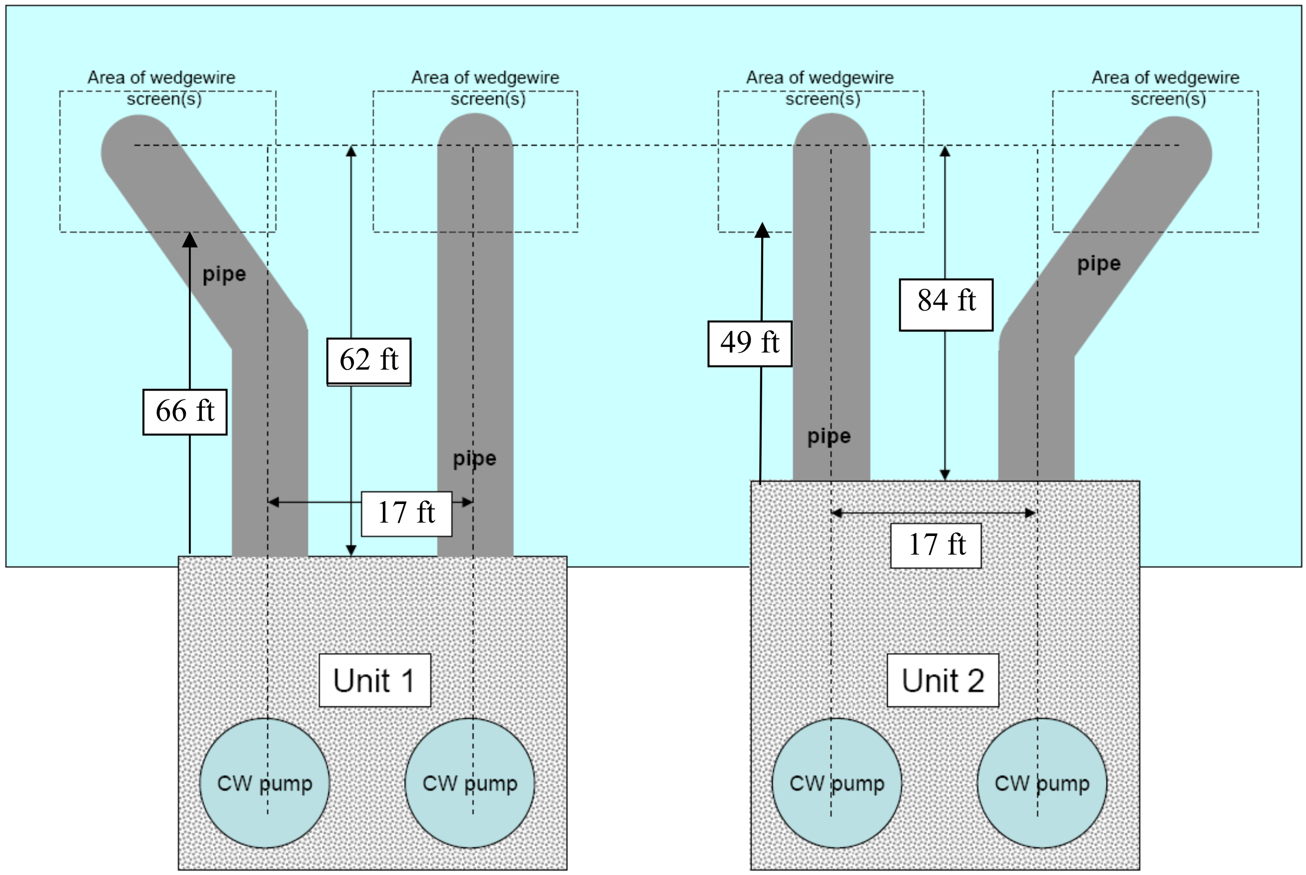
Unit 2 (140,000)

The sizing calculator indicates that flow could be accommodated with quantity of 16 - 3 ft diameter tee-type screens with 5 ft screen sections for a total length of a little over 13 ft for each screen. It is assumed that the wedgewire screens would begin 49 ft (15 m) from the Unit 2 screen house, and be spaced 5 ft apart, and that both headers would have 8 screens. Since the Unit 2 screen house extends 45 ft from the shore, the screens would project approximately 138 ft into the River.

When the river is 6 ft deep, the screens would only be 1.5 ft below the surface of the water. This would cause a substantial impact on the recreational use of the River, as shown on sketch PSNH001-SK-007 in Attachment 2.



Source: HendrichWater Intake Screens http://www.waterintake.com/



Not to scale

Evaluated Coarse Mesh Wedgewire Screen Design

Maintenance

When debris accumulates on the screen body, the screens could be cleaned with an airburst system daily, weekly, monthly or any predetermined time specified. Airburst piping should be designed for initial installation of an intake screen, even though the airburst system purchase may be deferred or delayed. The air manifold could be uncapped and connected when required.

Frazil Ice

Due to the screening mechanism of wedgewire screens, they are very susceptible to the formation of frazil ice on the screens. The formation of granular ice crystals in turbulent, supercooled water is referred to as 'frazil ice'. Supercooled water occurs when the water temperature begins to drop and passes through the 32°F point. At a temperature of less than 32°F, sometimes even a fraction of a degree less, tiny particles of ice form quickly and uniformly throughout the water mass. Frazil ice is extremely adhesive and would stick to any solid object, such as a screen, that is at or below the freezing point. Currently, Merrimack Station uses operational measures to deal with frazil ice, as discussed in Section 5.4.2.

According to the wedgewire screen vendor contacted, a Station with an intake that has a history of frazil ice should not consider installing wedgewire screens as a feasible technology.

The vendor referenced an Army Corps of Engineers paper entitled "Frazil Ice Blockage of Intake Trash Rakes" (Reference 11.10) which support the basis for his recommendation.

Due to the large impact on the River due to the required number of wedgewire screens, and based on the conclusions of the Army Corps of Engineers paper regarding frazil ice, wide-slot wedgewire screens are infeasible for implementation at Merrimack Station.

8.1.5 Angled Traveling Screens and Modular Inclined Screens

Angled Traveling Screens work by diverting fish past the traveling water screens. The screen is set at an angle to the incoming flow. The flow of water guides the fish past the screens and toward an area at the end of the screens where they can be transported back to the source water body. Also, this arrangement creates an area of turbulence along the screen face that fish will avoid as they are directed to the escape bypass. Modular inclined screens (MIS) are a variation of the angled screens whereby modules are provided which consist of an entrance with trash racks, dewatering stop logs in slots, an inclined screen set at a 10-20 degree angle to the flow, as well as a bypass to direct fish back to the source water body.

In order to change to angled traveling screens or modular inclined screens at Merrimack Station, the entire intake structure for each unit would have to be replaced. The installation of angled traveling screens would require the complete replacement of each CWIS at the Station because all of the components of each existing intake are oriented perpendicular to the shoreline. Moreover, the bypass system is an integral part of the intake. The installation of modular inclined screens would require such complete CWIS replacement because modular inclined screens are only supplied as complete systems. As a result, neither angled traveling screens nor modular inclined screens are feasible for implementation at Merrimack Station.

8.1.6 Louvers

Louver systems consist of a series of evenly spaced, vertical panels that are aligned across a channel and placed at an angle to the flow. The louver panels cause an abrupt change in the velocity and direction of the flow, which in turn causes turbulence, which fish avoid. Fish tend to align themselves with the direction of the current, which is parallel to the face of the louvers. Louver systems are typically designed so that the current leads fish to a bypass or handling system located at the end of the louvers.

Although louver systems can be effective at diverting fish in certain source water bodies, they have several limitations that render them infeasible for implementation at Merrimack Station. First, they rely on a consistent water level to maintain the most efficient flow velocity. Hooksett Pool water level ranges from 6 to 10 feet, which represents a potential variation in water level of over 60%. Second, efficiently designed louver systems are comprised of a long line of louvers set at shallow angles. The shoreline adjacent to which Merrimack Station's intakes are located are not sufficiently long to allow for installation of an efficiently designed, properly operational louver system. Also, after an extensive search, no vendors were found that produced louvers for this type of application.

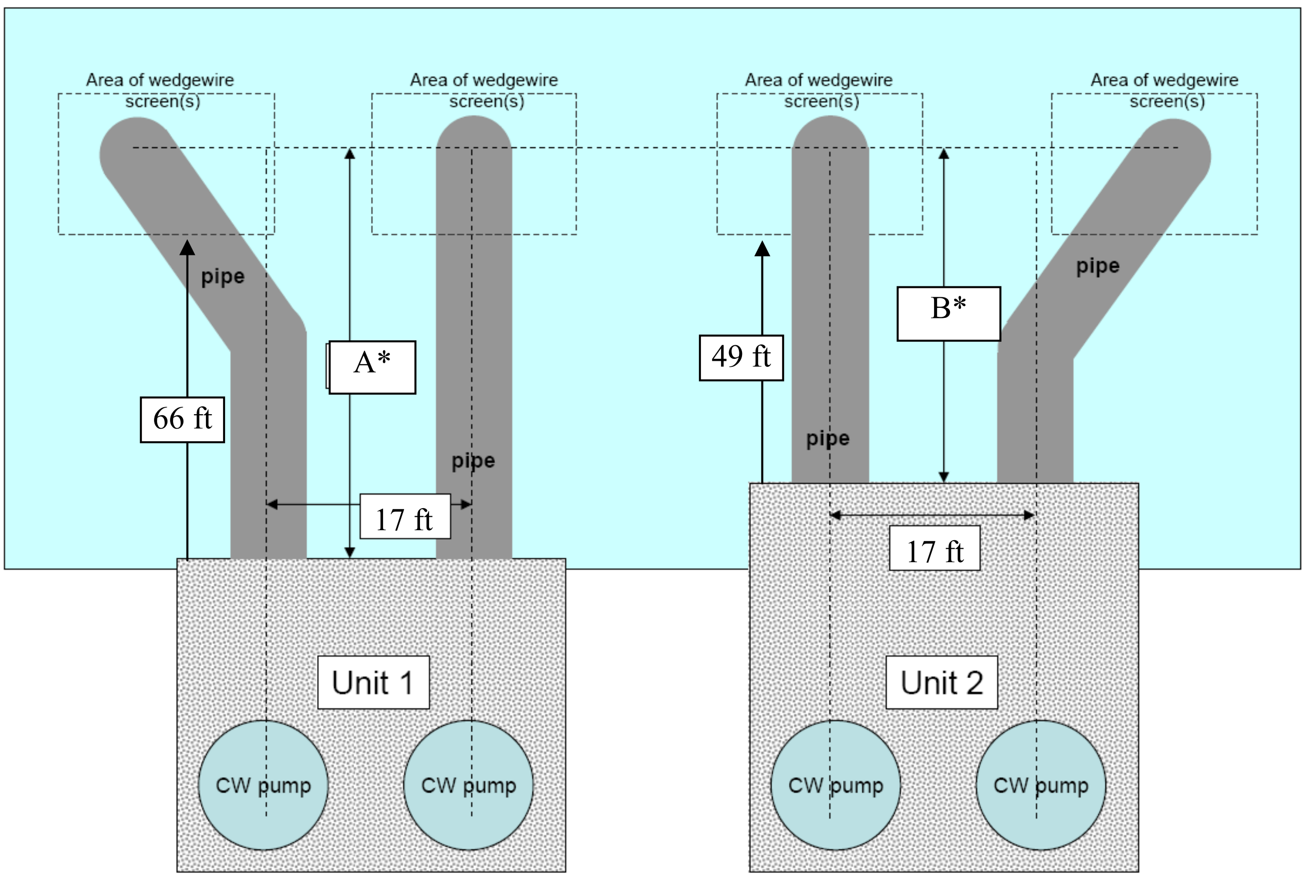
8.2 Alternate Technologies that Reduce Entrainment

8.2.1 Narrow-slot Wedgewire Screens

Narrow-slot wedgewire screens have the same characteristics as wide slot wedgewire screens, except that the slot size is small enough to reduce entrainment of aquatic organisms.

Since entrainment reduction is based on slot-size, several screens were sized for purposes of the evaluation directed by EPA, based on analysis provided by Normandeau in Table 10 of Attachment 6.

At Merrimack Station, each circulating water pump would be fed from a header attached to a series of wedgewire screens as shown in the following figure. Therefore, the total number of wedgewire screens would be divided amongst the headers.



Evaluated Fine Mesh Wedgewire Screen Design

* See Table below for approximate distance from intake to end of wedgewire screen system

Unit 1 (59,000 gpm)

Slot Size	Screen Dia.	Screen Section Length	Overall Screen Length	# of Screens	Screens per Header	Total combined length of screen	A See figure above
1.5 mm	3 ft	5 ft	13 ft	7	3 on 1, 4 on 1	22 ft	88 ft
1.0 mm	3 ft	5 ft	13 ft	9	4 on 1, 5 on 1	27.5 ft	93.5 ft
0.8 mm	3 ft	5 ft	13 ft	11	5 on 1, 6 on 1	33 ft	99 ft

Unit 2 (140,000 gpm)

Slot Size	Screen Dia.	Screen Section Length	Overall Screen Length	# of Screens	Screens per Header	Total combined length of screen	B See figure above
1.5 mm	3 ft	5 ft	13 ft	17	8 on 1, 9 on 1	49.5 ft	98.5 ft
1.0 mm	3 ft	5 ft	13 ft	22	8 on both	60.5 ft	109.5 ft
0.8 mm	3 ft	5 ft	13 ft	25	12 on 1, 13 on 1	71 ft	120 ft

The end of the Unit 1 screen house is 30 ft from the shoreline. The Unit 2 screenhouse extends 45 ft from shore. Therefore, the Unit 1 wedgewire screen system would extend approximately 118 to 129 ft into the River, based on the screen evaluated. The Unit 2 wedgewire screen system would extend approximately 143.5 to 165 ft into the River. When the river is 6 ft deep, the screens would only be 1.5 ft below the surface of the water. This would cause a significant impact on the recreational use of the River, as shown on sketch PSNH001-SK-008 in Attachment 2.

Maintenance

The same maintenance technique would be required for the narrow-slot wedgewire screens as the wide-slot wedgewire screens.

Frazil Ice

As the wedgewire slot size decreases, the effect of frazil ice increases. Therefore, based on the conclusions of the Army Corps of Engineers paper regarding frazil ice, as well as due to the large impact on the River due to the required number of wedgewire screens, narrow-slot wedgewire screens are infeasible for implementation at Merrimack Station

8.2.2 Fine Mesh Ristroph Screens

In addition to the fish handling provisions noted above, traveling water screens can be further modified to incorporate screen mesh with openings as small as 0.5 mm to collect fish eggs and larvae and return them to the source water body. For many species and early life stages, mesh sizes of 0.5 to 1.0 mm are required for effective screening. Various types of traveling screens, such as through flow, dual flow, and center flow screens, can be fitted with fine mesh screen material. Because entrainment is usually a seasonal occurrence, some fish baskets can be furnished with quick-change mesh inserts that can be customized for seasonal operating requirements. For example, an operator can replace the coarse mesh with a fine mesh during the breeding season to prevent the entrainment of eggs.

The primary concern with fine mesh screens is that they function by impinging early organism life stages that are entrained through coarse mesh screens. Depending on species and life stage, mortality from impingement can exceed entrainment mortality. In order for fine mesh screens to provide a meaningful benefit in protecting fish, impingement survival of target species and life stages must be substantially greater than survival through the circulating water system. In addition, at Merrimack Station in particular, in order to maintain existing head loss across the screen, the size of the intakes would need to be greatly expanded to accommodate fine mesh screens. This is due to the fact that much larger fine mesh screen would be required to provide the same total open area as the coarse mesh screens.

For all of these reasons, fine mesh screens are infeasible for implementation at Merrimack Station.

8.2.3 Aquatic Microfiltration Barriers

Aquatic microfiltration barrier systems are barriers that employ a filter fabric designed to allow for passage of water into a CWIS, but to exclude aquatic organisms. These systems are designed to be placed some distance from the CWIS within the source waterbody and to act as a filter for the water that enters into the cooling water system. These systems may be floating, flexible, or fixed. Since these systems generally have such a large surface area, the velocities that are maintained at the face of the permeable curtain are very low. One company, Gunderboom, Inc., has a patented full-water-depth filter curtain comprised of polyethylene or polypropylene fabric that is suspended by flotation billets at the surface of the water and anchored to the substrate below. The curtain fabric is manufactured as a matting of minute unwoven fibers with an apparent opening size of 20 microns. Gunderboom systems also employ an automated "air burst" system to periodically shake the material and pass air bubbles through the curtain system to clean it of sediment buildup and release any other material back into the water column.

Gunderboom and other microfiltration systems have sizing and physical limitations as well as the potential to interfere with or prevent other existing uses of the source waterbody. With a 20-micron mesh, 100,000 and 200,000 gallon per minute intakes would require filter systems 500 and 1,000 feet long (assuming 20 foot depth). At Merrimack Station, which has a total combined intake flow rate of approximately 200,000 gallons per minute, the source water body is only 6-10 feet deep. This source water body depth would require scaling what is usually a 20 ft tall curtain down to a 6 ft tall curtain, which in turn would compel an increase in the length of the curtain to be deployed to approximately 3,000 ft long. The space limitations that PSNH would encounter in attempting to install such a long curtain, and the impairment of other uses in the Merrimack River that would result if PSNH were able to install the curtain, preclude its successful deployment. Thus, Gunderboom and other microfiltration systems are infeasible for implementation at Merrimack Station.

8.2.4 Porous Dikes and Artificial Filter Beds

Porous dikes and artificial filter beds are filters resembling a breakwater that are installed surrounding a CWIS. They work on the idea that fish will not pass through physical barriers in front of an intake. In order to be effective, they must be large enough such that there is a low approach velocity. Due to the minimal length of the Merrimack Station intakes, installing a porous dike or artificial filter bed at either CWIS at the Station is not practical. Therefore, porous dikes and artificial filter beds are infeasible for implementation at Merrimack Station.

8.3 Behavioral Barriers

Behavioral barriers use a fish's natural reactions to stimuli to deflect it away from intakes. The three main behavioral barrier systems are bubble barriers, artificial lighting arrays, and underwater acoustic fish deterrence systems. Based on a recommendation from Fish Guidance Systems, Ltd. (FGS) a worldwide leader in the manufacture and installation of behavioral barriers, an underwater acoustic fish deterrence system was evaluated for implementation at Merrimack Station, on the grounds that such a system potentially could have the desired deflective effect on certain of the specific species of fish in Hooksett Pool of the Merrimack River. FGS's recommendation of an acoustic fish deterrence system is consistent with Normandeau's field testing of bubble systems, strobe light arrays, and acoustic fish deterrence systems. There are at least two installed and successful operating acoustic fish deterrence systems; one at the D.C. Cook Nuclear Plant in Bridgman, Michigan (Lake Michigan), and the other at the J.A. FitzPatrick Nuclear Power Plant near Oswego, New York (Lake Ontario). Both of these systems are designed to reduce the impingement of adult and juvenile alewives by keeping these fish away from the offshore intake structures at these plants. By deterring adult alewives, these systems may also contribute to reduced entrainment of alewives during the spring spawning season. Both systems are operated from April to October, and are removed and reinstalled each year to prevent ice damage to the projectors and cable system. Both systems operate at ultra sound frequencies (above 126 kHz). These ultra sound frequencies have been shown to have little effect on such Hooksett Pool resident species as yellow perch, smallmouth bass, and white perch.

To efficiently guide fish away from a CWIS, an acoustic fish deterrence system has an array of sound projectors that is typically installed along the face of the CWIS (i.e., screen house). The conical beam of each transducer must overlap each adjacent projector to provide a sound pressure level at a distance from the CWIS that is consistent and of a magnitude to elicit the desired avoidance behavior far enough away from the intake to prevent the fish from being entrained into the intake flow. Aiming the projectors outward along the face of the CWIS causes fish to experience a gradient of increasing sound pressure level as the fish moves closer to the intake, thus providing the necessary directional stimulus encouraging the fish to avoid the sound by swimming away from the intake.

The material provided by FGS suggests that their acoustic fish deterrence system could attain a level of effectiveness at Merrimack Station Unit 1 or Unit 2. However, the efficacy of the FGS system in deflecting the species of resident and migratory fish present in Hooksett Pool has not been tested, and FGS's claim is supported solely by interpolation from the test results for European fish species considered similar to those found in Hooksett Pool. The reaction of different fish species to sound, even among the clupeiforms (like alewife), is highly variable and species specific (Mann et al. 2001), providing a great deal of uncertainty to any interpolation of effectiveness from other fish species to those found in Hooksett Pool. Without upstream passage at Hooksett Dam, there is no access to Hooksett Pool by migratory clupeids in the Merrimack River other by trucking and stocking. Therefore, species with proven avoidance to installed acoustic fish deterrence systems are currently not present in any abundance in Hooksett Pool. If clupeids become abundant in the future, PSNH could test the effectiveness of an acoustic fish deterrence system installed at the CWIS of Unit 1 or Unit 2. However, at this time, there is unlikely to be a demonstrated benefit to installing such a system at Merrimack Station.

8.4 Alternative Intake Location

In addition to the above described technologies to reduce impingement and entrainment, EPA directed PSNH to evaluate the relocation of the existing intake structures. For purposes of this Report, this evaluation involved an assessment of the type and location of the intake relative to the water level and topography of the Merrimack River in the vicinity of Merrimack Station, the location of the plant discharge, navigational routes, recreational areas, ease of construction, and aesthetics. This evaluation also relied on biological field studies performed by Normandeau Associates on behalf of PSNH to provide insight into the most beneficial changes to the intake. Areas of high fish concentrations must be avoided when analyzing a modification to the intake location.

The source water body for Merrimack Station is Hooksett Pool. Hooksett Pool is a narrow stretch of the Merrimack River between Garvins Falls Dam and Hooksett Dam. It is approximately 10 feet deep. The source water body is fairly homogenous due to its controlled water supply, its narrow width, and its shallow depth. Biological studies have not shown any fish concentrations located near the intake. Therefore, relocating the intake at Merrimack Station would not significantly alter the quantity or species of impinged and entrained aquatic organisms.

8.5 Flow Reduction

This Report assumes, for purposes of performing the evaluation required by EPA, that impingement and entrainment abundance is directly proportional to CWIS flow, and that therefore, by reducing intake flow, impingement and entrainment can be reduced proportionally. It should be noted that the relationship between impingement and intake flow is probably not linear below a certain flow rate. This is because there is believed to be a threshold velocity below which most fish can swim fast enough to avoid being impinged by the weak intake flow. It is generally accepted that impingement is negligible when the maximum intake through-screen velocity is below 0.5 feet per second, providing the basis for EPA's conclusion for the Phase II Regulations that reducing through-screen velocity to 0.5 ft/s or less is equivalent to reducing impingement mortality by at least 80 to 95%. At Merrimack Station, however, the maximum intake through-screen velocity has not been measured, so discussions in this section do not assume any threshold effect on impingement at low flows.

Based on the average organism densities observed in two years of sampling at Merrimack Station (Reference 11.17), weekly impingement and entrainment estimates for each of the Station's two units indicate the approximate periods when flow reductions would provide the greatest reduction in entrainment and impingement (see Figures 1a and 1b below and data presented in Attachment 6). The period with the highest impingement estimates was the period of weeks 20-24 at Unit 1 (early May through mid-June) and weeks 23-26 (June) at Unit 2. The earlier peak impingement period for Unit 1 compared to Unit 2 could be an artifact of high week-to-week variability in observed impingement rates, rather than a consistent seasonal difference between the two units. The general pattern was a period of highest impingement at Merrimack Station occurring from early May through the end of June. Therefore, reductions in intake flow rate during early May through the end of June could be expected to provide a greater reduction in impingement than the same flow reductions at another time of year.

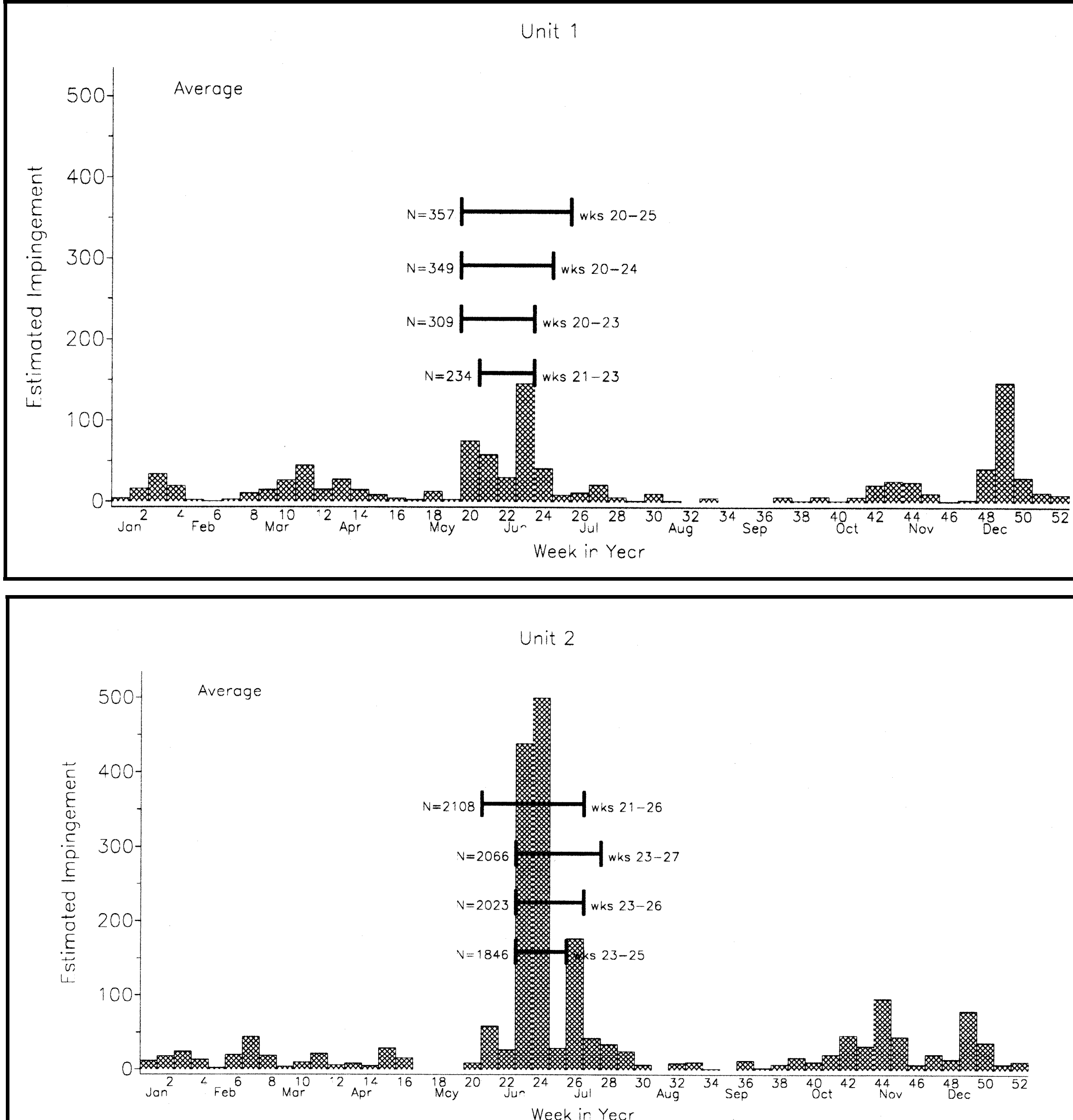


Figure 1a. **Weekly total impingement of fish at Units 1 and 2 of Merrimack Station based on average daily impingement estimates from late-June 2005 through late-June 2007. Brackets represent maximum estimated impingement for 3, 4, 5, and 6 consecutive weeks. Note week 52 represents last 8 days of a year.**

The highest entrainment estimates were also during May and June. Entrainment of eggs at Merrimack Station was inconsequential, with only about 2% as many eggs entrained as larvae. This is because eggs of the local freshwater fish species are demersal and adhesive (they sink and stick to the bottom), rather than being pelagic (drifting suspended in the water column where they would be vulnerable to entrainment). Entrainment estimates for larvae were highest for weeks 19-26 at Unit 1 (May and June) and weeks 22-26 (late May through the end of June) at Unit 2. Therefore reductions in intake flow rate during May and June should provide a greater reduction in entrainment than the same flow reduction at another time of year.

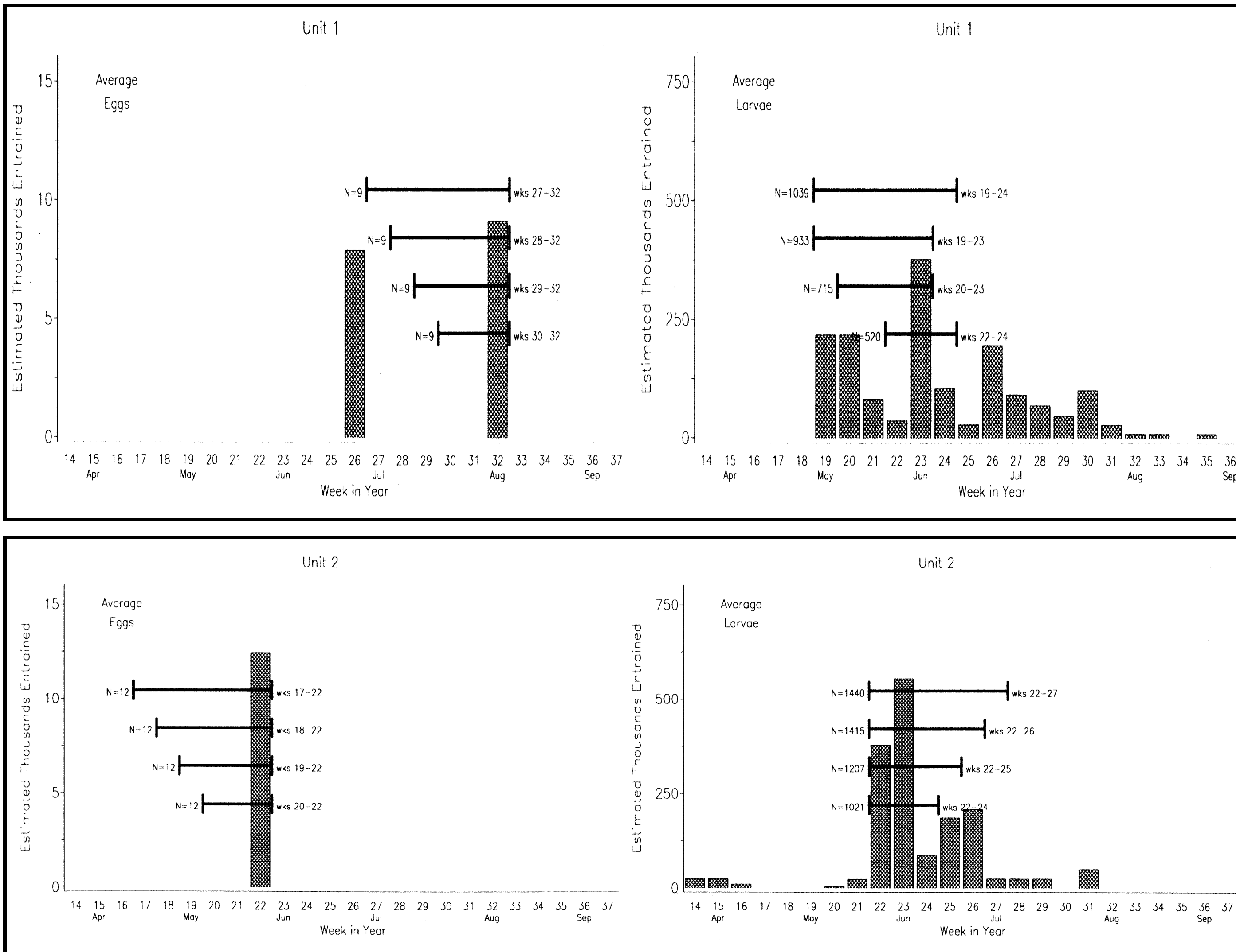


Figure 1b. Estimated weekly entrainment of fish eggs (left) and larvae* (right) at Unit 1 (top) and Unit 2 (bottom) from April through mid-September at Merrimack Generating Station. Brackets indicate maximum entrainment for periods of 3, 4, 5, and 6 consecutive weeks. * includes yolk-sac larvae, post-sac larvae, young-of-the-year, and unidentified.
Note: Larval entrainment is assumed to be zero or negligible during other months due to the absence of larval stages of local fish species.

Although providing appreciable biological benefits, the use of flow reductions during warm river water months would significantly impact Station operational efficiency. As previously noted, current Station operation utilizes one-speed pumps, which do not offer variable flow control beyond the removal from service of one of the two circulating water pumps in the unit to have its flow reduced. Due to this limited ability to restrict flow, additional factors associated with removing a pump from service (i.e., Station outage and/or extremely low river water temperature), and limited operational data (i.e., data provided is limited to July and August) empirical analysis of flow reduction is exceptionally difficult; however, each unit would experience a decrease in heat rejection much greater than that experienced under complete closed-loop conversion (see Section 6), with the result that the Station's performance would be unquestionably affected by flow reduction.

The potential for flow reduction via one Unit 2 circulating water pump operation during cold river water months and the associated biological benefits are subsequently discussed in Section 8.6.2.

8.5.1 Variable Speed Pumps

For this Report, PSNH evaluated adjusting intake flow by replacing the existing circulating water pump motors with new single-speed pump motors and variable frequency drives.

Maintenance

By reducing flow through the condenser, there is an increased probability of condenser tube fouling due to lower flow velocities. Therefore, the installation of a condenser cleaning system would be recommended with any flow reduction technologies.

Cost

Variable frequency drives can be very expensive for high voltage motors, but because Merrimack Station would utilize low voltage motors, incorporating variable frequency drives would add approximately 30% to the price of each single-speed motor. From Attachment 4, the total estimated capital cost for the replacement of the four circulating water pump motors (two 300HP, one 600HP, and one 700HP) and accompanying variable frequency drives is $1,341,300.

Biological Benefit

The biological benefit of replacing the existing single-speed circulating water pumps with variable speed pumps (VSPs) would depend on the amount of flow reduction that could be attained and the time of year. In warmer months, thermal discharge limitations contained in Merrimack Station's NPDES permit could limit the use of flow reduction as a means of reducing impingement or entrainment more than could any engineering limitations. Also, the benefits of VSPs would not be available at times of scheduled maintenance outages (discussed below in Section 8.6.1).

Attachment 6 presents tables evaluating the potential reduction in impingement and entrainment that would be attainable under various flow reduction scenarios for Merrimack Station. Separate tables are provided for impingement and for entrainment, for Unit 1 and for Unit 2, and for estimated losses and for adult equivalent losses, in increments of 5% reductions in flow. For example, a hypothetical 50% reduction in flow during December through March would result in an annual impingement reduction of 23% at Unit 1 and 5% at

Unit 2. There would not be any entrainment reduction because entrainment only occurs during spring and early summer. (This hypothetical example is provided merely to illustrate the utility of the Attachment 6 tables, and is not evaluated here as a potential IM&E reduction strategy for Merrimack Station.)

8.5.2 Two-Speed Pumps

By replacing the existing circulating water pump motors with two-speed motors, the flow could be reduced to 75% flow, 50% flow, and 25% flow. However, two speed motors for this application would cost approximately 70% higher than single speed motors. In addition, two speed motors provide less flow control flexibility than variable speed drives. For this reason, the use of two speed pumps was determined to be a less effective technology and operational measure for flow reduction at Merrimack Station than the use of variable speed drives, and were not evaluated further.

8.5.3 Throttling

PSNH also evaluated reducing circulating water flow by placing a throttling valve on the discharge of each of the circulating water pumps. Such throttling valves would have to be specifically designed for long-term throttling conditions, and not susceptible to cavitation or flow induced erosion. Since the circulating water discharge lines leaving the screenhouses are buried several feet beneath grade elevation, the valves would need to be placed in a valve pit or provided with remote/extended operators. A control system consisting of a flow element and the associated flow-control loop would be required for precise positioning of each of the valves.

Throttling valves and associated valve pits, operators, and automatic flow control systems are comparable in initial cost to a variable speed pump for application at Merrimack Station. However, throttling valves would provide less flow control flexibility and be more difficult and more expensive to maintain. For these reasons, throttling was determined to be a less effective technology and operational measure for flow reduction at Merrimack Station than the use of other flow reduction technologies and operational measures evaluated, and was not evaluated further.

8.6 Operational Changes

8.6.1 Timing of Maintenance Outages

During a maintenance outage at Merrimack Station, there is no flow entering the CWIS for whichever unit is in the outage. For Unit 1, maintenance outages occur every two years and last approximately four weeks. For Unit 2, maintenance outages occur every year and also last approximately four weeks. The outages are staggered so that both Units are not offline at the same time due to power pool demands. Since there is no flow, there is a 100% reduction in impingement and entrainment during outages. Relocating an outage to the period of highest impingement and entrainment would yield the greatest increase in mortality reduction.

Relocating unit maintenance outages to the seasonal periods of highest total impingement and entrainment (discussed in Section 8.5) would yield the greatest increase in estimated total annual impingement and entrainment reduction as compared to the other technologies and operational measures that PSNH has evaluated for this Report, other than conversion to closed-loop cooling. Based on four weeks as the length of a unit outage, the four consecutive weeks with the highest impingement estimates were weeks 20-23 at Unit 1 (early May-early June) and weeks 23-26 (June) at Unit 2. Based on that pattern and the assumption that only one unit would be in outage at a time, back-to-back outages of the two units during an eight-week period from early May through early July would provide the greatest reduction in impingement mortality.

The highest entrainment estimates were also observed during May and June. Entrainment of eggs at Merrimack Station was inconsequential, with many fewer eggs entrained than larvae. Based on four weeks as the length of a unit outage, entrainment estimates for larvae were highest for the consecutive four-week periods of weeks 20-23 at Unit 1 (early May-early June) and weeks 22-25 (late May-late June) at Unit 2. Assuming that only one unit would be in outage at a time, back-to-back outages of the two units during the eight-week period from the beginning of May through the end of June would provide the highest reduction in entrainment compared to any other time of year.

The theoretical optimal periods for maximizing impingement reductions (early May through early July) and entrainment reductions (the beginning of May through the end of June) are slightly different. Because of high natural mortality during the larval and early juvenile stages, the total impingement and entrainment estimates are not directly comparable. The relative impact of appropriately scheduled maintenance outages on impingement and entrainment reduction can, however, be compared using adult equivalent estimates (presented in Attachment 6). During May and June, equivalent adult estimates for entrainment are about 200 times the equivalent adult estimates for impingement. Therefore, the optimal period for reducing entrainment (the beginning of May through the end of June) is also the optimal period for minimizing the combined effect of impingement and entrainment. The overall optimal scenario would be a May Unit 1 outage and a June Unit 2 outage, under which impingement mortality could be reduced 10%, entrainment could be reduced 43%, and the combined impact of impingement and entrainment, estimated on the basis of equivalent adults could be reduced by approximately 42% compared to 100% operation (Attachment 6).

However, due to operational constraints and power pool demands, the latest that Merrimack Station could schedule the end of a spring outage is mid-June. Therefore, PSNH evaluated how most effectively to use a maintenance outage at the Station before mid-June to reduce impingement and entrainment. Unit 2 outages are more frequent than Unit 1 outages (occurring every year rather than every other year), and Unit 2 has a higher intake flow than Unit 1. As a result, the impingement and entrainment reduction potential for a Unit 2 maintenance outage generally is greater than the impingement and entrainment reduction potential for a Unit 1 maintenance outage, and could be maximized by scheduling Unit 2 outages to occur during the peak impingement and entrainment season of May-June. To evaluate the impingement and entrainment potential for Unit 2 maintenance outages, the outages were assumed to end on 15 June of each year. The average length of Unit 2 outages is 33.6 days (they last four weeks in four consecutive years and are eight weeks long every fifth year). Assuming that 18.6 days of the outages fall in May, on average, Unit 2 outages would have the potential to reduce estimated total annual impingement at Merrimack Station by 41% and estimated total annual entrainment by 40%.

Because spring outages are not scheduled any later than mid-June, and also because back-to-back outages are impractical, Unit 1 outages would not be able to take advantage of the May-June season of high impingement and entrainment. Therefore, Unit 1 outages were assumed to occur in the fall during alternate years. Duration is four weeks for two consecutive outages and eight weeks for the next one, for an average of 18.67 days per year. Assuming these outages to fall in October, the Unit 1 outages would have the potential to reduce impingement by 5%. There would be no entrainment reduction potential for October outages because entrainment is negligible at that time of year.

Cost

The cost of delaying a 33-day Unit 2 outage one month from mid-May through mid-June each year would cost approximately $127,000 annually. It must also be noted that the proposed outage shift is subject to ISO-NE approval.

Biological Benefit

Rescheduling Unit 2 outages would have the potential to reduce estimated total annual impingement at Merrimack Station by 51.1% and estimated total annual entrainment by 27.3% (annual reductions assume outage rescheduling in combination with an upgraded fish handling system).

8.6.2 One-pump Circulating Water Operation (Unit 2 Only)

One Unit 2 circulating water pump operates at approximately 70,000 gpm (100.8 MGD, 156 cfs), so one-pump operation reduces the Station total intake flow by 70,000 gpm. As discussed in Section 5.4.2, the Station currently operates with only one Unit 2 circulating water pump for a short period each winter for deicing purposes. This period of one-pump operation could be extended to last from December 15th through March 15th each year with minimal operational losses and significant biological benefits relative to impingement reduction.

Cost

One-pump circulating water operation for Unit 2 from December 15th through March 15th each year would cost approximately $75,000 annually. This cost would primarily be from the increased condenser tube fouling due to lower flow velocities, and the more frequently required condenser tube cleaning. There would also be some slight loss of operational efficiency, which is conservatively omitted from this cost assessment.

Biological Benefit

One-pump circulating water operation (Unit 2 only) from December 15th through March 15th each year would have the potential to reduce estimated total annual impingement at Merrimack Station by 53% with no corresponding reduction in entrainment (annual reductions assume one-pump circulating water operation in combination with an upgraded fish handling system).

9 Comparison of Alternatives Considered

9.1 Comparative Matrix

The following comparative matrix identifies the various technologies and operational measures that PSNH evaluated for CWA § 316(b) compliance enhancements at Merrimack Station as required by EPA in the § 308 Letter. The matrix provides the estimated total costs and biological (i.e., IM&E reduction) effectiveness of each technology and operational measure, and ranks the technologies and operational measures by their biological cost effectiveness.

Comparative Matrix of Technologies or Operational Measures Utilized for CWA 316b Compliance
(Note 1)

Technology or Operational Measure	Cost		Biological Effectiveness (% Reduction from Baseline)		Biological Cost Effectiveness Ranking (High/Med/Low)	Comments
	Initial	Annual	Impingement	Entrainment		
Cooling Towers						
1. Conversion to Closed Loop Cooling (Both Units)	$67,980,500	$6,505,800	95.0	96.1	Low	Annual costs = Op efficiency loss, parasitic loss, O&M, and water treatment. Will result in increased air emissions as discussed in Section 6.3.5.4.
2. Conversion to Closed Loop Cooling (Unit 1 Only)	$24,654,500	$1,220,500	84.6	68.6	Low	Annual costs = Op efficiency loss, parasitic loss, O&M, and water treatment. % Reductions are based on the Recommend BPJ options being effected to Unit 2. Will result in increased air emissions as discussed in Section 6.3.5.4.
3. Conversion to Closed Loop Cooling (Unit 2 Only)	$48,985,400	$5,353,000	74.9	70.6	Low	Annual costs = Op efficiency loss, parasitic loss, O&M, and water treatment. % Reductions are based on the Recommend BPJ options being effected to Unit 1. Will result in increased air emissions as discussed in Section 6.3.5.4.
Coarse Mesh Screening Technologies						
4. Ristroph thru-flow traveling screens w/ fish return	$1,357,700	Note 2	55.4	0.0	Medium	Annual costs= O&M costs.
5. Ristroph dual-flow traveling screens w/ fish return	Note 4	Note 4	NA	NA	NA	Annual costs= O&M costs.
6. MultiDisc® type screens w/ fish return	$2,270,800	Note 3	64.2	0.0	Medium	Annual costs= O&M costs.
7. "WIP" type screens w/ fish return	$2,065,300	Note 3	65.9	0.0	Medium	Annual costs= O&M costs.
8. Wedgewire screens	Note 4	Note 4	NA	NA	NA	Infeasible due to frazil ice and intrusiveness to river waterway
Fine Mesh Screening Technologies						
9. Wedgewire screens	Note 4	Note 4	NA	NA	NA	Infeasible due to frazil ice and intrusiveness to river waterway
Fish Return Systems						
10. Fish return system (w/ continuous operation of existing traveling screens for 9 months)	$335,100	$60,000	47.5	0.0	High	Assumes continuous traveling screen operation
Variable Speed Pumps						
11. New circulating water pump motors and VFDs	$1,341,300	Note 2	See Comments	See Comments	Low	Not feasible for U1, similar benefit can be attained on Unit 2 w/ 1 pump operation
12. Two-speed circulating water pump motors	$1,441,800	Note 2	See Comments	See Comments	Low	More costly than variable speed, and less flexible operating parameters
Deterrence Systems						
13. Acoustic Fish Deterrence System	$1,330,000	$70,000	Note 5	Note 5	Low	Annual costs= O&M costs
Operational Measures						
14. Timing of maintenance outages (Unit 2 only)	NA	$127,000	51.1	27.3	High	Note that the proposed outage shift is subject to ISO-NE approval
15. One-pump circulating water operation (Unit 2 only)	NA	$75,000	53.0	0.0	High	Based on December 15th through March 15th Unit 2 one-pump operation

Notes:
1. Only technologies or operational measures initially deemed feasible are listed in this matrix
2. Annual maintenance and/or operational cost not appreciably higher than existing component(s)
3. Annual maintenance and/or operational cost slightly lower than existing component(s) due to increased access to system components
4. Component(s) determined to be infeasible for implementation at Merrimack Station
5. Unlikely to be a demonstrated benefit

9.2 Best Technology Available for Minimizing AEI from Merrimack Station CWISs under CWA § 316(b)

The following discussion reviews the technologies and operational measures that PSNH evaluated, as required by EPA in the § 308 Letter, to determine the "best technology available" (BTA) for minimizing AEI from Merrimack Station's CWISs under CWA § 316(b). It then identifies the combination of technologies and operational measures that the engineering evaluation presented in this Report and the biological data from the Station's monitoring programs support as constituting BTA for the Station's CWISs under § 316(b).

Existing CWIS Technologies and Operational Measures (refer to Section 5)

Existing operational flow reductions at Merrimack Station occurring due to maintenance outages (Section 5.4.1), Unit 2 single pump operation (Section 5.4.2), and de-icing recirculation flow (Section 5.4.3) result in a combined annual flow reduction from a full flow baseline of 6.3% at Unit 1 and 9.0% at Unit 2. However, by far the greatest overall existing flow reductions for the Unit 1 and Unit 2 CWIS comes from the loss of intake pumping efficiency due to head loss from design full pond elevation as Hooksett Pool water levels change daily due to hydropower operation of the Garvins Falls (upstream) and Hooksett (downstream) hydroelectric stations. Head loss alone accounts for a 22.9% intake flow reduction for Unit 1 and a 14.5% intake flow reduction for Unit 2. When the actual operational flow reductions during the June 2005 through June 2007 entrainment and impingement studies are weighted by the monthly abundance of impingement and entrainment and compared to the design flows, an overall annual reduction of adult equivalent losses of 17% for entrainment and 22% for impingement is attributable to the Station's existing operational flow reductions.

Conversion to Closed Loop Cooling (refer to Sections 6 and 7)

Converting one or both units at Merrimack Station to closed-loop cooling would provide reductions in entrainment and impingement proportional to the River intake flow reduction attained by such a conversion. In particular, retrofitting closed-loop cooling at both units would be expected to reduce estimated total intake flow at the Station by approximately 95%, meaning that full conversion to closed-loop cooling could have the greatest degree of biological effectiveness (i.e., impingement and/or entrainment reduction impact) of any of the technologies or operational measures identified and evaluated in this Report.

However, the estimated costs of converting Merrimack Station to closed-loop cooling (including initial capital costs, ongoing annual operational and maintenance costs, and the costs associated with the resultant adverse electric system (i.e., ISO-NE) and air quality impacts of such a conversion) would be the highest, by a very significant margin, of all the technologies and operational measures evaluated. More importantly, because the overall number of fish (i.e., of all resident and migratory species observed in Hooksett Pool, at all life stages) impinged or entrained by the Station's CWISs is so extremely low, the costs of converting Merrimack Station to closed-loop cooling would be wholly disproportionate to any environmental benefits (i.e., reductions in impingement and entrainment) that might be gained by the conversion. In addition, and for the same reason, retrofitting closed-loop cooling at one or both units at the Station would not be cost-effective, because other technologies and operational measures evaluated in this Report would provide a qualitatively similar degree of protection from impingement and entrainment to these resident and migratory species, including the RIS populations, at a much lower total cost than the total cost of conversion to closed-loop cooling. Additionally, closed-loop operation of the Station would generate more stack emissions and material waste per net unit of electricity generated than the Station's current cooling water system.

Coarse Mesh Screening Technologies (refer to Section 8.1)

Replacement coarse mesh traveling screens with impingement reduction features, as well as other coarse mesh screening technologies, were found to provide incremental impingement reduction benefits over the existing traveling screens when evaluated based on continuous operation and coupled with an optimized fish return system. The best coarse mesh traveling screen evaluated, when operated continuously and coupled with an optimized fish return system, would result in a 55.4% reduction in impingement mortality.

Given the relatively slight improvement in impingement reduction that upgraded coarse mesh traveling screens would provide over the existing screens, this Report concludes that the total costs of their implementation at Merrimack Station would be wholly disproportionate to any environmental benefits that might be gained. In addition, this Report concludes that upgraded coarse mesh traveling screens would not be cost-effective, because other technologies and operational measures evaluated in this Report would provide a similar degree of protection from impingement and entrainment to all life stages of resident and migratory species in Hooksett Pool at a lower total cost than the total cost of upgraded coarse mesh traveling screens.

Fine Mesh Screening Technologies (refer to Section 8.2)

Fine mesh screening technologies were determined to be infeasible for Merrimack Station application due to the required significant increase in size over the current traveling screens. To accommodate fine mesh traveling screens the existing CWISs would have to be totally replaced with new, significantly larger intake structures.

Fish Return Systems (refer to Section 8.1)

The existing fish return system at Merrimack Station was found to be largely ineffective. Replacing the existing system with an optimized fish return system would provide significant improvements in impingement mortality. As stated previously, the estimated reduction in impingement mortality for the existing traveling screens when coupled with a new optimized fish return system is 47.5%.

The total costs associated with upgrading to an optimized fish return system are among the lowest for the technologies and operational measures evaluated in this Report, and the biological benefits of upgrading to such a system are comparatively significant. Therefore, this Report concludes that the total costs of replacing the existing fish return system with an optimized system would be at least proportionate to, if not less than, the environmental benefits that would be gained. In addition, this Report concludes that replacing the existing fish return system with an optimized system would be cost-effective, because an upgraded fish return system, in combination with certain operational measures (as discussed below), would provide a similar degree of protection from impingement and entrainment to the resident and migratory species in Hooksett Pool at a lower total cost than other technologies and operational measures evaluated in this Report.

Variable Speed Pumps (refer to Section 8.5)

Because of Unit 1 operating limitations, significant flow reductions could not be tolerated, even in winter months when the River water temperatures are low. Unit 2, however, could sustain appreciable flow reductions during periods when the River water temperatures are low. However, similar benefits to the flow reductions attained by variable speed pumps can be attained by operational measures. For this reason, this Report concludes that the total costs of replacing the existing circulating water pump motors with new single-speed pump motors and variable frequency drives would be wholly disproportionate to any environmental benefits that might be gained. In addition, this Report concludes that replacing the existing circulating water pump motors with new single-speed pump motors and variable frequency drives would not be cost-effective, because other technologies and operational measures evaluated in this Report would provide a similar degree of protection from impingement and entrainment to all life stages of resident and migratory species in Hooksett Pool at a lower total cost.

Deterrence Systems (refer to Section 8.3)

Based on this Report's conclusion that the potential biological effectiveness of an acoustic fish deterrence system on Merrimack River specific species is uncertain, this Report also concludes that at this time, without additional study, the total costs of installing an acoustic fish deterrence system at Merrimack Station must be considered wholly disproportionate to any environmental benefits that might be gained. In addition, this Report concludes that installing an acoustic fish deterrence system at the Station would not be cost-effective, because other technologies and operational measures evaluated in this Report would provide similar biological benefits at a lower initial and ongoing cost.

Operational Measures (refer to Section 8.6)

Several operational measures to reduce both entrainment and impingement mortality were evaluated for Merrimack Station. Each provides definite biological benefits and can be effected without major operational impacts or disproportionately high costs.

- Continuous operation of the Unit 1 and Unit 2 traveling screens from April through December with an optimized fish return system, which alone would provide an estimated associated Station impingement mortality reduction of 47.5%.
- One-pump reduced flow operation for Unit 2 from December 15th through March 15th in conjunction with an optimized fish return system, which in combination with an upgraded fish return system would provide an estimated associated impingement reduction of 53% for Merrimack Station.
- Scheduling of the Unit 2 maintenance outages in periods of high impingement and entrainment during early summer (ending on June 15th), which in combination with an upgraded fish return system would provide an estimated associated impingement

reduction of 51% and an estimated associated entrainment reduction of 27.3%, compared with design flow.

Best Technology Available for Minimizing AEI from Merrimack Station CWISs under CWA § 316(b)

Based on the engineering evaluation presented in this Report (as summarized in the comparative matrix provided in Section 9.1 and the preceding discussion) and the biological data from the Station's monitoring program, the following combination of technologies and operational measures constitutes BTA for Merrimack Station:

- Upgraded fish return systems for both Unit 1 and Unit 2
- Continuous operation of the Unit 1 and Unit 2 traveling screens from April through December.
- One-pump reduced flow operation for Unit 2 from December 15th through March15th.
- Scheduling of Unit 2 maintenance outages to coincide with periods of high impingement and entrainment during early summer (ending June 15th) at Unit 2.

The cumulative reductions in impingement and entrainment for each unit following implementation of these recommended improvements to Merrimack Station's existing CWIS technologies and operational measures, as compared to the Merrimack Station baseline, is as follows:

For Unit 1, estimated total annual entrainment reduction is 19%, and estimated total annual impingement reduction is 60%

For Unit 2, estimated total annual entrainment reduction is 51%, and estimated total annual impingement reduction is 72%

10 Evaluation of River Temperature Differential Reduction Technologies

As EPA directed in the § 308 Letter, this section evaluates the retrofitting of a mechanical draft cooling tower at Merrimack Station for use in a 'helper tower' or 'chiller' configuration to contribute to reducing thermal discharges. PSNH notes that data from biological and thermal studies performed at Merrimack Station over the past forty years demonstrate that the Station's thermal discharge into Hooksett Pool has not caused any prior appreciable harm to the BIP and will not cause appreciable harm to the BIP in the future assuming the continuation of Station operations at their current level. EPA directed in the § 308 Letter that PSNH identify and evaluate means by which Merrimack Station could attain and maintain a maximum ambient temperature differential of 5°F in Hooksett Pool (i.e., between Station N10, which is above the Station's thermal discharge point, and Station S4, which below that discharge point).

The requested evaluation is performed in the subsequent sections, however, the appropriateness of the downstream Station S4 sampling location must be questioned. Per Reference 11.15, "Monitoring Station S-4 (downstream from the cooling canal discharge) is frequently and variably stratified during the open water period and therefore is not consistently representative of in-river water temperatures experienced by the BIP in lower Hooksett Pool. Thermal stratification at Monitoring Station S-4 varies daily, and even within the day, as river flow changes due to upstream hydroelectric generation,

atmospheric heating and cooling of the surface water, and the Station's thermal discharge. Daytime stratification places the warmest portion of the Station's thermal discharge near the River surface where it receives additional heating from solar input (Normandeau 1996). Temperature monitoring during May-June and September-October of 1995 (Normandeau 1996) confirms the observed strong horizontal and vertical thermal stratification at Monitoring Station S-4.
However, since most of the fish in Hooksett Pool orient towards the river bottom habitat, the surface water temperatures observed at Monitoring Station S-4 do not measure the thermal conditions experienced by the Station's RIS (Normandeau 2007)."

10.1 Closed-Loop Cooling Assessment

EPA directed in the § 308 Letter that PSNH identify and evaluate means by which Merrimack Station could attain and maintain a maximum ambient temperature differential of 5°F in Hooksett Pool (i.e., between Station N10, which is above the Station's thermal discharge point, and Station S4, which below that discharge point). Therefore, this Report analyzes whether converting either Unit 1 or Unit 2 to closed-loop operation would facilitate the attainment of this specified maximum ambient temperature differential. Complete closed-loop conversion, as described in Section 6, would effectively eliminate all thermal discharge to the Merrimack River and is therefore assumed to represent a complete thermal reduction (i.e., river water temperature unaltered by Station operation). The following individual closed-loop unit conversion thermal analysis was conducted using Station operational data, meteorological records, and ambient river measurements in order to historically predict the occurrence interval in attainment of the evaluated temperature differential scenario.

10.1.1 Closed-Loop Conversion of Unit 1

If only Unit 1 were converted to closed-loop operation, the thermal discharge from Unit 2 would be rejected unaltered from current Station operation (discussed in detail in Section 3.4.3.1), but Unit 1's 48,000 gpm of discharge heated by operation at 120 MWe would be recirculated and thus not discharged to the Merrimack River. Under this scenario, the ambient river water temperature at Station S0 would be calculated as a function of the electrical output of Unit 2, Station N10 river water temperature, and dry bulb temperature. In turn, the Station S4 river water temperature would be calculated as a function of Station S0 river water temperature, Station N10 river water temperature, dry bulb temperature, and river water flow rate. The resulting relationship between ambient environmental and operational conditions and the resulting Station S4 river water temperature would be determined primarily by river water flow rate, whereby a low flow condition would effectively create a stagnant heat reservoir in which the Station's thermal discharge would be the principal temperature driver.

For this Report, the defining operational condition (Unit 1 closed-loop, Unit 2 full power) was input over five years of meteorological data and river water temperatures for comparison against 21 years of daily average measured river flow rate values. The resulting analysis yields a bounding percentage of hours in which the 5°F Station N10-Station S4 temperature differential could be attained (i.e., the percentage of time when the 21-year daily minimum flow rate attains the 5°F temperature differential).

Merrimack Station Current PSM and Discharge Canal Performance
Unit 1 Closed-Loop - Unit 2 Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours Attaining 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	8.4%	N/A[2]	N/A[2]	N/A[2]	100.0%	35.0%
April	44.9%	15.3%	56.3%	63.3%	80.4%	56.3%
May	16.1%	18.3%	40.4%	19.5%	31.5%	25.1%
June	2.7%	0.0%	0.0%	2.7%	3.3%	1.7%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
November	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
December	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%	0.0%
Measured Attainment[3]	8.8%	3.4%	10.9%	9.7%	14.0%	9.5%
Annual Attainment[4]	44.5%	43.1%	46.0%	40.9%	38.7%	42.6%

[1]River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3]Measured attainment calculated by dividing the average hours meeting the evaluated scenario by the number of hours with recorded data

[4]Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario

As shown in the table above, the greatest percentage of hours in which the 5°F Station N10-Station S4 temperature differential could be attained occurs from March through May; however, even in these months there is significant percentage of historical occurrences beyond the evaluated temperature differential. Overall, conversion of Unit 1 to closed-loop operation would not greatly impact the Station's current thermal discharge performance.

10.1.2 Closed-Loop Conversion of Unit 2

Similar to the analysis conducted on Unit 1, conversion of Unit 2 to closed-loop operation would allow the thermal discharge from Unit 1 to remain unaltered from current Station operation (discussed in detail in Section 3.4.3.1), while closed-loop conversion of Unit 2 would remove 130,000 gpm of discharge heated by operation at 350 MWe from the Merrimack River. Likewise, under this scenario, the Station S4 river water temperature would be calculated as a function of the electrical output of Unit 1, Station N10 river water temperature, dry bulb temperature, and river water flow rate.

For this Report, the resulting operational condition (Unit 1 full power, Unit 2 closed-loop) was input over five years of meteorological data and river water temperatures for comparison against 21 years of daily average measured river flow rate values. The resulting analysis yields a bounding percentage of hours in which the 5°F Station N10-Station S4 temperature differential could be attained.

Merrimack Station Current PSM and Discharge Canal Performance
Unit 1 Full Power - Unit 2 Closed-Loop

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours Attaining 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	95.6%	96.9%	96.1%	96.0%	93.5%	95.6%
September	96.6%	96.7%	96.8%	96.7%	96.7%	96.7%
October	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Attainment[3]	98.9%	99.1%	99.0%	99.0%	98.8%	99.0%
Annual Attainment[4]	99.3%	99.5%	99.4%	99.4%	99.2%	99.4%

[1]River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3]Measured attainment calculated by dividing the average hours meeting the evaluated scenario by the number of hours with recorded data

[4]Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario

Unlike the thermal performance attributable to Unit 1 closed-loop conversion, modification of Unit 2 to closed-loop operation would result in nearly complete attainment of the 5°F Station N10-Station S4 temperature differential. Extremely rare conditions occurring in August and September would result in minor occurrences outside this temperature differential; however, these conditions would be unlikely to occur with any frequency. With respect to attaining the 5°F Station N10-Station S4 temperature differential, conversion of Unit 2 to closed-loop operation represents an alternative that would attain similar results as the conversion of both units.

10.2 Thermal Discharge Cooling Tower

10.2.1 Conceptual Design

While converting a power plant designed to operate with a once-through cooling system to closed-loop cooling is largely unprecedented, the use of cooling towers to reduce the thermal loading in a plant's discharge is commonplace. Since a cooling tower is used only to cool the discharge, the impact on the rest of the Station is minimized, and the complexity of the installation is greatly reduced.

In the § 308 Letter, EPA directed PSNH to evaluate the use of cooling towers to reduce Merrimack Station's thermal discharge to Hooksett Pool. The optimum cooling tower design for cooling the discharge canal flow to attain the 5°F Station N10-Station S4 temperature differential is considerably different from that for a cooling tower designed to accommodate conversion of the Station to closed-cycle cooling. Whereas a cooling tower designed to support conversion to closed-cycle cooling would have to have a very close approach to wet bulb, to minimize Station operational impacts, one designed for cooling of the discharge flow would only have to cool the discharge flow as required to attain the specified downstream river mix temperatures.

Extensive local meteorological data, river flow data, and Station operational data were reviewed to determine the appropriate design conditions for a discharge canal cooling tower capable of maintaining the temperature differential scenario to be attained, i.e., a maximum upstream to downstream temperature differential of 5°F, as measured at the upstream Station N10 and downstream Station S4 sampling locations. The initial river flow, cooling tower flow, and cooling load requirements were provided to SPX Cooling Technologies for selection of the optimum tower for the Merrimack Station application.

The tower originally evaluated by SPX was an 8-cell, back-to-back configuration FRP cooling tower with an ~ 13°F approach to wet bulb (Attachment 1, pages 7-18). The evaluated tower utilized a relatively high efficiency film fill. The capacity of the tower would be adequate for cooling load conditions for > 90% of the conditions evaluated based on the previous five years of data. However, for extreme low river flow conditions, the evaluated 8-cell tower could not handle the associated cooling load. For this reason, the tower ultimately evaluated for the Merrimack Station application was a 10-cell tower, more capable of attaining the EPA-specified 5°F Station N10-Station S4 temperature differential even at low river flow conditions.

Additionally, the configuration of the tower evaluated by SPX was changed to a linear FRP configuration, to support the addition of plume abatement and noise abatement. Because of the proximity of Merrimack Station to residential areas and public roads, both plume and noise abatement are required. Due to potentially heavy silt water conditions at Merrimack Station, the SPX evaluated fill was also changed to one capable of handling high silt loads without fouling. In summation, the discharge canal cooling tower evaluated for Merrimack Station is the following:

- 10-cell FRP linear configuration
- 13°F approach to wet bulb
- ~178,000 gpm flow capacity (U1 & U2 combined)

- Plume abated
- Noise abated
- Low-clog film fill (SPX AAFNCS, "Cleanflow")

The site layout for the discharge canal cooling tower, in the configuration noted above, is provided in Attachment 2, Sketch PSNH001-SK-005. Three of the ten cells are dedicated for Unit 1, and the remaining seven cells are dedicated for Unit 2.

10.2.1.1 Major Components

Pumping Station

Similar to the closed-loop conversion configuration, a cooling tower on the discharge canal would require a booster pumping station. Whereas the existing once-through configuration requires only enough pumping head (pressure) to overcome flow losses in passing water from the River through the condenser and returning to the River, a discharge canal cooling tower would require increased pump head to pump the circulating water up to the elevated cooling tower spray headers, and overcome the significant internal flow losses of the cooling tower. The new booster pumps would be expected to be required to produce approximately 36-38 feet of head. Single speed/flow rate pumps would be adequate and appropriate for this configuration. Attachment 1, Section 2, contains reference information on the evaluated new pumps (which are the same pumps that would be required for the closed-loop conversion).

The discharge canal cooling towers and the booster pumps would represent additional electrical loads. Preliminary data for the cooling tower indicates that (10) 200 HP fans would be in-service. A new substation, fed directly from the switchyard, would be required to supply electrical power to the tower and the new booster pumping station. The new booster pumps would require an estimated 360 HP each (single speed) for Unit 1, and 1469 HP each (single speed) for Unit 2.

Primary Circulating Water Pipe

As noted above, a new 'booster' pumping station would be required on the discharge side of the condenser to increase the circulating water system pumping head adequately for it to rise up to and pass through the cooling tower. This would require new runs of circulating water piping from the booster pumping station, located where the current discharge piping enters the cooling canal, to the cooling tower located on the island south of the Station, and then gravity flowing from the tower basins into the discharge canal via spargers that would encourage mixing within the discharge canal.

The Unit 1 cooling tower supply would be ~54 inch diameter, AWWA specification, concrete-lined steel piping, and the Unit 2 cooling tower supply piping would be ~84 in. diameter AWWA specification, concrete-lined steel piping. These piping runs would be manifolded at the tower to supply each tower cell individually.

10.2.1.2 Site Layout for Conversion

Refer to Attachment 2, Sketch PSNH001-SK-005, for a simplified site layout of the evaluated 10-cell discharge canal cooling tower configuration.

Cooling Tower Location(s)

Refer to Attachment 2, Sketch PSNH001-SK-005, for a simplified site layout of the evaluated 10-cell discharge canal cooling tower configuration.

Cooling Tower Location(s)

The location for the Merrimack Station discharge canal cooling tower would be south of the Station on the island created by the discharge canal. This location would provide the necessary space and be relatively close to the Station, minimizing the required length of circulating water piping and associated pumping losses, and would require minimal earthwork to be suitable for the tower erection. The proximity of the island to the discharge canal would ensure that a minimal length of discharge piping to the canal spargers would be required.

Associated electrical power supply modifications are shown on Sketch PSNH001-SK-001. As with the cooling tower required for conversion to closed-loop cooling, a dedicated substation would be required for the discharge canal tower. A pre-fabricated metal building, Attachment 2, Sketches PSNH001-SK-002 through -004, would be required to house the substation transformers, switchgear, and tower control system. The substation for the tower would have to be located as close as practical to the tower to reduce cable runs from the substation to the tower.

Pumping Station Location

The new booster pumphouse would be located where the circulating water piping discharges to the cooling canal as shown on Attachment 2, Sketch PSNH001-SK-005. The booster pumps in the new pumphouse would supply circulating water to the new towers via 54 inch diameter, AWWA specification, concrete-lined steel pipes for Unit 1, and 84 inch diameter, AWWA specification, concrete-lined steel pipes for Unit 2. As discussed in Section 10.2.1.1, the tower outflow would go to the discharge canal via spargers with the necessary static head achieved from the elevation of the cooling tower basin.

Primary Circulating Water Pipe Routing

As with the closed-cooling configuration, the large bore AWWA piping to the discharge canal cooling tower would be routed from the booster pumping station along the east side of the discharge canal to where the existing roadway crosses to the island. The circulating water discharge piping from the Station would cross the canal along the roadway built-up area, and then run north-south to supply the manifolds feeding the individual tower cells.

The circulating water return (cold-water) piping from the cooling tower basin would discharge via spargers into the discharge canal. Refer to Attachment 2, Sketch PSNH001-SK-005, for the evaluated circulating water piping layout.

10.2.1.3 Operational Features and Schemes

To minimize the parasitic losses associated with a discharge canal cooling tower, an automated control system would be required. For the Merrimack Station application, the tower would likely operate at maximum capacity (all fans running) during maximum load conditions, i.e., high ambient temperatures and low river flows, to attain discharge canal water temperatures required to maintain downstream River temperatures within the evaluated temperature differential scenario.

However, the need to operate all the tower cell fans during low load conditions would be totally dependent on ambient and river flow conditions. A programmable logic control (PLC) system would be utilized to reduce tower operating cost (parasitic losses) to a minimum via shutdown of fans on unneeded tower cells, while maintaining discharge canal water temperatures as near as possible to that required to achieve downstream River temperatures within the evaluated temperature differential scenario.

10.2.2 Evaluated Thermal Discharge Temperature Differential Impacts

Similar to the thermal discharge analysis required for the single unit closed-loop conversion, it is necessary to calculate the expected percentage of hours a thermal discharge cooling tower could attain the 5°F Station N10 - Station S4 temperature differential. Unlike the previous single unit conversion analysis, empirical functions modeling Station performance based on operational and environmental conditions must be enhanced to include the cooling tower performance over the entire range of conditions and exclude the cooling performance attributable to PSM operation. Additionally, thermal discharge towers of varying sizes must be compared to ensure the appropriate tower design is chosen for the Station's specific conditions.

As previously noted, cooling tower performance is measured by its approach to wet-bulb temperature; however, this approach to wet bulb is not constant throughout all environmental and operational conditions. Expected cooling tower operational values were provided by SPX Cooling Technologies and used to model the performance of both 10-cell and 14-cell cooling towers. Furthermore, as circulating water discharge temperature is strongly correlated with Station N10 river water temperature when the Station is at full power, PSM system operation was excluded by inputting circulating water discharge temperature into the thermal discharge tower model and conservatively assuming that the cooling tower discharge temperature was equal to Station S0 river water temperature.

10.2.2.1 10-Cell Thermal Discharge Cooling Tower Assessment

As described above, analysis of the 10-cell thermal discharge cooling tower utilized Station N10 river water temperature, Station electrical output, and SPX provided cooling tower performance to calculate the Station S0 river water temperature. In turn, the Station S4 river water temperature was calculated as a function of Station S0 river water temperature, Station N10 river water temperature, dry bulb temperature, and river water flow rate. Similar to the single unit closed-loop conversion assessment, the resulting relationship between ambient environmental and operational conditions and the resulting Station S4 river water temperature was determined primarily by river water flow rate. As such, five years of meteorological data and river water temperatures were compared against 21 years of daily average measured river flow rate values to yield a bounding percentage of hours in which the 5°F Station N10-Station S4 temperature differential could be attained with implementation of a 10-cell thermal discharge cooling tower.

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours Attaining 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	80.9%	91.5%	95.8%	79.5%	75.8%	84.7%
July	57.8%	87.5%	61.6%	70.6%	46.0%	64.7%
August	65.5%	35.1%	43.8%	61.3%	52.8%	51.7%
September	22.7%	20.3%	22.5%	27.2%	26.8%	23.9%
October	34.3%	23.9%	31.6%	35.5%	32.4%	31.5%
November	55.7%	62.0%	77.1%	60.4%	61.3%	63.3%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	93.1%	93.4%
Measured Attainment[3]	66.2%	61.9%	64.1%	66.4%	63.8%	64.5%
Annual Attainment[4]	79.4%	77.6%	78.2%	78.0%	74.2%	77.5%

[1]River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3]Measured attainment calculated by dividing the average hours meeting the evaluated scenario by the number of hours with recorded data

[4]Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario

Comparison of the 10-cell thermal discharge cooling tower (tabulated above) and the current Station performance utilizing PSMs (see Section 3.4.3.1) demonstrates the increased thermal discharge performance (i.e., decrease in Station N10-Station S4 temperature differential) with implementation of a 10-cell thermal discharge cooling tower; however, even with a 10-cell thermal discharge cooling tower in operation there is a risk of exceeding the 5°F Station N10-Station S4temperature differential from July through November.

Note: Since the above tabulation is based on the bounding historical daily flow rates, the % attainment of the 5°F Station N10-Station S4 temperature differential is very conservative, i.e., each day of the month is considered to be at the lowest historical river flow rate. For typical historical daily flow rates, the % attainment would be appreciably higher and would more accurately represent the tower's anticipated performance in attaining the 5°F Station N10-Station S4 temperature differential, as demonstrated in Section 10.2.2.4.

10.2.2.2 14-Cell Thermal Discharge Cooling Tower Assessment

A nearly identical analysis was conducted for the 14-cell thermal discharge cooling tower as was used to calculate the 10-cell thermal discharge cooling tower performance, with the only difference in analysis being the variance in the cooling tower model to account for the increased number of cooling tower cells. The table below lists the bounding percentage of hours in which the 5°F Station N10-Station S4 temperature differential could be attained with implementation of a 14-cell thermal discharge cooling tower.

Merrimack Station 14-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours Attaining 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	95.2%	98.7%	100.0%	95.7%	94.9%	96.9%
July	91.7%	100.0%	97.4%	98.7%	96.5%	96.9%
August	94.5%	78.7%	90.9%	93.5%	93.4%	90.2%
September	71.7%	64.4%	73.3%	78.6%	73.8%	72.4%
October	68.1%	60.2%	77.0%	67.8%	74.2%	69.5%
November	100.0%	88.8%	98.4%	86.8%	87.9%	90.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	97.7%	97.8%
Measured Attainment[3]	89.2%	85.0%	91.3%	90.1%	90.6%	89.3%
Annual Attainment[4]	93.4%	91.2%	94.7%	93.5%	93.3%	93.2%

[1]River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3]Measured attainment calculated by dividing the average hours meeting the evaluated scenario by the number of hours with recorded data

[4]Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario

As shown above, there would be increased thermal performance by adding additional tower cells, however, some occurrences beyond the evaluated temperature differential scenario in September and October remain. Overall, increasing the size of the thermal discharge cooling tower would improve thermal performance, however, the increase in performance does not affect the conclusion that a significant percentage of time the Station would exceed the 5°F Station N10 – Station S4 temperature differential. Furthermore, as the tower size is increased there is notable diminishing return of thermal performance (i.e., as the total number of cells are increased, the performance improvement for each additional cell decreases).

Note: Since the above tabulation is based on the bounding historical daily flow rates, the % attainment of the 5°F Station N10-Station S4 temperature differential is very conservative, i.e., each day of the month is considered to be at the lowest historical river flow rate. For typical historical daily flow rates, the % attainment would be appreciably higher and would more accurately represent the tower's anticipated performance in attaining the 5°F Station N10-Station S4 temperature differential, as demonstrated in Section 10.2.2.4.

10.2.2.3 Thermal Discharge Cooling Tower Theoretical Limit

Like all wet cooling towers, the thermal discharge cooling tower is limited to a theoretical 5°F approach to wet bulb. To demonstrate both the diminishing return of adding cells to the thermal discharge tower and the controlling effect river water flow rate would have on the thermal performance, the number of hours in which the 5°F Station N10-Station S4 temperature differential could be attained utilizing the theoretical cooling tower limit at bounding daily river flow rate conditions (i.e., the minimum daily average flow rate recorded over 21 years) is tabulated below.

Merrimack Station Theoretical Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours Attaining ΔT at Theoretical 5°F Wet-Bulb Approach					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	99.3%	100.0%	100.0%	100.0%	100.0%	99.8%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	98.7%	99.9%	100.0%	99.6%	99.7%	99.6%
July	99.9%	100.0%	100.0%	100.0%	100.0%	100.0%
August	100.0%	97.4%	100.0%	100.0%	99.9%	99.5%
September	99.0%	98.8%	99.2%	99.2%	99.4%	99.1%
October	96.8%	92.3%	99.3%	99.3%	96.6%	96.9%
November	100.0%	97.5%	100.0%	96.5%	96.1%	97.3%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Attainment[3]	99.1%	98.1%	99.8%	99.3%	99.0%	99.1%
Annual Attainment[4]	99.5%	98.9%	99.9%	99.6%	99.3%	99.4%

[1]*River flow rate conditions based on 21 years of recorded daily averages (1984-2004)*

[2]*N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

[3]*Measured attainment calculated by dividing the average hours meeting evaluated scenario by the number of hours with recorded data*

[4]*Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario*

Clearly, designing to meet the absolute minimum flow conditions is not only difficult but theoretically impossible. Likewise, increasing the thermal discharge cooling tower size would not ensure complete attainment with the evaluated temperature differential scenario under all recorded flow conditions. In general, it is important to define the point at which the diminishing return of the increased cooling tower size would preclude implementation. Per the analysis above, a 10-cell thermal discharge cooling tower would provide notably improved thermal performance even though not designed for the absolute coincidental environmental and operational conditions.

10.2.2.4 10-Cell Thermal Discharge Cooling Tower Analysis Based on Historical Daily Conditions

Analysis of the 10-cell thermal discharge cooling tower was limited to bounding river flow rate conditions in order to define the tower's operational design; however, to provide a daily performance estimate the 10-cell thermal discharge cooling was also analyzed over measured coincident river water flow rates and ambient river water and meteorological temperatures. The table below provides the number of historical hours in which the 5°F Station N10-Station S4 temperature differential could be attained utilizing a 10-cell thermal discharge cooling tower.

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	**Percentage of Hours Attaining 5°F Temp. Differential Scenario**			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	100.0%	N/A[1]	N/A[1]	100.0%
April	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%
July	98.1%	100.0%	100.0%	99.4%
August	90.7%	100.0%	99.7%	96.8%
September	41.0%	100.0%	100.0%	80.4%
October	61.8%	100.0%	100.0%	87.2%
November	72.5%	100.0%	100.0%	96.2%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Attainment[2]	84.5%	100.0%	100.0%	94.7%
Annual Attainment[3]	90.6%	100.0%	100.0%	96.8%

[1]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions
[2]Measured attainment calculated by dividing the average hours meeting evaluated scenario by the number of hours with recorded data

[3]Annual attainment calculated assuming all N/A values are within 5°F temp differential scenario

The values tabulated above, in conjunction with the theoretical thermal discharge cooling tower values provided in Section 10.2.2.3, provide adequate basis to conclude that a 10-cell thermal discharge cooling tower would provide notably improved thermal performance over daily historical conditions while not attempting to design for the absolute coincidental environmental and operational conditions.

10.2.3 Economic Estimates

10.2.3.1 Initial Capital Costs

The capital cost assessment for the design, procurement, and implementation of a discharge canal cooling tower, and all the associated required Station changes including the PLC control system, booster pumping station, electrical substation, intake and discharge piping and spargers, would be performed in the same manner described for closed-loop conversion in Section 6.2.1.

Minimizing assumptions, and relying instead on well-developed, detailed conceptual designs, greatly increases the accuracy of the ensuing estimates. Attachment 2 to this Report includes some of the conceptual drawings utilized for subsequent construction estimates. The resulting Direct Capital Cost Estimate and Project Schedule represent well thought out approaches with a reasonable level of detail in order to generate an accurate capital cost assessment.

The estimating basis relied less on theoretical national production rates and cost factoring and focused more directly toward soliciting the various assets capable of providing real world solutions. Vendors were contacted for quotations on the major equipment and material components, while established construction cost estimating tools were utilized in developing the labor, equipment, and scheduling requirements.

- RS Means (Factored Construction Cost Data)

  The Means catalogue is one of the nation's most respected guidelines for estimating construction related cost of building. When other resources were unclear or not available, Enercon used the typical factored cost per commodity for the portion of work.

- Construction Industry Institute (CII)

  CII focuses on the industrial construction and maintenance contracting industry as a trade organization devoted to continuous improvement of the means and methods used in construction. Their ideas related to the minimization of field required labor through modularization and prefabrication were considered as we built our construction strategies and cost estimates were prepared.

- Engineering News Record (ENR)

  Construction Cost Index, Building Cost Index, Materials Cost Index, which are updated monthly, provided some trending analysis with regard to the industry in general.

Attachment 1 to this Report includes vendor data and budgetary cost estimates for major equipment components. Few allowances were applied and only when time did not permit further task development or reasonable vendor contact and quotation.

Attachment 4 to this Report provides the detailed capital cost assessment for the modification of Merrimack Station to include a discharge canal cooling tower.

From Attachment 4, the total estimated capital cost for the modification of Merrimack Station to include a discharge canal cooling tower is $31,973,100.

10.2.3.2 Costs Due to New Condenser Operating Parameters

The addition of a discharge canal cooling tower would have no effect on the condenser operating parameters, as the Station intake and intake water temperatures would remain unchanged by the addition of the discharge canal cooling tower.

10.2.3.3 Parasitic Losses (Costs) Attributable to New Components

As with the conversion to closed loop cooling, an estimate of fan and pump horsepower requirements for the evaluated cooling towers and new circulating water pumphouses was developed in order to estimate total Station parasitic losses due to the modification of Merrimack Station to include a discharge canal cooling tower.

The existing circulating water pumps and the new circulating water booster pumps would be a constant load; i.e., there would be no operational variations in power consumption, all pumps for each unit would operate at full capacity at all times. To calculate the total circulating water pump load due to the modification of Merrimack Station to include a discharge canal cooling tower, the power requirements of the existing pumps are simply added to that of the additional booster pumps required for the new configuration.

Unit	Parasitic Electrical Load, Circ Water Pumps	
	Existing Circ Water Pumps	Additional Booster Pumps
1	0.42 MW	0.96 MW
2	1.46 MW	3.65 MW

Likewise the cooling tower fans would be a constant load; i.e., there would be no operational variations in power consumption, all fans for each unit would operate at full capacity at all times. This load would represent a corresponding new parasitic loss to the output of each Unit.

Tower Usage $_{\text{Each Tower}}$ = fan MW

Merrimack Station U1 Usage (MW) = (3) 200 HP fans = 0.45 MW

Merrimack Station U2 Usage (MW) = (7) 200 HP fans = 1.04 MW

Merrimack Station Unit 1 = 0.96 MW $_{\text{New Circ. Water Pumps}}$ + 0.45 MW $_{\text{Tower Fans}}$

Merrimack Station Unit 2 = 3.65 MW $_{\text{New Circ. Water Pumps}}$ +1.04 MW $_{\text{Tower Fans}}$

Based on the estimated power requirements of the new circulating water booster pumps and the cooling tower fans, the estimated total average parasitic losses due to the addition of a discharge canal cooling tower is as follows:

Merrimack Station Unit 1 = 1.41 MW_{Loss}

Merrimack Station Unit 2 = 4.69 MW_{Loss}

The corresponding annual cost for the two-unit Station associated with this power loss is $3,847,400 Note: Based on market power value of $72 MW

10.2.3.4 Lost Generating Capacity During Implementation

Unlike the conversion of the Station to once-through cooling, the addition of a discharge canal cooling tower could be implemented with very minimal disruption to Station operation. There would be no changes to the Station intake required, and only the tie-in of the piping to the booster pumping station would be required on the Station discharge side. Electrical tie-ins from Station transformers to supply the cooling tower/booster pumping station electrical substation would also likely require an outage.

Merrimack Station currently has the following maintenance outage schedule:

- Unit 1; 4 wk outage every two years
- Unit 2; 4 wk outage every year

As long as the above described tie-ins of the piping to the booster pumping station and the electrical substation to Station transformers could be accommodated during a scheduled maintenance outage, additional Station down time would not be required to implement the discharge canal cooling tower.

Hence, at the conceptual design stage, there is no identified or assumed loss of generating capacity due to the installation of a discharge canal cooling tower and the associated auxiliary components and subsystems.

10.2.3.5 Operational and Maintenance (O&M) Cost

The O&M costs associated with the addition of a discharge canal cooling tower can be approximated by the same methodology utilized to estimate these costs associated with the conversion of the Station to closed-loop cooling in Section 6.2.5.

The booster pumping station would be essentially the same for either the closed-loop conversion or the addition of the discharge canal cooling tower. Hence, the associated estimated O&M costs would be the same.

The discharge canal cooling tower would be smaller, i.e., would have fewer cells and operating components, than that required for closed-loop conversion, so the associated O&M costs can be estimated simply by scaling down the cost from the closed-loop tower estimate. The scaling factor would be approximately 10/14, based on the 10-cell discharge canal cooling tower versus the 14 cell closed-loop tower. Essentially, the O&M costs for the discharge canal cooling tower would be the same as estimated for the same-size Unit 2 only closed-loop conversion tower in Section 6.2.5.

Summary of Additional O&M Annual Cost:

Years 1-5, (combined \$) x (10/14) x (1.30) = \$209,400

Years 6-15, (combined \$) x (10/14) x (1.30) = \$302,300

Years 16-30, (combined \$) x (10/14) x (1.30) = \$580,800

10.2.3.6 Water Treatment Costs

When a plant is designed for closed-loop cooling via the use of cooling towers, it is cost effective to impose a high level of water treatment to ensure high quality water is supplied to the towers. This allows cooling tower designers to utilize a higher-efficiency film-fill without fear of fill-fouling. Using a higher efficiency fill allows a smaller tower size and appreciably lower associated initial cooling tower capital cost as well as lower cooling tower operating cost.

Section 6.2.6 details both the required water treatment associated with cooling towers operating in a closed-loop configuration, and the associated cost increases from the existing level of water treatment.

However, when a cooling tower is added to a plant discharge canal, little can be done to improve water chemistry. Since Merrimack Station's canal discharges the full Station cooling effluent flow directly to the River, it is assumed that high concentrations of chemicals would not be allowed by the NPDES permit. Therefore, it is further assumed that the current level of water treatment, consisting basically of a low-level of biocide injection, would be maintained.

Cooling tower designers typically account for the lower water quality of discharge canal water by utilizing less-efficient low-clog film-fills. The discharge canal cooling tower evaluated for Merrimack Station would have film-fill that would be able to accommodate a moderate level of biological contaminants, as well as passing appreciable quantities of silt without fouling or suffering a significant loss of efficiency. This would make the tower somewhat larger and less efficient than if it were provided with higher-efficiency fill, but would accommodate the level of water treatment assumed to be allowed by the discharge permit.

As a result of the inherent water treatment limitations imposed on discharge canal cooling towers, as described above, there would be no anticipated increase in water treatment costs for Merrimack Station associated with the addition of a discharge canal cooling tower.

10.2.4 Environmental Considerations

As EPA directed in the §308 Letter, this section identifies, qualifies and quantifies, to the extent possible, the environmental impacts of installing a discharge canal cooling tower at Merrimack Station. Considerations and evaluations will include the long term positive and negative environmental benefits and impacts.

10.2.4.1 Cooling Tower Plume

Although the evaluated discharge canal cooling tower would be a plume abated tower, a visible plume would still exist during certain environmental conditions. As previously discussed in Section 6.3.1, the predominant direction of plume travel would be up or down the Merrimack River (north or south). The potential environmental impacts attributed to a cooling tower plume can be categorized as visual impact and physical impact.

The visual impact of a cooling tower plume would be both aesthetically displeasing and hazardous. When atmospheric conditions are conducive to a visible plume, typically anytime during the winter months when the ambient air temperature is below the 27°F 'plume point', a dense plume would exit from the tower fan discharge shrouds. Depending upon the wind direction, thermal conditions, and other factors, the plume could extend skywards for hundreds of feet, or become inverted as a ground-level fog. Local residences would either view the plume intruding high into the sky, or be immersed in a dense fog obscuring their view altogether. Driving on nearby roads and highways could be significantly impacted, with visibility and safety severely compromised.

The potential physical impacts from a tower plume would arise primarily from 1) the moisture content, which could cause icing and fogging during winter conditions, 2) the mineral content of the entrained moisture which could damage vegetation, and 3) the heat content, which could potentially degrade Station heating, ventilating and air conditioning (HVAC) systems. It is important to note that a hybrid tower produces an invisible plume under most conditions, however, the plume still exists and creates the above noted physical impacts.

10.2.4.2 Cooling Tower Noise

Without the benefit of noise attenuation, mechanical draft cooling towers produce relatively high levels of constant noise. The noise emanating from a cooling tower is due both to the cascading water, and to the large mechanical draft fans.

The hybrid cooling towers evaluated for Merrimack Station would be equipped with sound attenuators. The noise level would be expected to be <30dB(A) at one-half mile distance from the tower. As a point of comparison, this sound level corresponds to the typical late-night noise levels in a small town. The noise standard for many townships is in the range of 45-50 dB(A), which would be met at approximately 350 feet from the evaluated tower. Although the noise level would increase on the River in close proximity to the Station, adjacent residential areas should be mostly unaffected by the noise generated from the cooling tower.

10.2.4.3 Reduced Intake Flow

Since the discharge canal cooling tower would not alter the Station intake or any of the condenser operating parameters, there would be no change in intake flow rates as a result of the cooling tower addition.

10.2.4.4 Loss of River Water Due to Evaporation

As previously noted in Section 6.3.4, cooling towers evaporate large quantities of water which are effectively lost from the source water body. In the case of a discharge canal cooling tower at Merrimack Station, the estimated daily water loss from the Merrimack River due to evaporation would be approximately the same as previously calculated for the conversion to closed-loop cooling. [See note below]

Note: Although indicated below to be the same as for the closed-loop conversion cooling tower, differences in cooling tower fill and overall design could account for slight changes to the quantity of river water loss calculated.

Evaporation $_{\text{Wet Summer}}$ can be approximated as Water Flow $_{\text{Total}}$ x 0.0167 gpm [Reference 11.3]

Unit 1 Water Flow = 59,000 gpm

E_{Wet} = 0.0167 x 59,000 gpm = 985 gpm

Unit 2 Water Flow = 140,000 gpm

E_{Wet} = 0.0167 x 140,000 gpm = 2338 gpm

Total Loss of river water due to evaporation = 3323 gpm, or 4.79 million gallons/day.

10.2.4.5 Site Aesthetics

Aesthetics are an important issue at Merrimack Station since it is located on the Merrimack River, a recreational use area for many boaters. Any closed-loop cooling conversion-related aesthetic degradation of the area must be considered a negative environmental impact.

Tower size

A cooling tower sized for the discharge canal cooling needs of Merrimack Station would be a significant structure. A hybrid mechanical draft tower would be approximately 250 feet in length, with a discharge elevation of approximately 65 feet.

Cooling tower plume

Although a hybrid, or plume abated, tower would be utilized to reduce the visible plume most of the time, a visible plume would occur during the colder periods of the year. The plume could potentially extend hundreds of feet into the sky, and travel for up to a few miles horizontally.

Construction of the tower would require permanent modification of the terrain along the shore of the Merrimack River

The cooling tower would be located approximately 200 feet from the bank of the Merrimack River, and would have a substantial aesthetic impact. An area approximately 400 feet in length and 150 feet in width would be cleared for the tower. Views from the Merrimack River would be impacted. The Station is an industrial facility already visible from these vantage points, however, the addition of the tower would make the entire facility more visible.

The clear-cutting of the trees on the discharge canal island required for construction of the tower and to allow maximum airflow to the tower would remove a visual buffer from vantage points both up and down river.

10.3 Discharge Canal / PSM Modifications

10.3.1 Thermal Impact of Doubling Canal Length and PSMs

Like cooling towers, PSMs operate primarily on an approach to wet-bulb temperature, however, there is a measured degree of thermal performance which may be added by increasing the number of PSMs and concurrently lengthening the discharge canal. The thermal performance attributable to doubling both the number of PSMs in the Merrimack Station discharge canal and the discharge canal length was evaluated in a manner similar to the single unit closed-loop analysis, with PSM performance as the condition where neither unit utilizes closed-loop cooling. The table below shows the bounding percentage of hours in which the 5°F Station N10-Station S4 temperature differential could be attained if both the number of PSMs in the discharge canal and the discharge canal length were doubled.

Merrimack Station Double PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours Attaining 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	74.7%	N/A[2]	N/A[2]	N/A[2]	100.0%	82.1%
April	87.8%	86.5%	93.1%	91.0%	97.1%	91.6%
May	89.7%	96.2%	94.6%	97.0%	96.9%	94.9%
June	13.2%	14.8%	20.8%	16.4%	15.4%	16.1%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
November	0.0%	1.6%	2.2%	3.1%	1.9%	2.1%
December	N/A[2]	N/A[2]	N/A[2]	0.0%	18.0%	17.5%
Measured Attainment[3]	27.4%	20.3%	24.6%	24.8%	26.3%	24.8%
Annual Attainment[4]	55.8%	53.1%	54.3%	50.8%	47.5%	52.3%

[1]*River flow rate conditions based on 21 years of recorded daily averages (1984-2004)*

[2]*N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

[3]*Measured attainment calculated by dividing the average hours meeting evaluated scenario by the number of hours with recorded data*

[4]*Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario*

Similar to the results of increasing the thermal discharge cooling tower size, doubling the number of PSMs and discharge canal length improves thermal performance, however, the conclusion that a significant percentage of time the Station would exceed the 5°F Station N10 – Station S4 temperature differential remains similar. Moreover, increasing the number of PSMs and lengthening the discharge canal would provide a diminishing level of thermal performance. Overall, current thermal performance of the PSMs is not distinctly improved by doubling the PSMs and discharge canal length.

Note: Since the above tabulation is based on the bounding historical daily flow rates, the % attainment of the 5°F Station N10-Station S4 temperature differential is very conservative, i.e., each day of the month is considered to be at the lowest historical river flow rate. For typical historical daily flow rates, the % attainment would be appreciably higher.

10.4 Effect of Increasing Sampling Frequency on Cost of Attainment

EPA requested in the § 308 Letter that PSNH identify and evaluate means by which Merrimack Station could attain and maintain a maximum ambient temperature differential of 5°F in Hooksett Pool (i.e., between Station N10, which is above the Station's thermal discharge point, and Station S4, which below that discharge point). However, EPA did not specifically qualify at which sampling frequency this temperature differential measurement was to occur. Therefore, in order to identify the relative effect sampling frequency has on the resulting percentage of occurrence in which the evaluated temperature differential is attained, the 10-cell thermal discharge cooling tower performance was analyzed on 1-hr, 8-hr, and daily average sampling frequencies.

10.4.1 Sampling Frequency Assessment – 10-Cell Thermal Discharge Cooling Tower

The sampling frequency assessment on the 10-cell thermal discharge cooling tower was identical to that conducted previously in Section 10.2.2.1, and was simply modified to allow evaluation of 1-hr, 8-hr, and daily average time intervals. Therefore, five years of meteorological data and river water temperatures were compared against 21 years of daily average measured river flow rate values to yield a bounding percentage of hours in which the 5°F Station N10-Station S4 temperature differential could be attained utilizing 1-hr, 8-hr, and 24-hr average sampling frequencies.

10-Cell Thermal Discharge Cooling Tower Performance at 1-Hr Sampling Frequency
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours Attaining 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	80.9%	91.5%	95.8%	79.5%	75.8%	84.7%
July	57.8%	87.5%	61.6%	70.6%	46.0%	64.7%
August	65.5%	35.1%	43.8%	61.3%	52.8%	51.7%
September	22.7%	20.3%	22.5%	27.2%	26.8%	23.9%
October	34.3%	23.9%	31.6%	35.5%	32.4%	31.5%
November	55.7%	62.0%	77.1%	60.4%	61.3%	63.3%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	93.1%	93.4%
Measured Attainment[3]	66.2%	61.9%	64.1%	66.4%	63.8%	64.5%
Annual Attainment[4]	79.4%	77.6%	78.2%	78.0%	74.2%	77.5%

[1]River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3]Measured attainment calculated by dividing the average hours meeting the evaluated scenario by the number of hours with recorded data

[4]Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario

10-Cell Thermal Discharge Cooling Tower Performance at 8-Hr Sampling Frequency Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of 8-Hr Segments Attaining 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	82.2%	90.0%	94.4%	79.5%	75.6%	84.4%
July	58.2%	88.2%	65.6%	71.0%	47.3%	66.1%
August	68.8%	34.4%	43.0%	61.3%	54.8%	52.5%
September	18.9%	17.8%	23.3%	26.7%	28.9%	23.1%
October	35.5%	23.7%	32.3%	35.2%	32.3%	31.7%
November	52.9%	60.7%	74.5%	62.2%	61.1%	63.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	93.2%	93.5%
Measured Attainment[3]	66.5%	61.3%	64.7%	66.7%	64.4%	64.8%
Annual Attainment[4]	79.5%	77.1%	78.5%	78.1%	74.6%	77.6%

[1]River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3]Measured attainment calculated by dividing the average hours meeting evaluated scenario by the number of hours with recorded data

[4]Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario

10-Cell Thermal Discharge Cooling Tower Performance at 24-Hr Sampling Frequency
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Days Meeting 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	86.7%	93.3%	96.7%	80.0%	80.0%	87.3%
July	51.6%	90.3%	64.5%	87.1%	41.9%	67.1%
August	77.4%	35.5%	45.2%	61.3%	58.1%	55.5%
September	10.0%	13.3%	16.7%	23.3%	20.0%	16.7%
October	35.5%	25.8%	32.3%	30.0%	29.0%	30.5%
November	50.0%	57.9%	81.3%	53.3%	60.0%	60.4%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	93.3%	93.8%
Measured Attainment[3]	66.1%	62.0%	65.2%	66.7%	63.2%	64.6%
Annual Attainment[4]	79.2%	77.4%	78.6%	78.0%	73.7%	77.4%

[1]River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2]N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

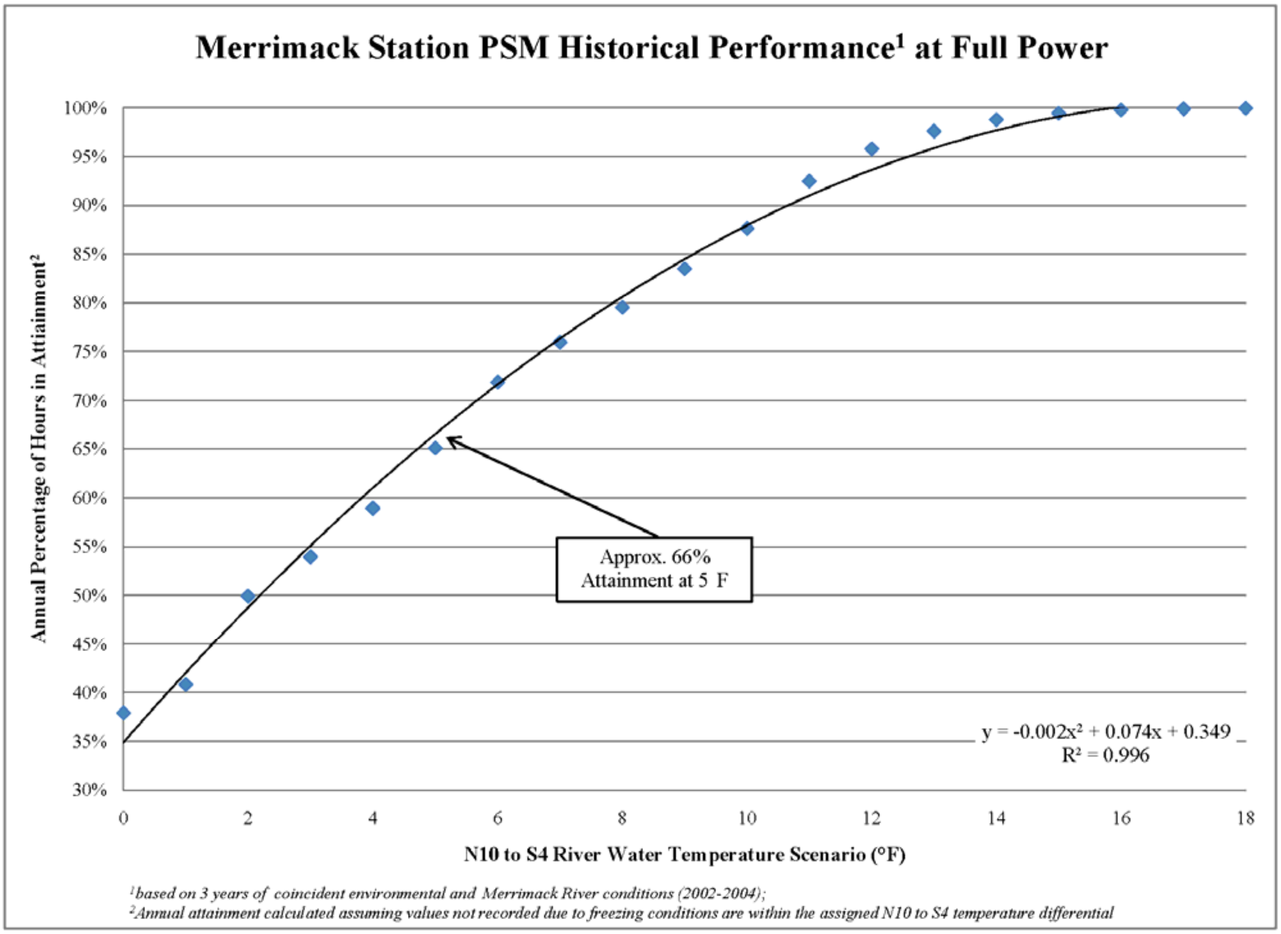
[3]Measured attainment calculated by dividing the average hours meeting the evaluated scenario by the number of hours with recorded data

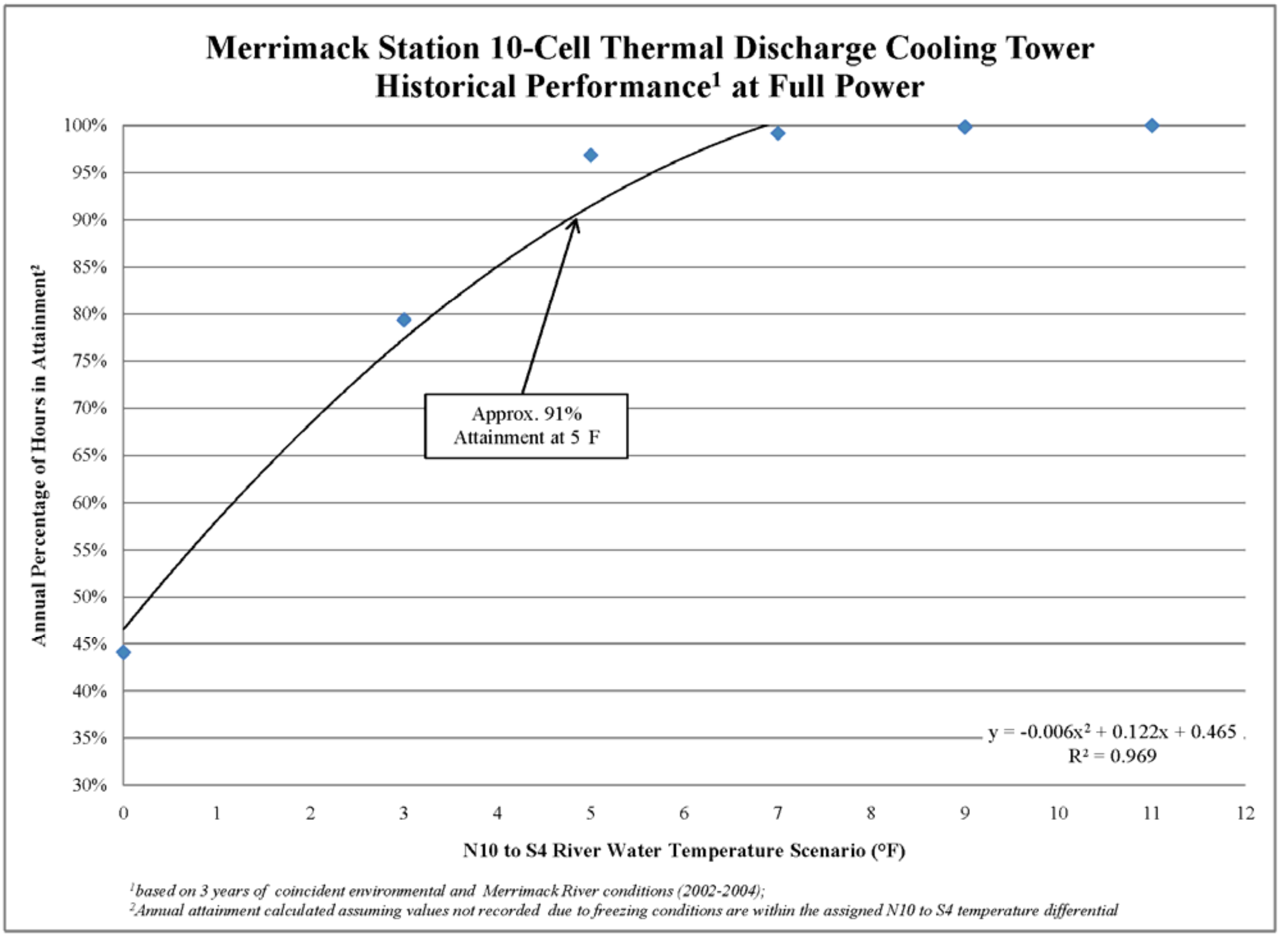
[4]Annual attainment calculated assuming all N/A values are within 5°F temperature differential scenario

As shown in the tables above, there is no appreciable difference to the degree of attainment of the 5°F Station N10-Station S4 temperature differential by either decreasing or increasing the sampling frequency.

10.5 Analysis of Bounding N10-S4 Temperature Differential Scenarios

In addition to directing PSNH to evaluate the "least expensive, cost effective" means by which Merrimack Station could attain and maintain a maximum ambient temperature differential of 5°F in Hooksett Pool, the § 308 Letter required the evaluation of "additional means to achieve other ambient temperature differential scenarios between Station N10 and different downstream S-Stations in the Hooksett Pool." While the empirical analysis done hereto has been limited to the discrete river water temperature locations provided, PSNH has also evaluated the thermal performance of both the current Station operation (i.e., discharge canal cooling via PSMs) and the most effective alternative (i.e., 10-cell thermal discharge cooling tower) over a range of river water differential scenarios. The current PSM operation and the 10-cell thermal discharge cooling tower operation were analyzed over bounding temperature differential scenarios (i.e., between a 0°F temperature differential scenario and 100% thermal attainment) at historical daily conditions (see Section 10.2.2.4 for further discussion into historical daily condition analysis).





As shown in the figures above, based on historical daily river flow rate and ambient temperature conditions the Station could attain the EPA-specified 5°F N10-S4 temperature differential 66% of the time utilizing current PSM operation and 91% utilizing a 10-cell thermal discharge cooling tower. Additionally, full attainment based on historical daily conditions would be met with the current PSM operation at an approximate Station N10-Station S4 temperature differential of 16°F and with a 10-cell thermal discharge cooling tower at an approximate Station N10-Station S4 temperature differential scenario of 7°F.

10.6 Benefits of Reconfiguring Canal to Reduce Recirculation

The current configuration of the discharge canal rejects the Station's thermal output against the Merrimack River's prevailing current (i.e., the Station's discharge is directed upstream from Station S0). Reconfiguring the discharge canal could provide increased Station operational performance under low river flow rate conditions. In general, the circulating water output is strongly correlated with Station N10 river water temperature and the electrical output of the Station, and is normally unaffected by river water flow rate. As such, the empirical data is inconclusive and does not support a canal reconfiguration analysis. However, the operational data used for this analysis is limited (i.e., data provided is limited to the bounding months of July and August). If canal reconfiguration were to occur, specific focus should remain on directing the thermal discharge to coincide with the prevailing current with a river entry point at a maximum distance from circulating water suction.

11 References

11.1 NCDC Local Climatological Data

11.2 Engineering Manual 1110-2-3105, Mechanical and Electrical Design of Pumping Stations, *U. S. Army Corps of Engineers, Changes 1 and 2, Nov. 30, 1999.*

11.3 Cooling Tower Fundamentals, Marley Cooling Tower Company, Second Edition, 1998.

11.4 ASHRAE Fundamentals, American Society of Heating, Refrigerating and Air Conditioning Engineers, 2001 edition

11.5 Pankratz, Tom, P, Screening Equipment Handbook, Technomic Publishing Company, Inc, Copyright 1995.

11.6 Proceeding Report, Symposium on Cooling Water Intake Technologies to Protect Aquatic Organisms, May 6-7, 2003, Hilton Crystal City at National Airport, Arlington, VA.

11.7 Science Report, Screening for Intake and Outfalls: A Best Practice Guide, *Environment Agency*, Copyright February 2005

11.8 Proposal for Information Collection to Address Compliance with the Clean Water Act § 316 (B) Phase II Regulations at Merrimack Station, Bow, New Hampshire, *Normandeau Associates*, April 2005

11.9 A Probabalistic Thermal Model of the Merrimack River Downstream of Merrimack Station, *Normandeau Associates*, April 2007

11.10 Daly, Steven, F, Frazil Ice Blockage of Intake Trash Racks, Cold Regions Technical Digest, No. 91-1, March 1991, US Army Corp of Engineers

11.11 Mann, D.A., D.M. Higgs, W.M. Tavolga, M.J. Souza, and A.N. Popper. 2001. Ultrasound detection by clupeiform fishes. J. Acoust. Soc. Am. 109(6): 3048-3054

11.12 Normandeau Associates, Inc., Merrimack River monitoring program summary report. March 1979. Submitted to PSNH.

11.13 Normandeau Associates, Inc., Proposal for Information Collection to Address Compliance with the Clean Water Act §316(b) Phase II Regulations at Merrimack Station, Bow, New Hampshire. April 2005. Submitted to PSNH.

11.14 Normandeau Associates, Inc., Merrimack Station Thermal Discharge Effects on Downstream Salmon Smolt Migration. Final Report December 2006. Submitted to PSNH

11.15 Normandeau Associates, Inc., A Probabalistic Thermal Model of Merrimack River Downstream of Merrimack Station. Final Report April 2007. Submitted to PSNH.

11.16 Normandeau Associates, Inc., Merrimack Station fisheries survey analysis of 1967 through 2005 catch and habitat data. Final Report April 2007. Submitted to PSNH.

11.17 Normandeau Associates, Inc., Entrainment and Impingement Studies Performed at Merrimack Generating Station from June 2005 through June 2007. Final Report October 2007. Submitted to PSNH.

11.18 Zoli, Elise, N, Goodwin Proctor, letter to Murphy, Linda, EPA, Regarding Merrimack Station Proposal for Information Collection, November 1, 2005.

Attachment 1

Major Components; Vendor Data and References

Section 1: Cooling Towers - SPX/Marley

a. **Closed Cycle Conversion Tower**
b. **Discharge Canal Tower**

Section 2: Circulating Water Pumps

a. **Existing**
b. **New Boosters - Sulzer**

Section 3: Variable Speed Pumps

a. **GE Industrial**

Section 4: WIP Screens

a. **Beaudrey USA**

Section 5: Traveling Water Screen and Fish Return

a. **EIMCO Water Technologies**
b. **Passavant-Geiger**
c. **Siemens**

Section 6: Behavioral Barrier Systems

a. **Fish Guidance Systems**

Section 7: Wedgewire Screens

a. **Beaudrey USA**

Sam R Beaver

From:	John.Arntson@ct.spx.com
Sent:	Wednesday, July 25, 2007 10:18 AM
To:	sbeaver@enercon.com
Cc:	Richard.Coughlin@ct.spx.com; TERRY.DWYER@ct.spx.com; JIM.VANGARSSE@ct.spx.com; DAVE.RAND@ct.spx.com
Subject:	PSNH Merrimack Station: Study for Enercon
Attachments:	WtrcondREV15a.pdf; PSNH Merrimack Station 200 HP Summary.pdf

Sam,
Attached find preliminary selection's with budgetary pricing for Public Service of New Hampshire Merrimack Station. All the selections provided are based on 200 HP mechanical equipment. I have not allowed any significant margin on nameplate motor HP thus the motors will run into the service factor during cold weather operation which should be acceptable. The tower selections are based upon the use of 5.3 ft. of DF-254 fill. See attached water quality guidelines.

The budgetary pricing is based upon an FRP structure erected on a basin provided by others. Lightning protection is provided however all power and control wiring and the associated cable trays is excluded. Also excluded at this time are the risers and expansion joints and a fire protection system.

I have assumed use of a single riser/header feeding two cells with the Unit 1 cells (4) operating independently of the Unit 2 cells (10). As Unit 1 consists of only four cells, we may want to use individual risers for each cell to maximize cooling in the event that one of the four cells is down. Alternatively, we could inter-tie the Unit 1 & 2 inlet headers and the basins (sluice gates) to provide additional cooling for Unit 1 if one or more fans are down.

Please adjust the budgetary pricing if sales or use taxes are to be included.

Sam, let me know what else you need at this time.

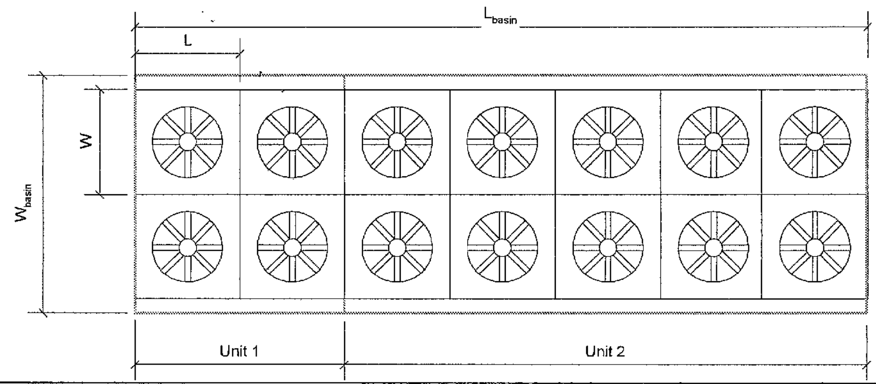
Regards,
John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

Phone: 913-664-7854
Fax: 913-693-9633
E-mail: john.arntson@ct.spx.com

SPX Cooling Technologies
Balcke | Hamon Dry Cooling | Marley

Public Service of New Hampshire
Merrimack Station
Closed Cycle Cooling Optimization
For
Enercon Services

200 HP Selections

Case 1 **8 °F Approach**	**Design Conditions:** Ambient Wet Bulb = 74 °F; Inlet Wet Bulb = 76 °F; Unit 1 Flow = 59,000 gpm; Unit 1 Range = 19 °F; Unit 2 Flow = 140,000 gpm; Unit 2 Range = 22.6 °F; Unit 1 & Unit 2 CWT = **84.0** °F	
	No. Cells Unit 1/Unit 2 =	4/10
	W (ft) =	54
	L (ft) =	54
	L basin =	379
	W basin (ft) =	123.67
	Unit 1 Motor Output Power (HP) =	4 x 200
	Unit 1 Pump Head (ft)	36
	Unit 2 Motor Output Power (HP) =	10 x 200
	Unit 2 Pump Head (ft) =	38
	Tower Model No. =	F 499-5.3-14B
	Budgetary Price =	$ 6,950,000
	* Sales and use taxes not included	

SPX Cooling Technologies
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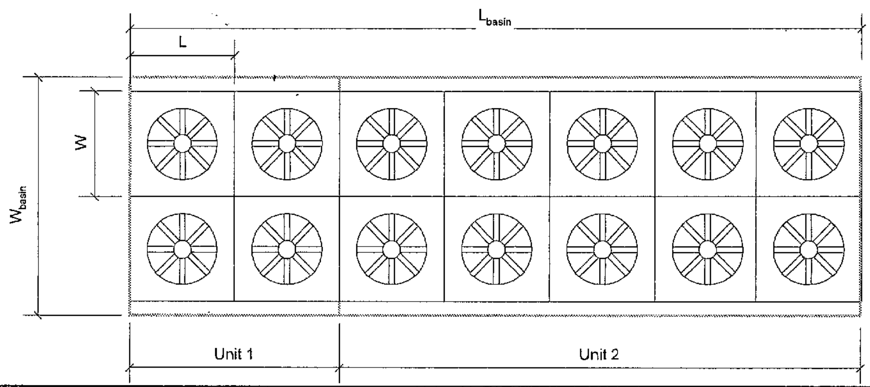
Public Service of New Hampshire

Merrimack Station
Closed Cycle Cooling Optimization
For
Enercon Services

200 HP Selections

Case 2
10 °F Approach

Design Conditions:
Ambient Wet Bulb = 74 °F
Inlet Wet Bulb = 76 °F
Unit 1 Flow = 59,000 gpm
Unit 1 Range = 19 °F
Unit 2 Flow = 140,000 gpm
Unit 2 Range = 22.6 °F
Unit 1 & Unit 2 CWT = **86.0 °F**



No. Cells Unit 1/Unit 2 =	4/10
W (ft)=	48
L (ft) =	54
L basin =	379
W basin (ft) =	108.67
Unit 1 Motor Output Power (HP) =	4 x 200
Unit 1 Pump Head (ft)	34
Unit 2 Motor Output Power (HP) =	10 x 200
Unit 2 Pump Head (ft) =	34
Tower Model No. =	F 489-5.3-14B
Budgetary Price =	$ 6,350,000*

* Sales and use taxes not included

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Public Service of New Hampshire
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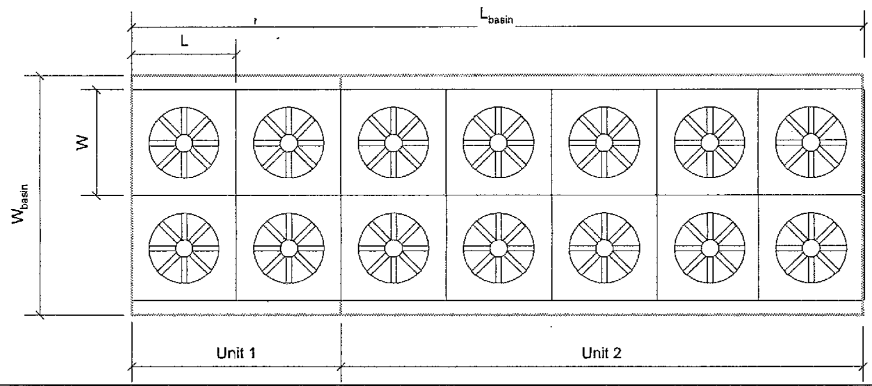
Closed Cycle Cooling Optimization
For
Enercon Services

200 HP Selections

Case 3
12 °F Approach

Design Conditions:
Ambient Wet Bulb = 74 °F
Inlet Wet Bulb = 76 °F
Unit 1 Flow = 59,000 gpm
Unit 1 Range = 19 °F
Unit 2 Flow = 140,000 gpm
Unit 2 Range = 22.6 °F
Unit 1 & Unit 2 CWT = **88.0 °F**



No. Cells Unit 1/Unit 2 =	4/10
W (ft)=	42
L (ft) =	48
L basin =	337
W basin (ft) =	97
Unit 1 Motor Output Power (HP) =	4 x 200
Unit 1 Pump Head (ft)	35
Unit 2 Motor Output Power (HP) =	10x 200
Unit 2 Pump Head (ft) =	35
Tower Model No. =	F 478-5.3-14B
Budgetary Price =	$ 5,100,000

* Sales and use taxes not included

Sam R Beaver

From: John.Arntson@ct.spx.com
Sent: Friday, August 03, 2007 4:20 PM
To: Sam R Beaver
Subject: RE: PSNH Merrimack Station

With regard to their discharge permit, do they have both summer & winter limitations? If summer only, plume abatement will not be a major problem.

John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

Sam R Beaver

From: John.Arntson@ct.spx.com
Sent: Wednesday, July 18, 2007 6:03 PM
To: Sam R Beaver
Cc: TERRY.DWYER@ct.spx.com
Subject: Re: Enercon Project - PSNH Merrimack Station

Sam,
There is no proven design for a B-B plume abated tower. May be possible but would be an R& D project.

John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

1. **Case 1 – Proposed cooling tower for closed-loop cooling conversion**
    a. Base tower quoted by SPX
        i. 14-cell, 8°F approach, back-to-back configuration, FRP, 200 hp fans, 5.3 ft of DF-245 fill
        ii. Cost = $6,950,000
    b. Option 1 – plume abatement
        i. Linear configuration
        ii. Cost = 2x base tower cost, = $6,950,000.00 adder
    c. Option 2 – noise abatement
        i. Water noise abatement cost = base + 15% = $1,042,500 adder
        ii. Low noise fans cost = base + 20% = $1,390,000 adder

Proposed closed-loop conversion cooling tower total cost w/ all adders,

Base tower price	=	$6,950,000
+ plume abated	=	$6,950,000
+ water noise abated	=	$1,042,500
+ low noise fans	=	$1,390,000
Total proposed tower cost	**=**	**$16,332,500.00**

Sam R Beaver

From: John.Arntson@ct.spx.com
Sent: Monday, August 20, 2007 10:08 AM
To: Sam R Beaver
Cc: JIM. VANGARSSE; TERRY.DWYER@ct.spx.com; DOUG.RANDALL@ct.spx.com
Subject: Re: PSNH Merrimack Station

Sam,
FYI,

You have asked a question for which there are few answers without some design point data. Both plume and noise abatement costs are highly dependent on the the severity of the design point.

I believe that we have we have supplied several plume abated towers in the NE and I will research the design data for plume abatement & sound.

Plume abatement costs dramatically increase as the design point temperature approaches 32 deg. F.

Sound abatement costs vary significantly depending on the near field and far field requirements. Depending on the design requirements, measures such as water noise attenuation, low noise fans, inlet and exit attenuators can be utilized.

Let me do some checking & I will get back to you.

Jim, Doug, what is our experience in New Hampshire with plume & noise abatement.
FYI,
John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

Sam R Beaver

From: John.Arntson@ct.spx.com
Sent: Tuesday, August 28, 2007 2:55 PM
To: sbeaver@enercon.com
Cc: JIM.VANGARSSE@ct.spx.com; TERRY.DWYER@ct.spx.com; Richard.Coughlin@ct.spx.com
Subject: PSNH Merrimack Station: Helper Tower
Attachments: Merrimack Budget-200 HP.pdf; Merrimack Budget -250 HP.pdf; psnh merrimack perf curve.pdf

Sam,
Attached find two selections for Merrimack based on your Case 4 river and ambient data. We have provided selections for both 200 and 250 HP based on a 8 cell FRP tower in a B-B arrangement. 3 ft of DF-254 film fill has been used in both selections. The attached performance curve is applicable to either design.

For talking purposes the price of a plume abated tower (8 in-line cells) will be approximately 2 x of the above budgetary pricing. If water noise sound abatement is required.... add 15 %. If low noise fans are required....add 20 %.

I also looked at reducing the tower flow rate but this results in a more costly tower due to the increased range and closer approach temperature.

Let me know what else you need on this project.
Regards,

John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

Sam R Beaver

From: John.Arntson@ct.spx.com
Sent: Monday, August 27, 2007 5:23 PM
To: sbeaver@enercon.com; rclubb@enercon.com
Cc: JIM.VANGARSSE@ct.spx.com
Subject: PSNH Merrimack Station

Sam,
FYI, the last case governs.

	Tower Design Point			
Parameter	Case 1	Case 2	Case 3	Case 4
Flow, gpm	150200	150200	150200	150200
HWT, deg. F	112.63	112.63	108.53	106.63
CWT, deg. F	96.95	96.95	92.85	90.95
IWBT, deg. F	77.9	83.4	73	77.6
Range, deg. F	15.67	15.67	15.67	15.67
Approach to IWBT, deg. F	19.05	13.55	19.85	13.35
River Temp @ N10, deg. F	84.1	84.1	80	78.1
Ambient Wet Bulb, deg. F	75.6	81.3	71	75.6
CTI Recirculation Allowance, deg. F	2.3	2.1	2.3	2.1
River Temp @ S4, deg. F	89.1	89.1	85.0	83.1

It may be more economical to reduce the tower flow to say 100,000 gpm with an increased range and reduced approach to achieve the same result. I will check.

John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

9/8/2007

SPX Cooling Technologies
Balcke | Hamon Dry Cooling | Marley

, / Tel: 913-664-7854 / Fax: 913-693-9633 / john.arntson@ct.spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO:	Enercon Services, Inc.	DATE:	August 28, 2007
ATTN:		FROM:	John Arntson

PROJECT: PSNH Merrimack Station

BUDGETARY SELECTION

DESIGN CONDITIONS:	Flow	150200 gpm
	Hot Water	106.6 °F
	Cold Water	90.95 °F
	Wet Bulb	77.7 °F
	Plume Abatement	
TOWER DESCRIPTION:	Model	F478A-5.3-8B
	Number of Cells	8
	Pump Head	36.58 ft
	Fan Diameter	30 ft
	Motor Size	8 @ 250 Hp
	Brake Horsepower	8 @ 242.3 Hp
	Evaporation	2100 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Width	84.67 ft
	Tower Length	192.7 ft
	Tower Height	52.34 ft
	Fan Deck Height	38.59 ft
BASIN DIMENSION:	Basin Width	95.67 ft
	Basin Length	193 ft
BUDGET PRICE:	$ 3,400,000 USD	

This budget price is based upon a scope that includes engineering, prefabrication of materials, freight to jobsite and supervision and labor to field assemble the above field erected cooling tower. The following are not included, and should be provided by the purchaser: Sales and/or use taxes, concrete cold water basin, anchor bolts, fire protection sprinkler system (if required by Owner's insurance underwriter), pumps, piping, valves, water make-up, motor starter, disconnects, and controls.

C:\Documents and Settings\jarntson\Desktop\Old My Documents\Misl. Projects\PSNH Merrimack Station\Merrimack Budget -250 HP.doc

SPX Cooling Technologies
Balcke | Hamon Dry Cooling | Marley

, / Tel: 913-664-7854 / Fax: 913-693-9633 / john.arntson@ct.spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO: Enercon Services, Inc.
ATTN:

DATE: August 28, 2007
FROM: John Arntson

PROJECT: PSNH Merrimack Station

BUDGETARY SELECTION

DESIGN CONDITIONS:	Flow	150200 gpm
	Hot Water	106.6 °F
	Cold Water	90.95 °F
	Wet Bulb	77.7 °F
	Plume Abatement	
TOWER DESCRIPTION:	Model	F488A-5.3-8B
	Number of Cells	8
	Pump Head	34.11 ft
	Fan Diameter	30 ft
	Motor Size	8 @ 200 Hp
	Brake Horsepower	8 @ 191.2 Hp
	Evaporation	2100 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Width	102 ft
	Tower Length	192.7 ft
	Tower Height	52.34 ft
	Fan Deck Height	38.59 ft
BASIN DIMENSION:	Basin Width	107.7 ft
	Basin Length	193 ft
BUDGET PRICE:	$3,900,000 USD	

This budget price is based upon a scope that includes engineering, prefabrication of materials, freight to jobsite and supervision and labor to field assemble the above field erected cooling tower. The following are not included, and should be provided by the purchaser: Sales and/or use taxes, concrete cold water basin, anchor bolts, fire protection sprinkler system (if required by Owner's insurance underwriter), pumps, piping, valves, water make-up, motor starter, disconnects, and controls.

C:\Documents and Settings\jarntson\Desktop\Old My Documents\Misl. Projects\PSNH Merrimack Station\Merrimack Budget-200 HP.doc

BEST™ Version 2.45
Product Data: 11/10/2006

Optimization 1.opt
Revised 8/28/2007 9:57:19 AM by John Arntson

Customer
PSNH Merrimack Station
Enercon Services

Contact
SPX-OP

John Arntson
Tel
Fax

Definition

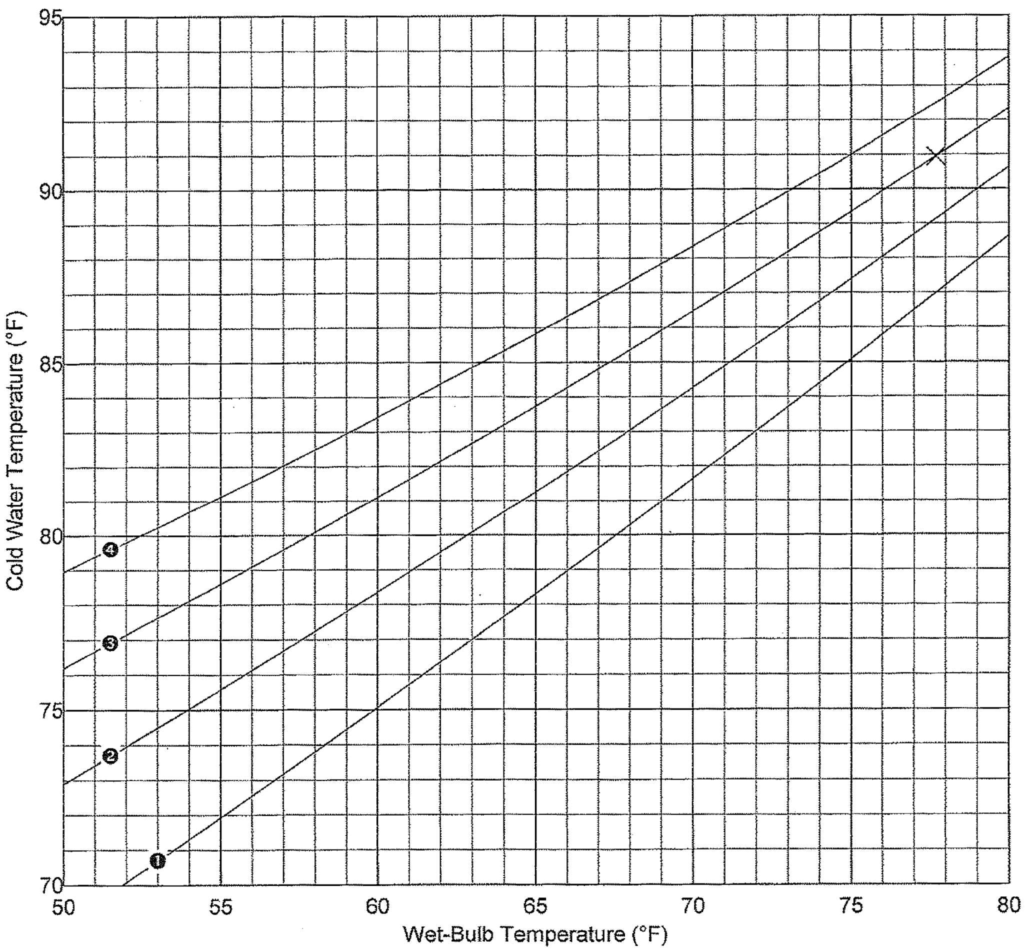
Model (ID 11)	F488A-5.3-8B		
Fill	DF254-5.3		
Eliminator	TU12C		
Louver	No louvers		
Fan	360HP7-7		
Stack	360"x14' Rflx/V Rib		
Speed Reducer	4000, 13.24:1		
Drive	400 Shaft		
Motor	1800 rpm, TEFC		
Closed Sides	0	Partitions	Yes
Closed Ends	2	Wind Walls	Yes
Air Inlet Guide	Yes		
Effective Air Inlet Ht.	19.00 ft		
Plenum Height	7.69 ft		

Design Conditions

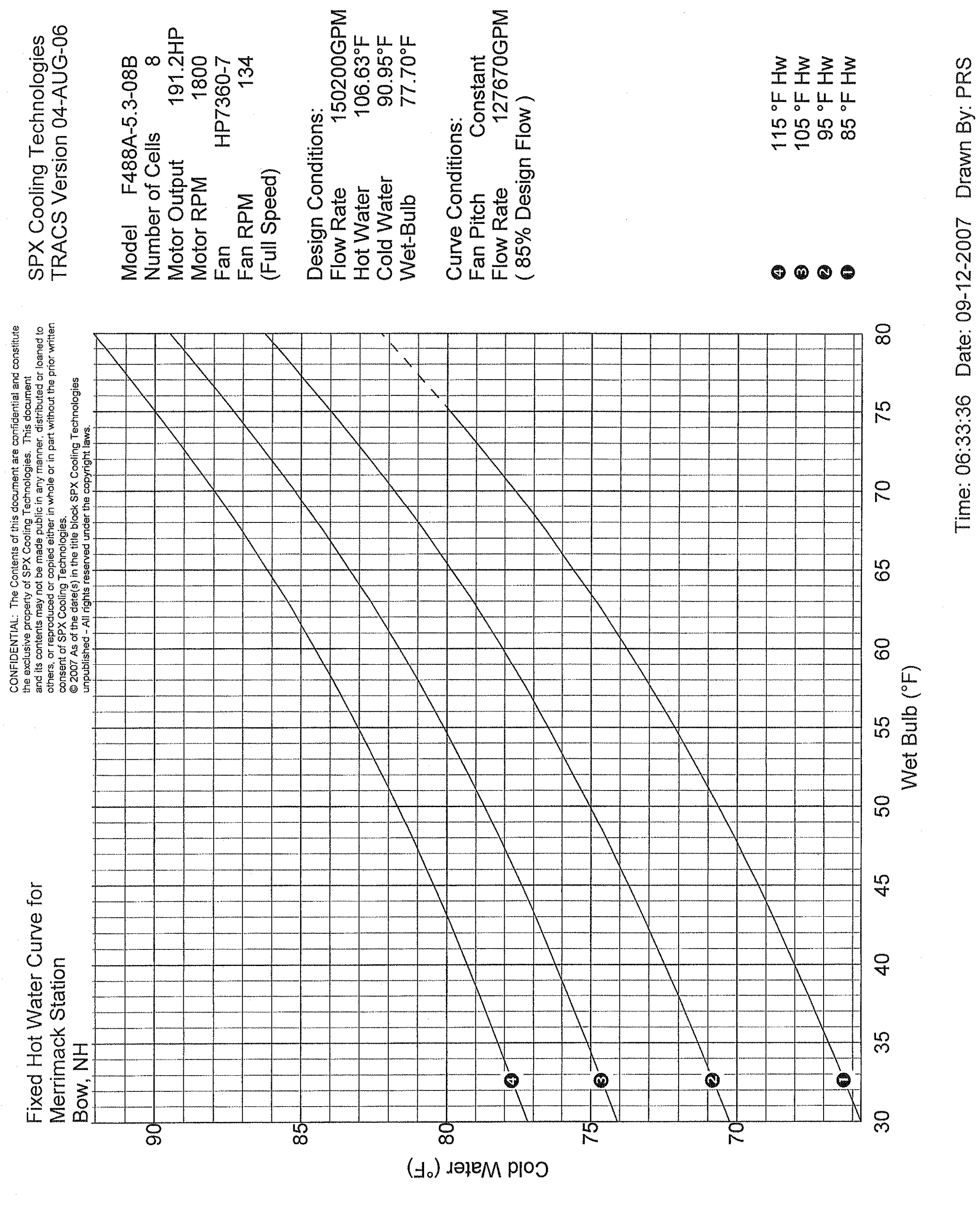
Tower Water Flow	150200 gpm
Hot Water Temperature	106.63 °F
Cold Water Temperature	90.95 °F
Wet-Bulb Temperature	77.70 °F
Relative Humidity	50 %
Total Dissolved Solids	0 ppm
Altitude	0 ft
Inlet P.D. Vel. Heads	0
Outlet P.D. Vel. Heads	0
Motor Output	191.2 BHp

Curve Conditions

Tower Water Flow (100 %)	150200 gpm
Fan Speed (100 %)	134 rpm
Motor Output	191.2 BHp



Legend
❶ 9.408 °F Range
❷ 12.54 °F Range
❸ 15.68 °F Range
❹ 18.82 °F Range
X Design Point


Fixed Hot Water Curve for
Merrimack Station
Bow, NH
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SPX Cooling Technologies
TRACS Version 04-AUG-06
Model F488A-5.3-08B
Number of Cells 8
Motor Output 191.2HP
Motor RPM 1800
Fan HP7360-7
Fan RPM 134
(Full Speed)
Design Conditions:
Flow Rate 150200GPM
Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 127670GPM
(85% Design Flow)
4 115 °F Hw
3 105 °F Hw
2 95 °F Hw
1 85 °F Hw
Cold Water (°F)
90
85
80
75
70
Wet Bulb (°F)
30
35
40
45
50
55
60
65
70
75
80
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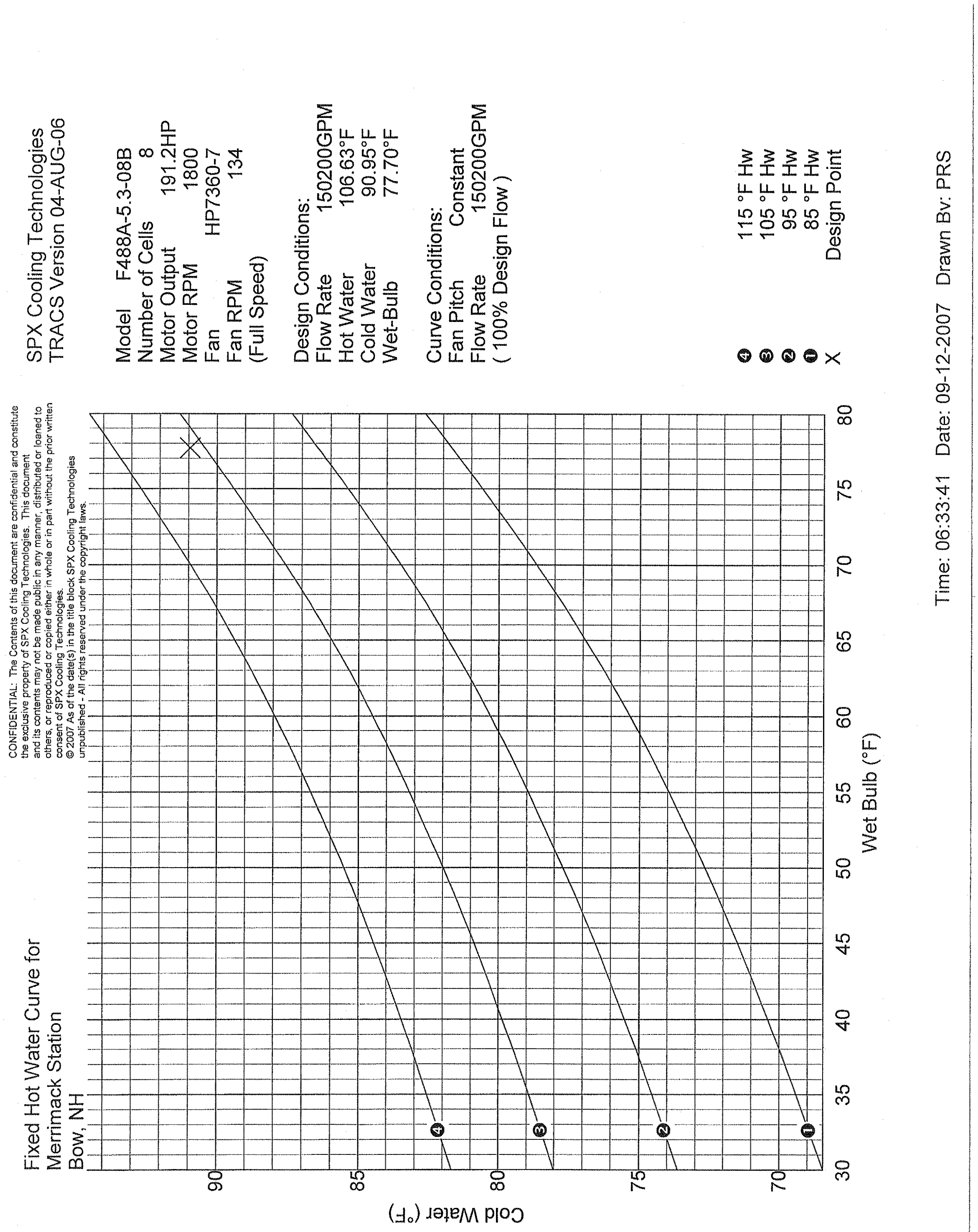
Fixed Hot Water Curve for
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Bow, NH
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Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 150200GPM
(100% Design Flow)
4 115 °F Hw
3 105 °F Hw
2 95 °F Hw
1 85 °F Hw
X Design Point
Cold Water (°F)
90
85
80
75
70
Wet Bulb (°F)
30
35
40
45
50
55
60
65
70
75
80
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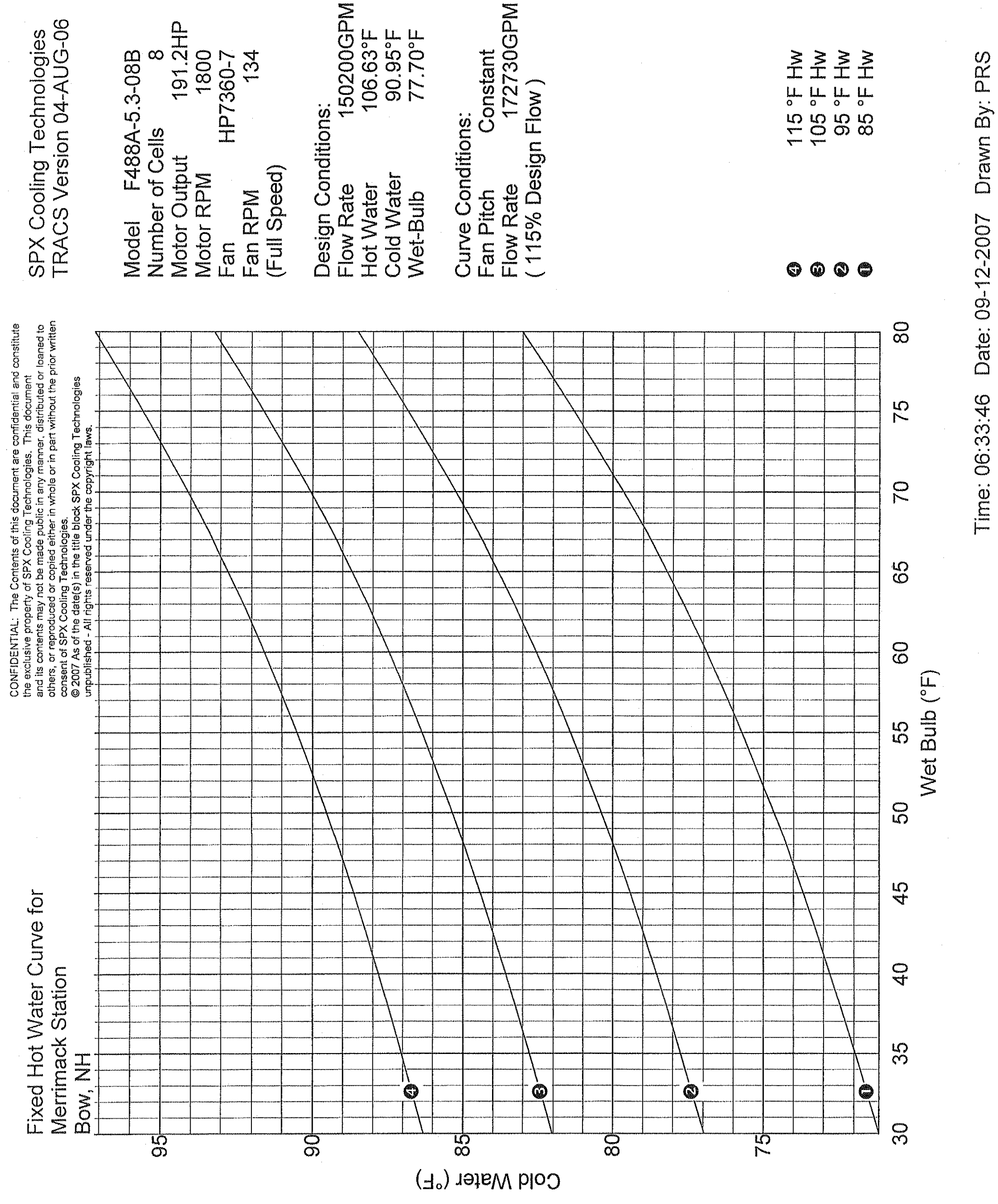
Fixed Hot Water Curve for
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Design Conditions:
Flow Rate 150200GPM
Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 172730GPM
(115% Design Flow)
4 115 °F Hw
3 105 °F Hw
2 95 °F Hw
1 85 °F Hw
Cold Water (°F)
95
90
85
80
75
Wet Bulb (°F)
30
35
40
45
50
55
60
65
70
75
80
Time: 06:33:46 Date: 09-12-2007 Drawn By: PRS

Merrimack Station **F488A-5.3-08B** **PRS 09-12-2007 06:33:48**

Fixed Hot Water Curve for
Merrimack Station
Bow, NH

127670 Flow Rate (gpm)

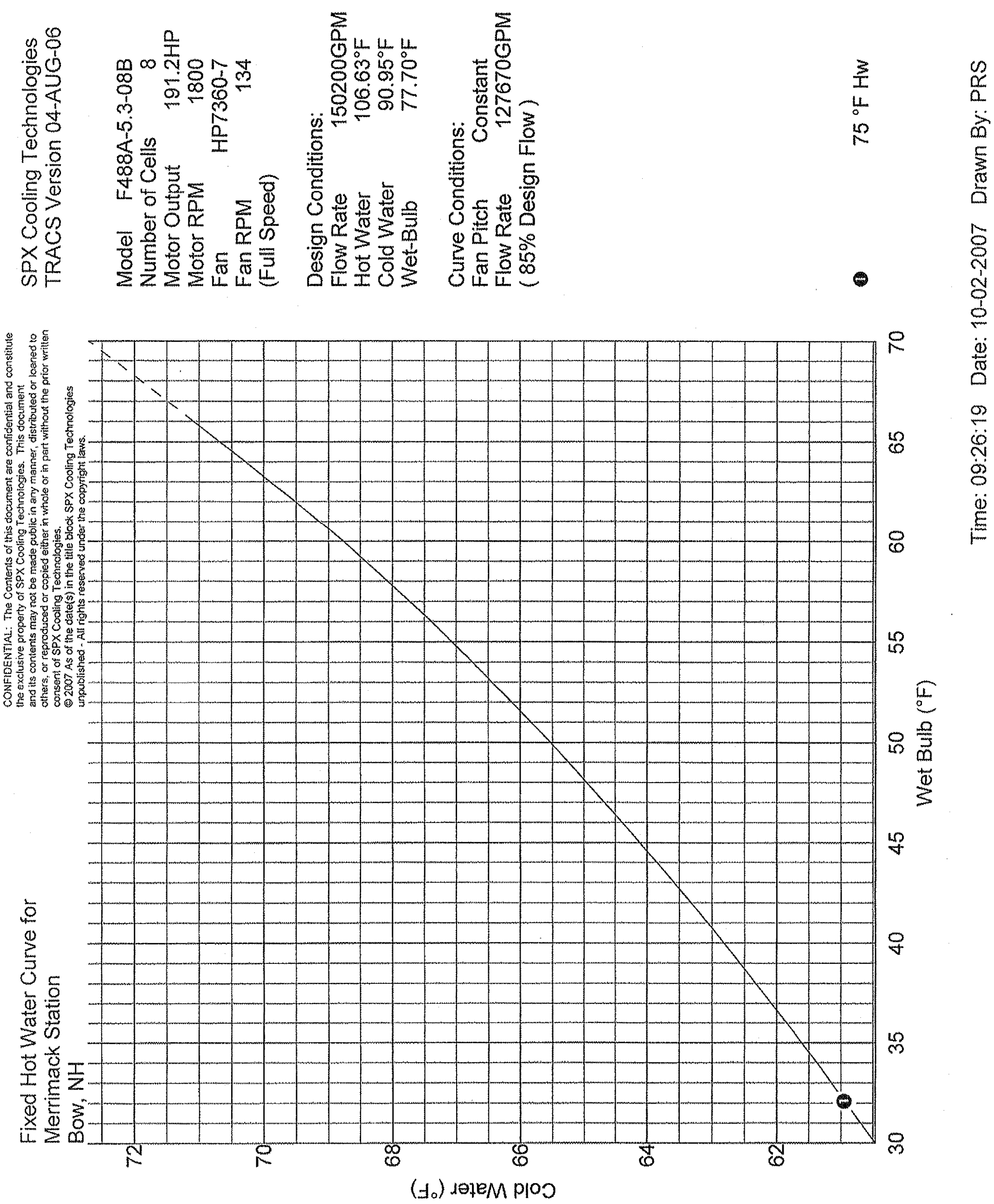
	Wet Bulb				
Hot Water	30.00	42.50	55.00	67.50	80.00
85.00	65.71	68.62	72.14	76.58	82.27
95.00	70.25	73.07	76.49	80.78	86.26
105.00	74.07	76.80	80.10	84.24	89.51
115.00	77.20	79.85	83.04	87.03	92.10
	Cold Water Temp. (°F)				

150200 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	42.50	55.00	67.50	80.00
85.00	68.45	70.93	73.94	77.74	82.64
95.00	73.61	76.01	78.94	82.62	87.36
105.00	78.01	80.35	83.18	86.73	91.31
115.00	81.68	83.94	86.68	90.11	94.50
	Cold Water Temp. (°F)				

172730 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	42.50	55.00	67.50	80.00
85.00	71.17	73.22	75.72	78.90	83.01
95.00	76.97	78.97	81.42	84.50	88.50
105.00	82.03	83.98	86.36	89.35	93.22
115.00	86.32	88.21	90.51	93.40	97.13
	Cold Water Temp. (°F)				


Fixed Hot Water Curve for
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Fan RPM 134
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Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 127670GPM
(85% Design Flow)
1 75 °F Hw
Cold Water (°F)
72
70
68
66
64
62
Wet Bulb (°F)
30
35
40
45
50
55
60
65
70
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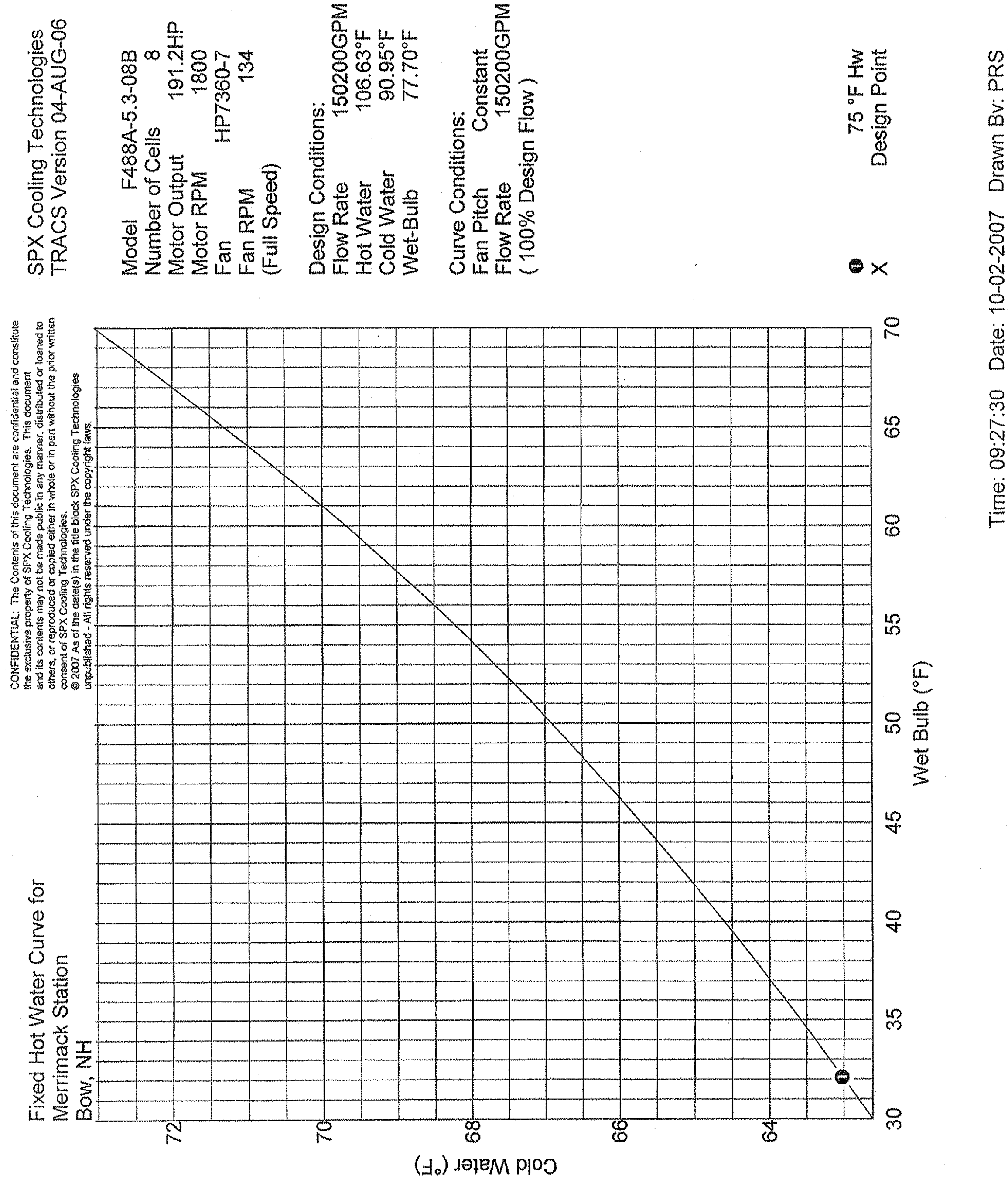
Fixed Hot Water Curve for
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Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 150200GPM
(100% Design Flow)
1 75 °F Hw
X Design Point
Cold Water (°F)
72
70
68
66
64
Wet Bulb (°F)
30
35
40
45
50
55
60
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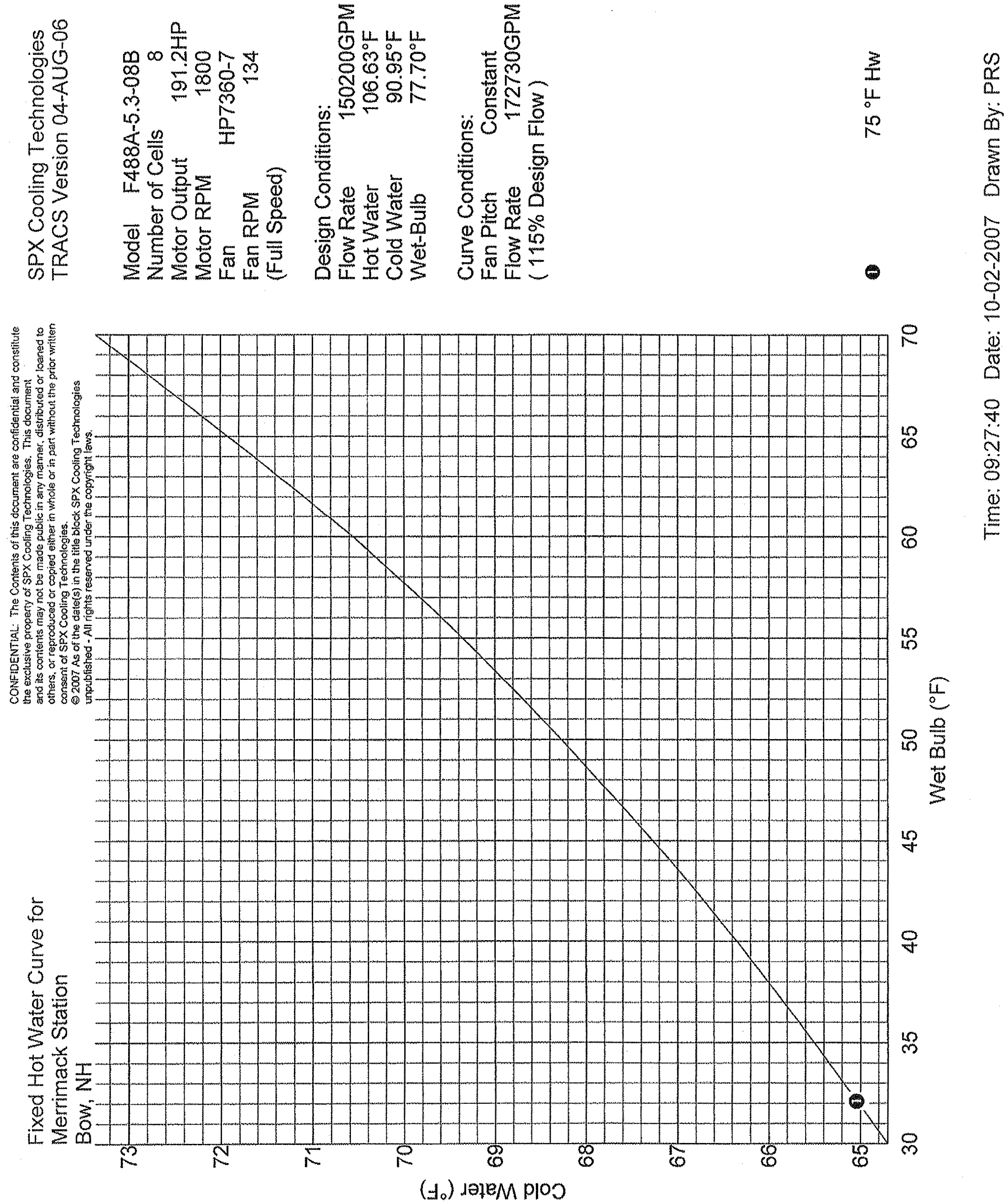
Fixed Hot Water Curve for
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Fan HP7360-7
Fan RPM 134
(Full Speed)
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Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 172730GPM
(115% Design Flow)
1 75 °F Hw
Cold Water (°F)
73
72
71
70
69
68
67
66
65
Wet Bulb (°F)
30
35
40
45
50
55
60
65
70
Time: 09:27:40 Date: 10-02-2007 Drawn By: PRS

Merrimack Station F488A-5.3-08B PRS 10-02-2007 09:29:43

Fixed Hot Water Curve for
Merrimack Station
Bow, NH

127670 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	40.00	50.00	60.00	70.00
75.00	60.46	62.81	65.53	68.77	72.71
	Cold Water Temp. (°F)				

150200 Flow Rate (gpm)

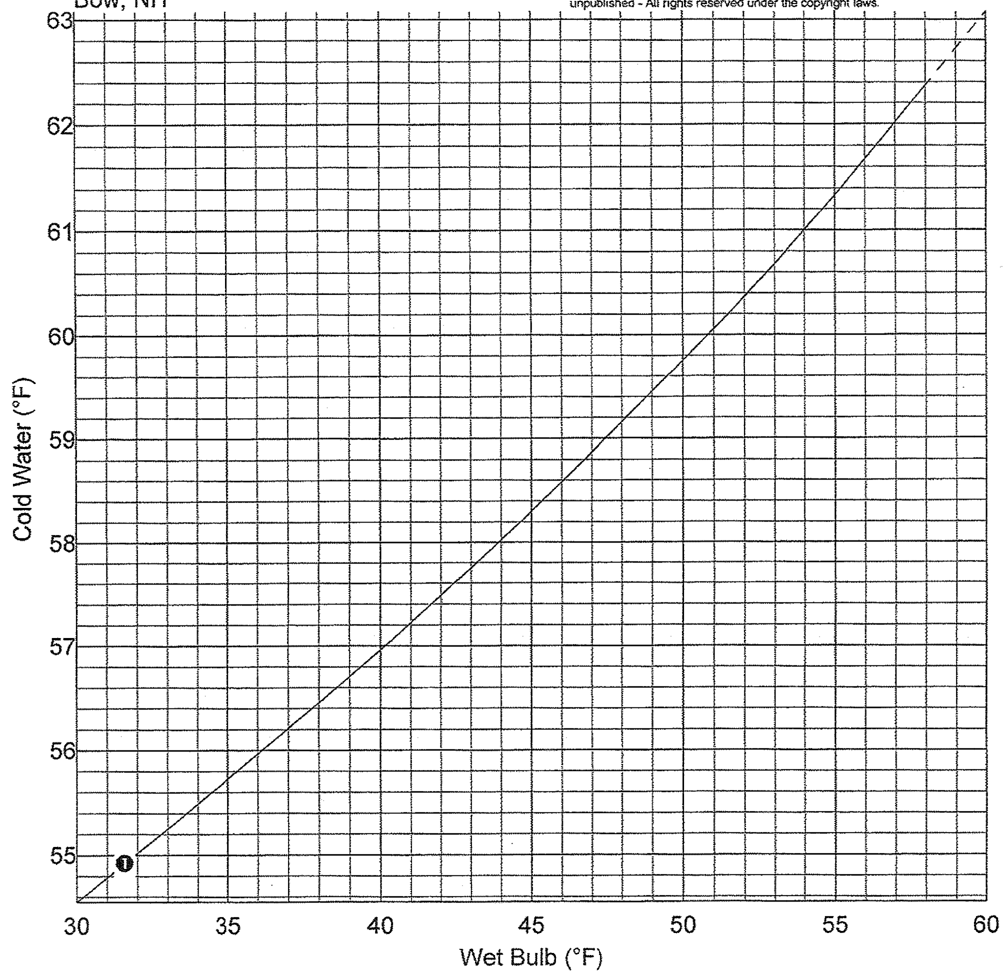
	Wet Bulb				
Hot Water	30.00	40.00	50.00	60.00	70.00
75.00	62.61	64.60	66.91	69.68	73.04
	Cold Water Temp. (°F)				

172730 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	40.00	50.00	60.00	70.00
75.00	64.70	66.35	68.27	70.56	73.36
	Cold Water Temp. (°F)				

Fixed Hot Water Curve for
Merrimack Station
Bow, NH

SPX Cooling Technologies
TRACS Version 04-AUG-06



Model	F488A-5.3-08B
Number of Cells	8
Motor Output	191.2HP
Motor RPM	1800
Fan	HP7360-7
Fan RPM	134
(Full Speed)	

Design Conditions:

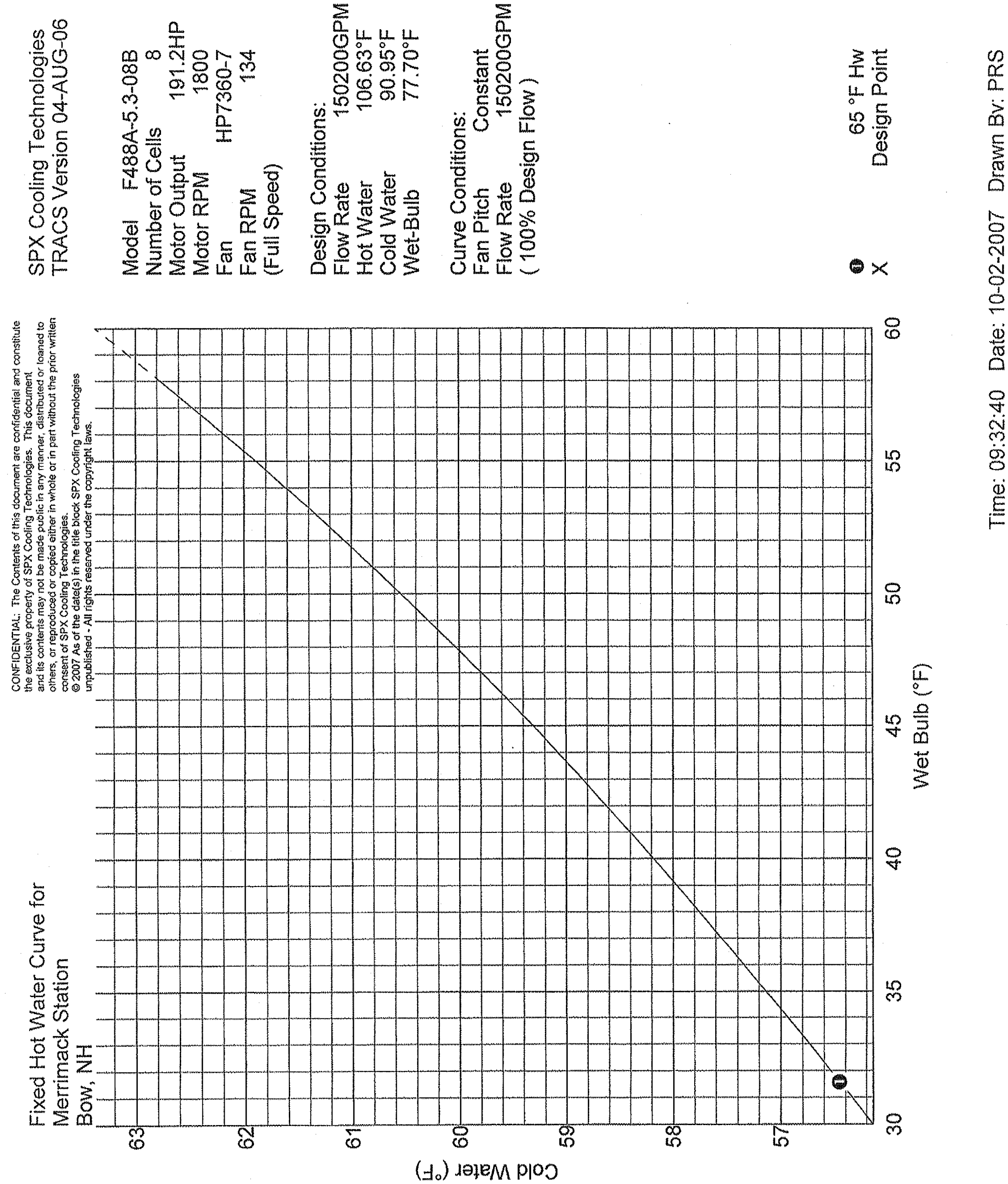
Flow Rate	150200GPM
Hot Water	106.63°F
Cold Water	90.95°F
Wet-Bulb	77.70°F

Curve Conditions:

Fan Pitch	Constant
Flow Rate	127670GPM
(85% Design Flow)	

❶ 65 °F Hw

Time: 09:32:35 Date: 10-02-2007 Drawn By: PRS


Fixed Hot Water Curve for
Merrimack Station
Bow, NH
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Motor RPM 1800
Fan HP7360-7
Fan RPM 134
(Full Speed)
Design Conditions:
Flow Rate 150200GPM
Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 150200GPM
(100% Design Flow)
1 65 °F Hw
X Design Point
Cold Water (°F)
63
62
61
60
59
58
57
Wet Bulb (°F)
30
35
40
45
50
55
60
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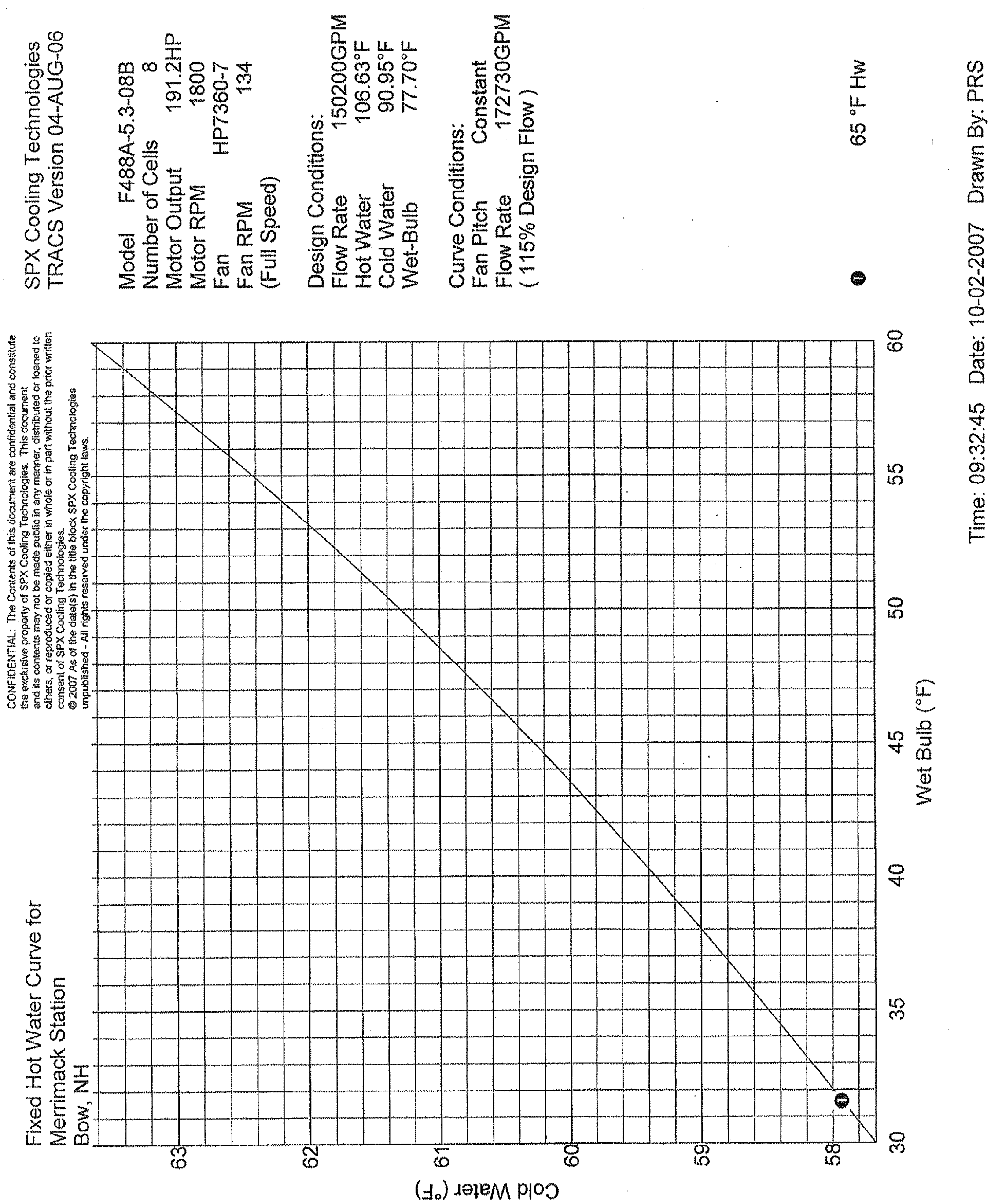
Fixed Hot Water Curve for
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Bow, NH
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TRACS Version 04-AUG-06
Model F488A-5.3-08B
Number of Cells 8
Motor Output 191.2HP
Motor RPM 1800
Fan HP7360-7
Fan RPM 134
(Full Speed)
Design Conditions:
Flow Rate 150200GPM
Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 172730GPM
(115% Design Flow)
1 65 °F Hw
Cold Water (°F)
63
62
61
60
59
58
Wet Bulb (°F)
30
35
40
45
50
55
60
Time: 09:32:45 Date: 10-02-2007 Drawn By: PRS

Merrimack Station **F488A-5.3-08B** **PRS 10-02-2007 09:32:48**

Fixed Hot Water Curve for
Merrimack Station
Bow, NH

127670 Flow Rate (gpm)

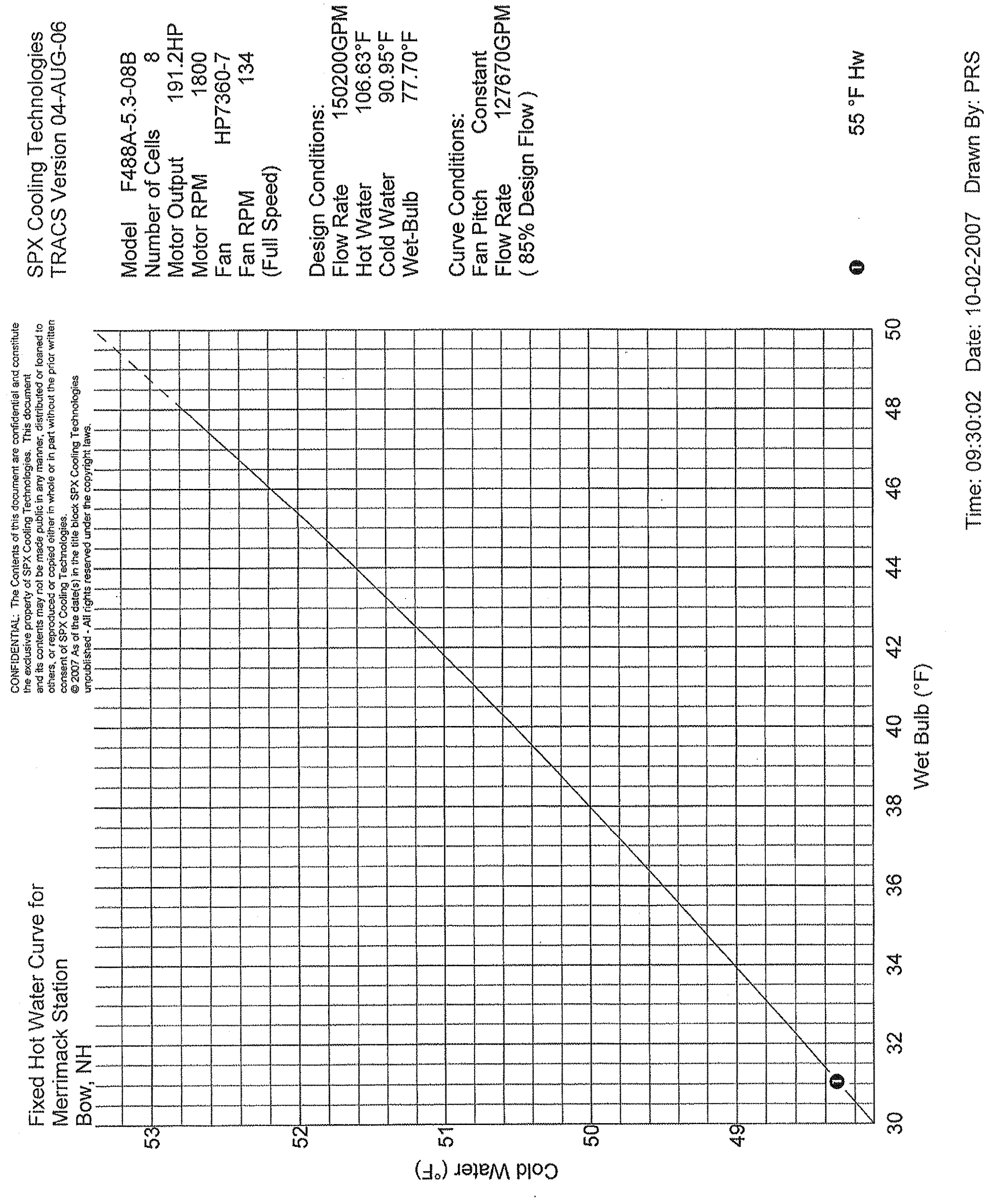
	Wet Bulb				
Hot Water	30.00	40.00	50.00	55.00	60.00
65.00	54.55	56.96	59.75	61.33	63.08
	Cold Water Temp. (°F)				

150200 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	40.00	50.00	55.00	60.00
65.00	56.14	58.18	60.54	61.89	63.37
	Cold Water Temp. (°F)				

172730 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	40.00	50.00	55.00	60.00
65.00	57.67	59.35	61.30	62.42	63.64
	Cold Water Temp. (°F)				


Fixed Hot Water Curve for
Merrimack Station
Bow, NH
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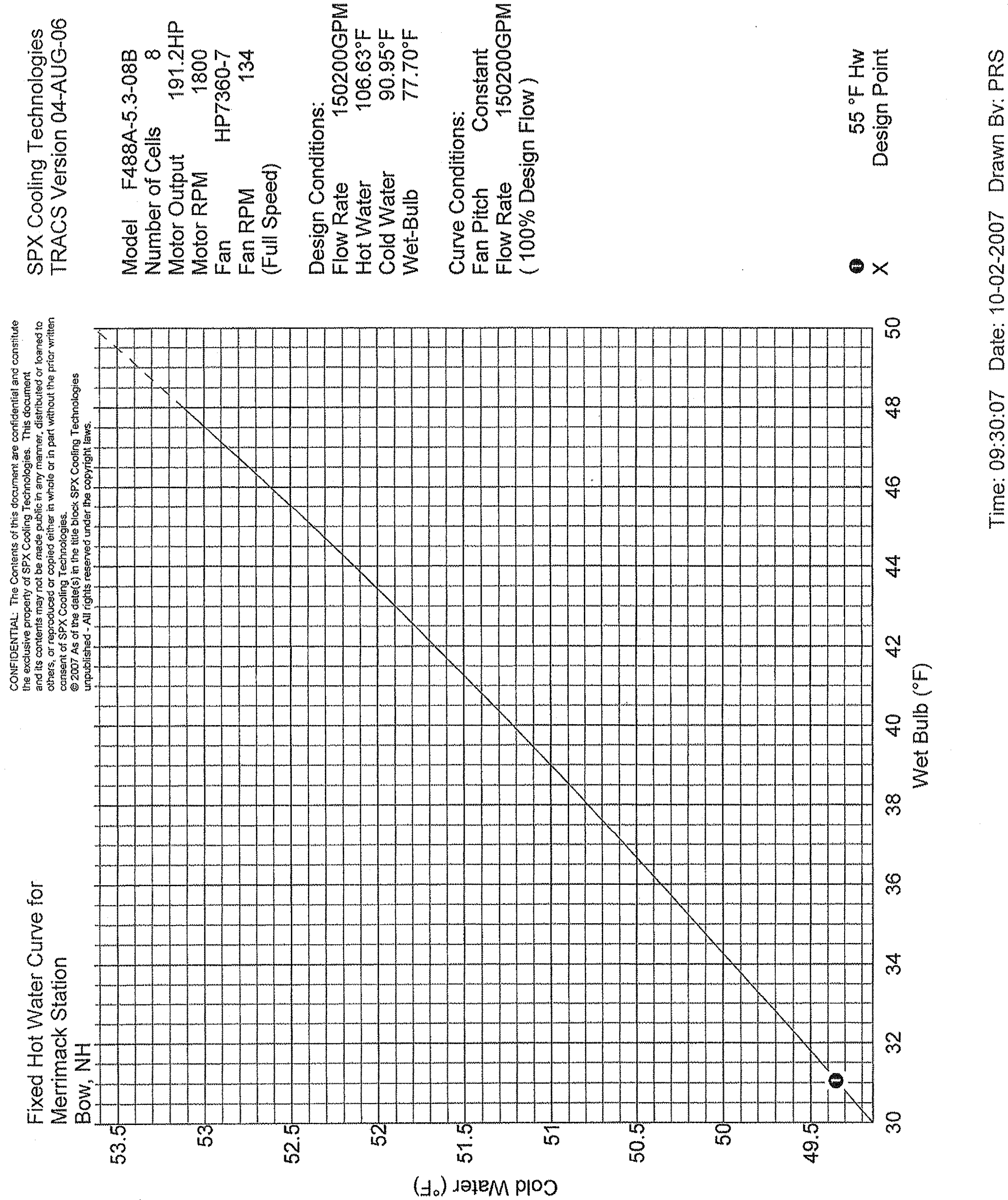
SPX Cooling Technologies
TRACS Version 04-AUG-06
Model F488A-5.3-08B
Number of Cells 8
Motor Output 191.2HP
Motor RPM 1800
Fan HP7360-7
Fan RPM 134
(Full Speed)
Design Conditions:
Flow Rate 150200GPM
Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 127670GPM
(85% Design Flow)
❶ 55 °F Hw
Cold Water (°F)
53
52
51
50
49
Wet Bulb (°F)
30
32
34
36
38
40
42
44
46
48
50
Time: 09:30:02 Date: 10-02-2007 Drawn By: PRS


Fixed Hot Water Curve for
Merrimack Station
Bow, NH
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SPX Cooling Technologies
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Motor RPM 1800
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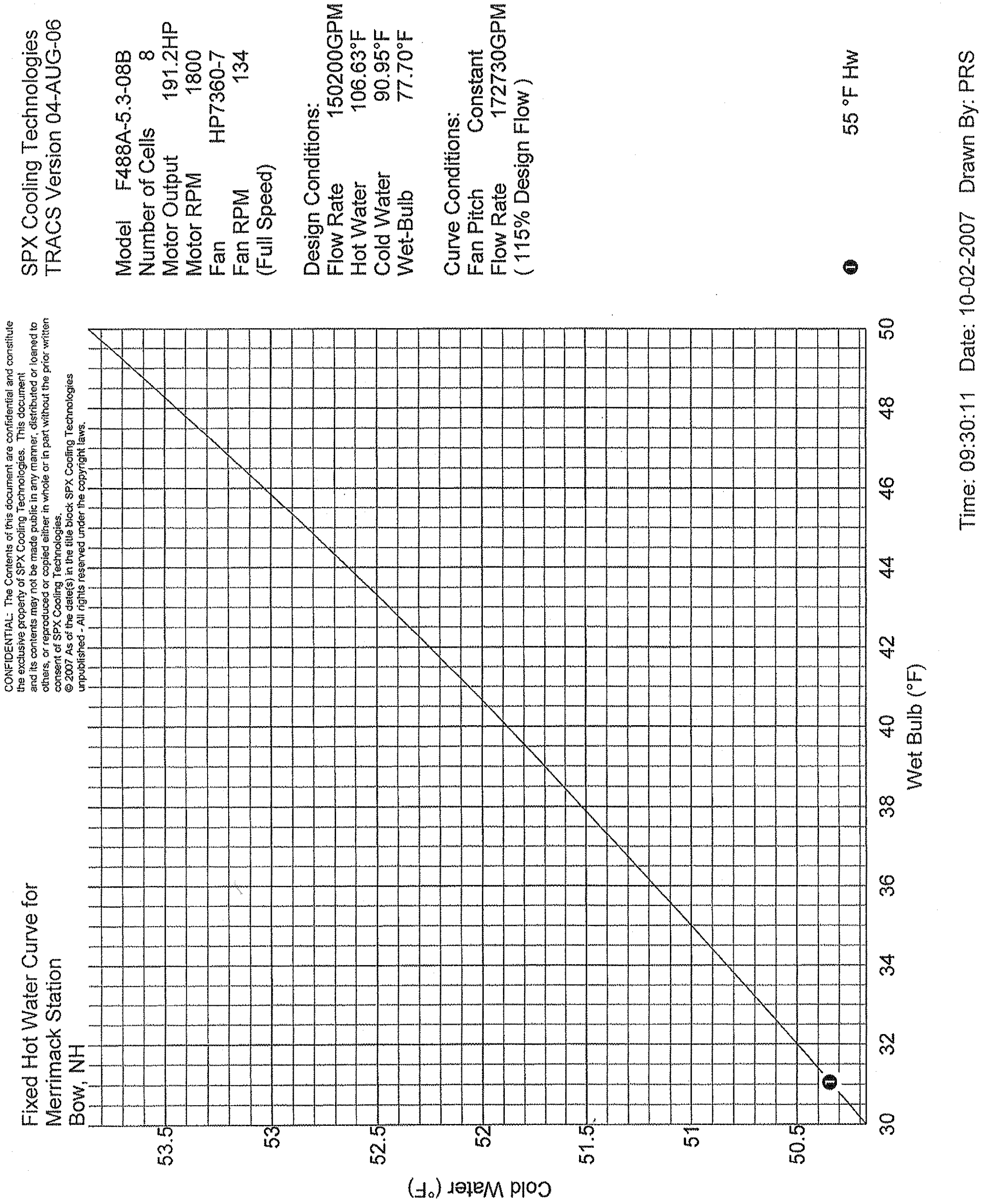
Fan RPM 134
(Full Speed)
Design Conditions:
Flow Rate 150200GPM
Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 150200GPM
(100% Design Flow)
1 55 °F Hw
X Design Point
Cold Water (°F)
53.5
53
52.5
52
51.5
51
50.5
50
49.5
Wet Bulb (°F)
30
32
34
36
38
40
42
44
46
48
50
Time: 09:30:07 Date: 10-02-2007 Drawn By: PRS


Fixed Hot Water Curve for
Merrimack Station
Bow, NH
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SPX Cooling Technologies
TRACS Version 04-AUG-06
Model F488A-5.3-08B
Number of Cells 8
Motor Output 191.2HP
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Fan RPM 134
(Full Speed)
Design Conditions:
Flow Rate 150200GPM
Hot Water 106.63°F
Cold Water 90.95°F
Wet-Bulb 77.70°F
Curve Conditions:
Fan Pitch Constant
Flow Rate 172730GPM
(115% Design Flow)
1 55 °F Hw
Cold Water (°F)
53.5
53
52.5
52
51.5
51
50.5
Wet Bulb (°F)
30
32
34
36
38
40
42
44
46
48
50
Time: 09:30:11 Date: 10-02-2007 Drawn By: PRS

Merrimack Station F488A-5.3-08B PRS 10-02-2007 09:30:14

Fixed Hot Water Curve for
Merrimack Station
Bow, NH

127670 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	35.00	40.00	45.00	50.00
55.00	48.07	49.26	50.52	51.89	53.38
	Cold Water Temp. (°F)				

150200 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	35.00	40.00	45.00	50.00
55.00	49.14	50.15	51.22	52.37	53.63
	Cold Water Temp. (°F)				

172730 Flow Rate (gpm)

	Wet Bulb				
Hot Water	30.00	35.00	40.00	45.00	50.00
55.00	50.17	51.00	51.88	52.83	53.86
	Cold Water Temp. (°F)				

Sam R Beaver

From: John.Arntson@ct.spx.com
Sent: Tuesday, August 28, 2007 3:18 PM
To: Sam R Beaver
Subject: RE: PSNH Merrimack Station: Helper Tower
Attachments: SP-DF254-A.pdf; WtrcondREV15a.pdf

Sam,
Please find attached water quality guide lines & cut sheet for DF-254.

John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

9/8/2007

SPX Cooling Technologies
Balcke | Hamon Dry Cooling | Marley

PREFERRED COOLING TOWER WATER CONDITION LIMITS

NOTE: Biological treatment and control of Legionella and other potentially health-threatening bacteria is essential. Consult a competent water treatment expert or service company.

pH	6.5 to 9.0 (special materials may be required beyond these limits)
Temperature	125° F (51.7° C) maximum, or up to 180° F (82.2° C) with special materials
Langelier Saturation Index	0.0 to 1.0 recommended; higher allowed if scale is controllable.
M-Alkalinity	100 to 500 ppm as $CaCO_3$
Silica	150 ppm as SiO_2 maximum (scale formation)
Iron	3 ppm maximum (staining and scale contributor)
Manganese	0.1 ppm maximum (staining and scale contributor)
Sulfides	Greater than 1 ppm can be corrosive to copper alloys, iron, steel, and galvanized steel. See table below for limits with film fill.
Ammonia	50 ppm maximum if copper alloys present; lower limits apply for film fill - see table.
Chlorine / bromine	1 ppm free residual intermittently (shock), or 0.4 ppm continuously maximum. Excess can attack sealants, accelerate corrosion, increase drift, and embrittle PVC.
Organic solvents	These can attack plastics and promote bio-growth. Trace amounts may be acceptable, depending on the solvent.
TDS	Over 5000 ppm can affect thermal performance and be detrimental to wood in alternately wet/dry zones such as fan deck and louver face.

Individual Ions:		MAXIMUM:
Cations:	**Calcium**	800 ppm as $CaCO_3$. (300 ppm with MX75 fill in arid climate)
	Magnesium	Depends on pH and Silica level
	Sodium	No limit
Anions:	**Chlorides**	450 ppm as Cl^- (300 for galvanized towers) upgrades are required for higher chloride levels.
	Sulfates	800 ppm as $CaCO_3$
	Nitrates	300 ppm as NO_3 (bacteria nutrient)
	Carbonates/Bicarbonates	300 ppm as $CaCO_3$ maximum preferred for wood

Fouling Contaminant Limits

Bacteria counts listed below relate to maintaining fill thermal efficiency only.
Biocidal treatment is required for all cooling tower installations. (see NOTE above).

Fill Type	Aerobic Bacteria Heterotrophic Plate Count	Total Suspended Solids (TSS)	Oil and Grease	Sulfides	Ammonia
MC75	10,000 CFU/ml	50 ppm	1 ppm	0.5 ppm	10 ppm
FB20, SNCS ("Coolfilm"),	100,000 CFU/ml	50 ppm	1 ppm	1.0 ppm	15 ppm
MX75 (crossflow), ClearFlow Modules	10,000 CFU/ml	150 ppm			
DF254, FC18, MCR16,	1,000,000 CFU/ml	50 ppm	5 ppm	1.5 ppm	25 ppm
DF381+1' MC75 overlay	100,000 CFU/ml	150 ppm			
DF381, Tricklebloc, MCR12, AAFNCS ("Cleanflow")	1,000,000 CFU/ml	250 ppm	10 ppm	2.0 ppm	25 ppm
Splash bar or grid fill	1,000,000 CFU/ml target	No specific limit	10 ppm	N/A	N/A

Note: Any amount of oil or grease is likely to adversely affect thermal performance. Sulfides and ammonia promote bacterial growth which can cause fill fouling; conformance to the limits above will assist in controlling bacteria to the recommended levels.

Drift Effects:

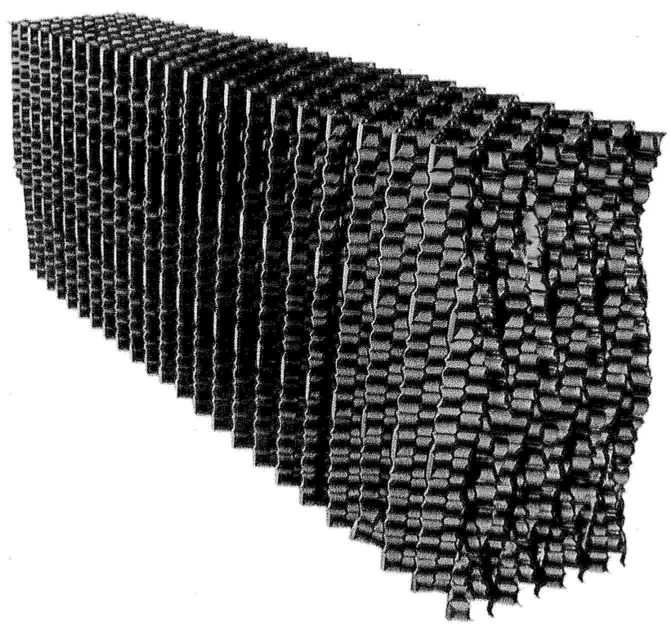
Certain contaminants or treatment chemicals such as surfactants, glycols, biodispersants and antifoams may increase drift rate. When minimizing drift is vital, the circulating water shall have a surface tension of at least 65 dynes/cm and a total organic carbon (TOC) level below 50 ppm. *Reclaim or re-use waters in particular may contain contaminants which increase drift rate either directly or by necessitating the use of treatment chemicals which increase drift rate.*

Miscellaneous Solids and Nutrients

Avoid high efficiency fill (MC75) with water containing bacteria nutrients such as alcohols, nitrates, ammonia, fats, glycols, phosphates, black liquor, or TOC greater than 50 ppm. Clog-resistant fills may be considered for contaminated water, case by case. For all film fills, avoid fibrous, oily, greasy, fatty, or tarry contaminants, which can plug fill.
In general, do not use film fill in Steel Plants, Pulp & Paper Mills, Food Processing Operations, or similar applications unless leaks and contamination by airborne or waterborne particulates, oil, or fibers are extremely unlikely. If film fill is used, biological-growth control must be stringent and diligent.

WtrcondREV15a.doc, 10/04/05 RWP

/ Marley DF254 Counterflow Fill /



Marley DF254—a film fill system designed to significantly reduce the risk of biological fouling without sacrificing high-performance heat transfer.

DF254 is a bottom support low-clog log fill configuration. Open, angular cross-corrugations allow debris and biological growth foulant to pass, while providing maximum surface area and turbulence to develop efficient heat transfer. Texturing creates thermal capability improvement with little effect on fouling. DF254 offers low pressure drop in an aerodynamic, durable design.

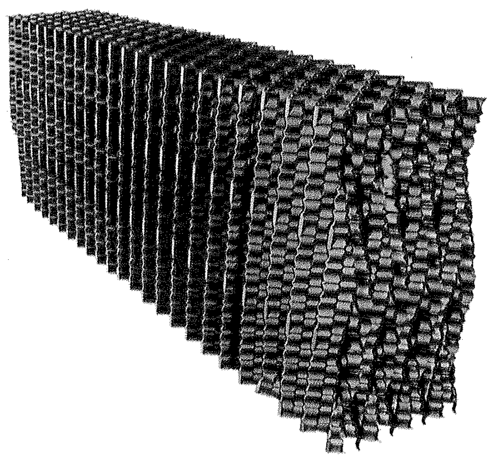
DF254 is easily adapted to your tower's configuration. To accommodate for various fill heights and/or desired duties, DF254 may be installed in multiple layers. DF254 fill is thermoformed from .020" thick, UV inhibited, chemically-resistant PVC (polyvinyl chloride). The material is extruded and manufactured to rigid specifications before forming, at one of Marley's plastics facility.

DF254 is now available worldwide for any counterflow cooling tower, regardless of a cooling tower's age, design or manufacturer.

Contact your nearest Marley sales representative for more information. To locate your Marley sales representative call SPX Cooling Technologies at 800 462 7539 or locate your Marley sales representative on the internet at www.spxcooling.com.

SPX Cooling Technologies

/ Marley DF254 Counterflow Fill /



/ Suggested Specification /

The fill will be used in counterflow cooling towers.

Construction and Materials

The fill must be film type, constructed of multiple sheets of thermoformed PVC. Each sheet must contain a pattern of angular cross-corrugations to develop the necessary heat transfer capabilities. Alternate reversal of corrugation angularity on adjacent sheets will establish the fill sheet spacing.

Fill shall be designed to be bottom-supported with a minimum number of supports.

Fill Depth (air travel)

The fill depth will be chosen to provide the proper thermal performance. To accommodate for various fill heights and/ or desired duties, the fill may be installed in multiple layers.

SPX Cooling Technologies
Balcke | Hamon Dry Cooling | Marley

/ 7401 W 129 Street // Overland Park, KS USA 66213 // +1 913 664 7400 // www.spxcooling.com /

SP-DF254-A

Sam R Beaver

From: John.Arntson@ct.spx.com
Sent: Tuesday, August 28, 2007 3:41 PM
To: Sam R Beaver
Cc: JIM.VANGARSSE@ct.spx.com; Richard.Coughlin@ct.spx.com
Subject: RE: PSNH Merrimack Station: Helper Tower

Sam,
Add 5% to go to 6.6 ft AAFNCS. Tower size & HP as previously noted.
FYI,
John K Arntson
SPX Cooling Technologies, Inc.
7401W 129 th St.
Overland Park, KS
66213

"Sam R Beaver" <sbeaver@enercon.com>

08/28/2007 02:31 PM

To <John.Arntson@ct.spx.com>
cc
Subject RE: PSNH Merrimack Station: Helper Tower

how would it affect the tower size/price if a fill that was more tolerant of high TSS (such as DF381, Tricklebloc, MCR12, or AAFNCS ("Cleanflow")) were utilized?

1. Case 2 – Proposed tower for discharge canal cooling

d. Base tower quoted by SPX
   i. 8-cell, ~13°F approach, back-to-back configuration, FRP, 200 hp fans, 3 ft of DF-254 fill
   ii. Cost = $3,900,000

e. Size increase for added cooling for extreme low river flow conditions
   i. 2 added cells, 10-cell total
   ii. Cost = original base + 25% = $975,000 adder

f. Option 1 – plume abated tower
   i. Linear configuration
   ii. Cost = (2) x 10-cell base tower cost, = $4,875,000.00 adder

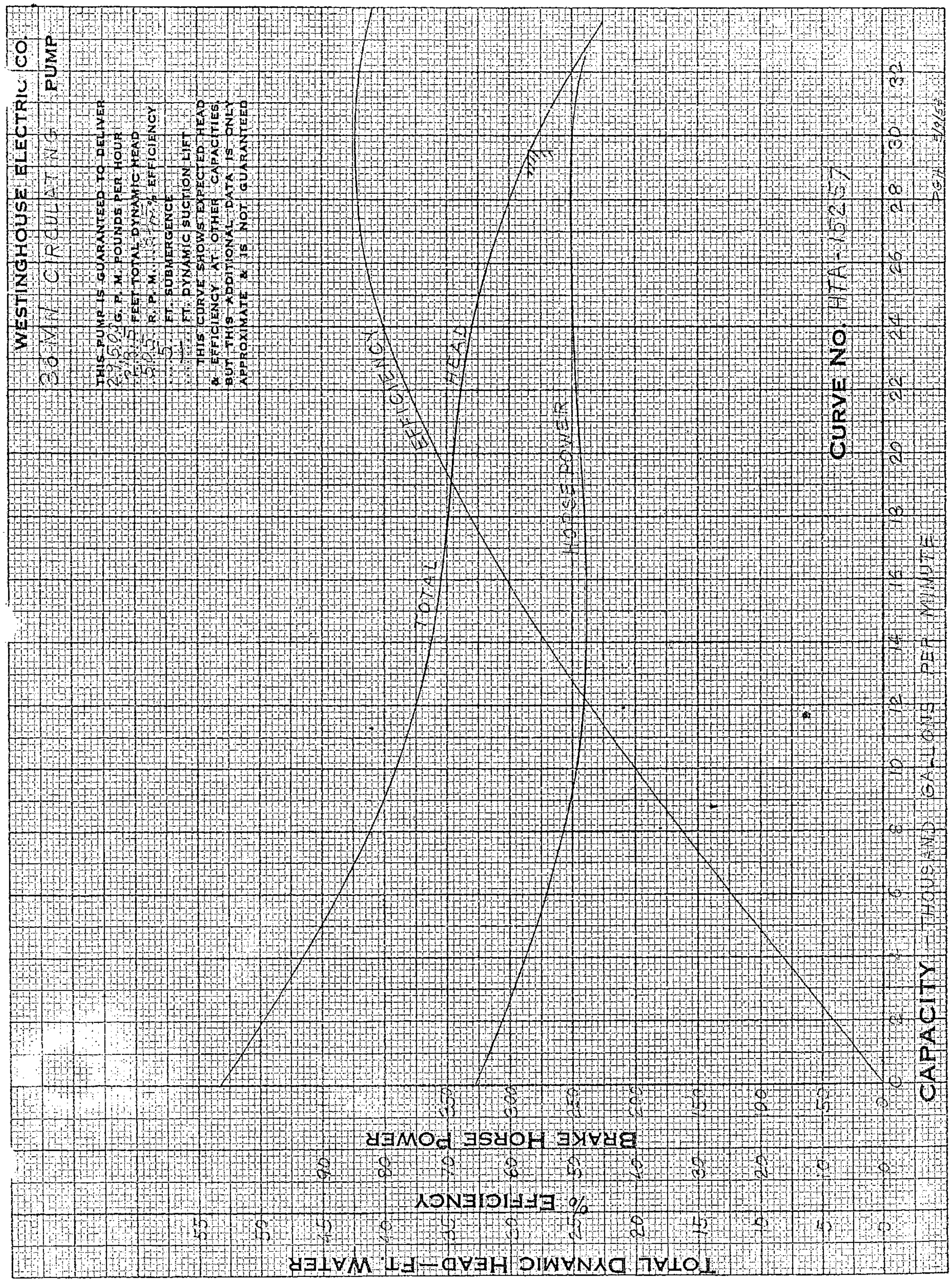
g. Option 2 – noise abatement
   i. Water noise abatement cost = 10-cell base + 15% = $731,000 adder
   ii. Low noise fans cost = 10-cell base + 20% = $975,000 adder

h. Option 3 – low-clog fill
   i. 6.6 ft AANSC low-clog fill
   ii. Cost = 10-cell base + 5% = $244,000 adder

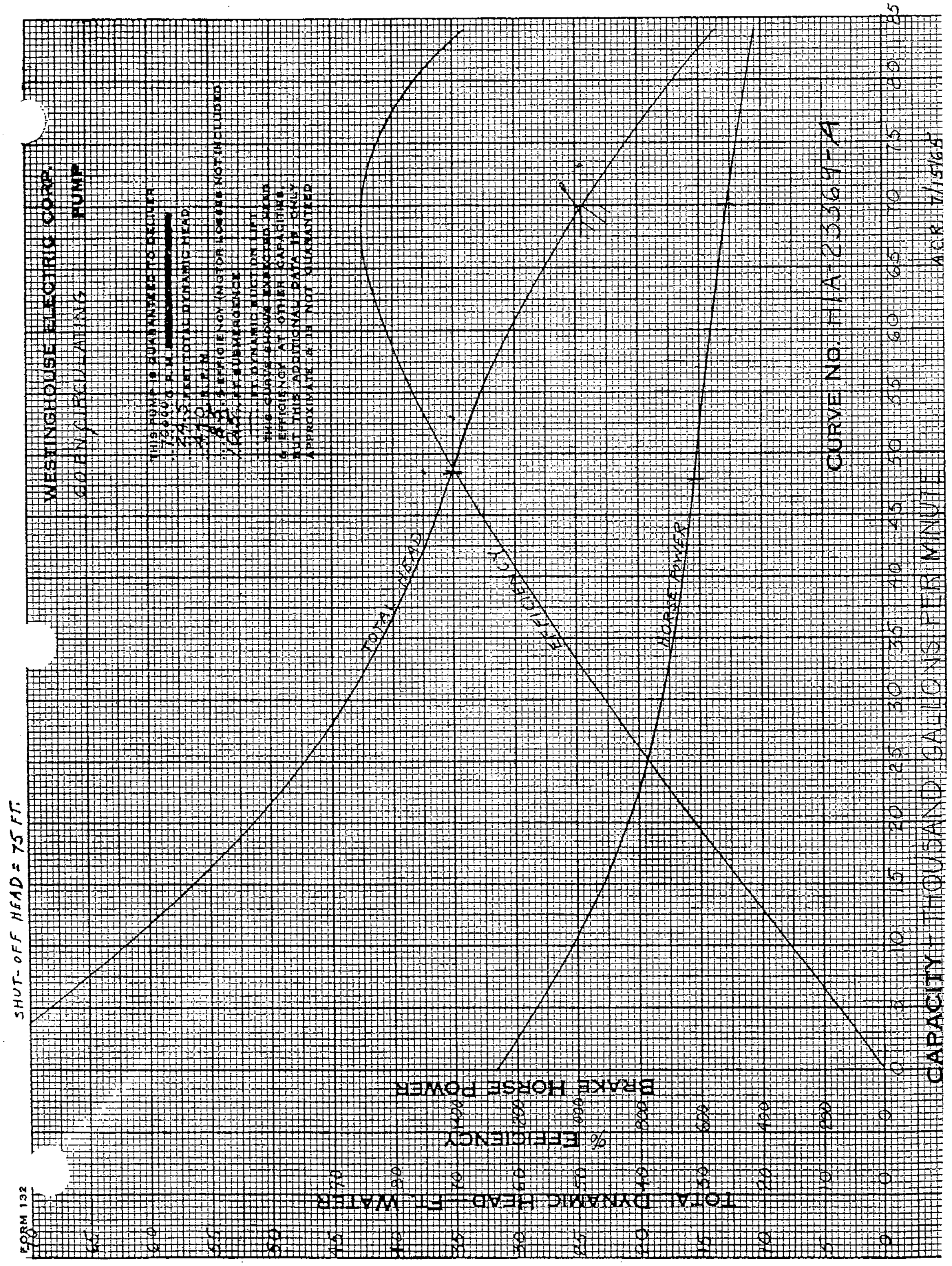
Proposed discharge canal cooling tower total cost w/ all adders,

Base tower price =	$3,900,000
+ 2 added cells =	$975,000
+ plume abated =	$4,875,000
+ water noise abated =	$731,000
+ low noise fans =	$975,000
+ low-clog fill =	$244,000
Total proposed tower cost =	**$11,700,000.00**

Existing Unit 1 Circ Water Pump Curve



Existing Unit 2 Circ Water Pump Curve



Sam R Beaver

From:	Trevillian, John [John.Trevillian@sulzer.com]
Sent:	Tuesday, October 02, 2007 2:08 PM
To:	sbeaver@enercon.com
Cc:	Harrelson, Jerry
Subject:	Merrick Station Circ Water Pumps Estimate
Attachments:	Enercon 140000 GPM.pdf; Enercon 36000 GPM.pdf

Sam,

The rough budget numbers are below, curves are attached.

Unit 1 - (2) pumps
Design Conditions: 59,000 gpm/ea @ 36 ft head
Selection: 42PS- 1 stage
Budget Price: $400,000 each

Unit 2 - (2) pumps
Design Conditions: 140,000 gpm/ea @ 36 ft head
Selection: 60 MS – 1 stage
Budget Price: $800,000 each

Best regards,

John Trevillian
Nuclear Power Business Manager
Sulzer Pumps (US) Inc
5100 Wood Valley Drive, Raleigh, NC 27613 USA
Tel. 919-518-2632
Mobile phone 919-740-9462
Fax 919-845-6339
E-mail mailto:john.trevillian@sulzer.com
Internet http://www.sulzerpumps.com

From: Sam R Beaver [mailto:sbeaver@enercon.com]
Sent: Monday, October 01, 2007 5:00 AM
To: Harrelson, Jerry
Subject: Circ Water Pumps

Jerry-

We're doing some work for a small fossil plant in the NE, Public Service New Hampshire's Merrimack Station. They are looking at putting a cooling tower on their discharge canal to maintain discharge permit limits. The tower would require a booster pumping station. Required pumps would be:

Unit 1 - (2) pumps, 59,000 gpm/ea @ 36 ft head
Unit 2 - (2) pumps, 140,000 gpm/ea @ 36 ft head

we're still in the conceptual stage at this point, but can you provide me some ballpark (rough) pricing. Call for additional info you may need for estimate,

10/5/2007

SULZER

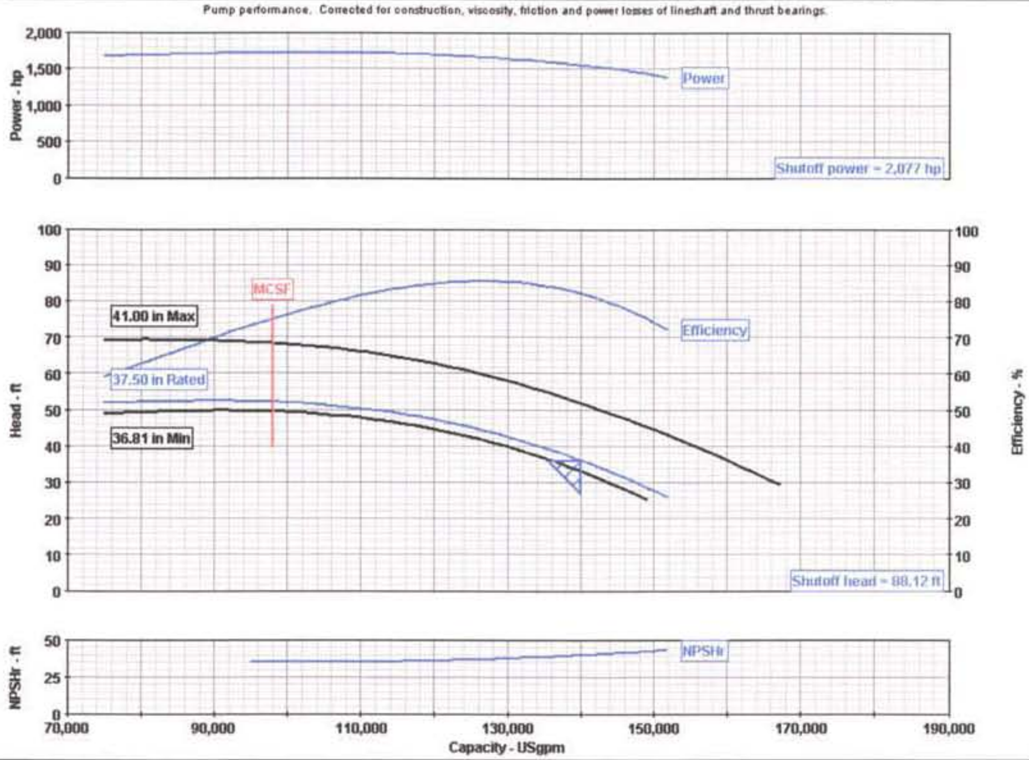
Pump Performance Datasheet

Customer	: enercon	Project ID	: Merrimack Station
Customer reference	:	Pump size	: 60MS
Item number	:	Stages	: 1
Service	:	Based on curve number	: JM-60MS-EC2250 Rev P
Quantity of pumps	: 2	Date last saved	: 02 Oct 2007 10:46 AM

Operating Conditions		Liquid	
Flow, rated	: 140,000.0 USgpm	Liquid type	: Water
Head, rated (requested)	: 36.00 ft	Additional liquid description	:
Head, rated (actual)	: 36.17 ft	Solids diameter, max	: 0.00 in
Suction pressure, rated / max	: 0.00 / 0.00 psi.g	Temperature, max	: 68.00 deg F
NPSH available, rated	: Ample	Fluid density, rated / max	: 0.998 / 0.998 SG
Frequency	: 60 Hz	Viscosity, rated	: 1.00 cP
		-	:

Performance		Material	
Pump speed, rated	: 355 rpm		
Impeller diameter, rated	: 37.50 in	Material requested	: Auto
Impeller diameter, maximum	: 41.00 in	Material selected	: Cast Iron Bowl, Bronze Impeller
Impeller diameter, minimum	: 36.81 in		
Efficiency (bowl / pump)	: 82.10 / - %	**Pressure Data**	
NPSH required / margin required	: 39.52 / 3.00 ft	Maximum working pressure	: 38.13 psi.g
Specific speed / Suction specific speed	: 6,611 / 8,455 US units	Maximum allowable working pressure	: 155.9 psi.g
MCSF	: 98,000.0 USgpm	Maximum allowable suction pressure	: 50.00 psi.g
Head, maximum, rated diameter	: 88.12 ft	Hydrostatic test pressure	: 57.00 psi.g
Head rise to shutoff	: 144.78 %	**Driver & Power Data**	
Flow, best eff. point (BEP)	: 126,737.6 USgpm	Driver sizing specification	: Rated power
Flow ratio (rated / BEP)	: 110.46 %	Margin over specification	: 0.00 %
Diameter ratio (rated / max)	: 91.46 %	Service factor	: 1.00
Head ratio (rated dia / max dia)	: 69.28 %	Power, hydraulic	: 1,270 hp
Viscous coefficients (CQ / CH / CE)	: 1.00 / 1.00 / 1.00	Power (bowl / pump)	: 1,547 / -
Selection status	: Acceptable	Power, maximum, rated diameter	: 2,077 hp
		Minimum recommended motor rating	: 2,100 hp

Pump performance. Corrected for construction, viscosity, friction and power losses of lineshaft and thrust bearings.



SULZER

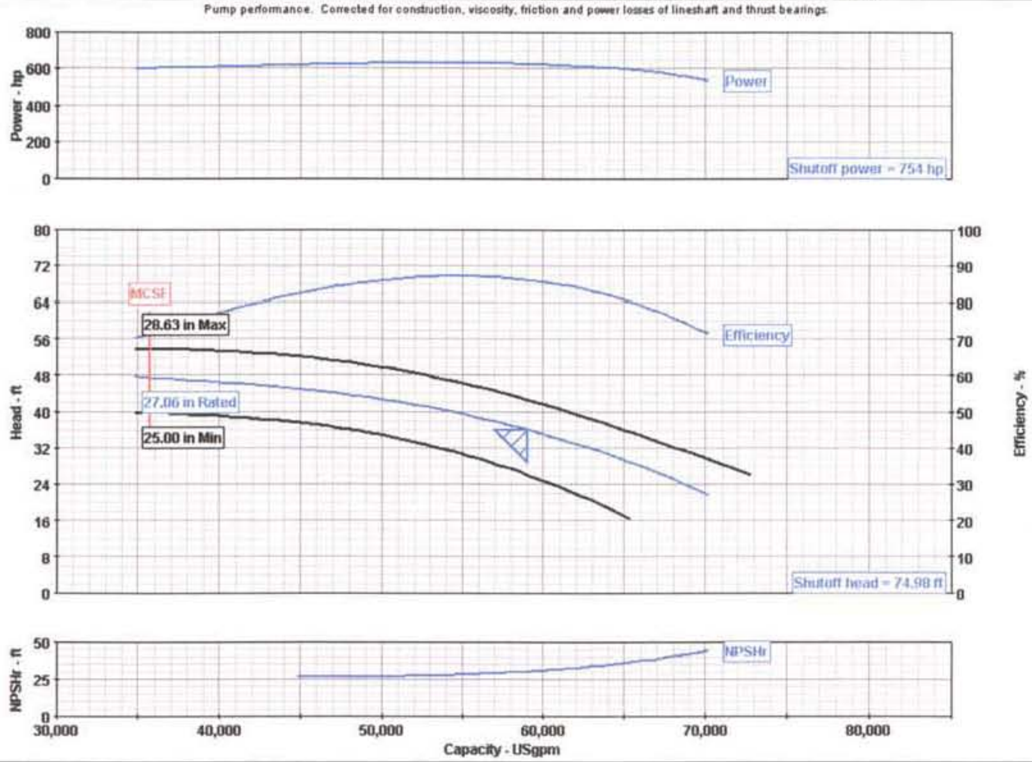
Pump Performance Datasheet

Customer	: enercon	Project ID	: Merrimack Station
Customer reference	:	Pump size	: 42PS-5V
Item number	:	Stages	: 1
Service	:	Based on curve number	: JM-42PS-EC0883-5V Rev A
Quantity of pumps	: 2	Date last saved	: 02 Oct 2007 10:45 AM

Operating Conditions		Liquid	
Flow, rated	: 59,000.0 USgpm	Liquid type	: Water
Head, rated (requested)	: 36.00 ft	Additional liquid description	:
Head, rated (actual)	: 36.13 ft	Solids diameter, max	: 0.00 in
Suction pressure, rated / max	: 0.00 / 0.00 psi.g	Temperature, max	: 68.00 deg F
NPSH available, rated	: Ample	Fluid density, rated / max	: 0.998 / 0.998 SG
Frequency	: 60 Hz	Viscosity, rated	: 1.00 cP
		-	:

Performance		Material	
Pump speed, rated	: 440 rpm	Material requested	: Auto
Impeller diameter, rated	: 27.06 in	Material selected	: Cast Iron Bowl, Bronze Impeller
Impeller diameter, maximum	: 28.63 in		
Impeller diameter, minimum	: 25.00 in	**Pressure Data**	
Efficiency (bowl / pump)	: 86.07 / - %	Maximum working pressure	: 32.45 psi.g
NPSH required / margin required	: 29.85 / 3.00 ft	Maximum allowable working pressure	: 195.9 psi.g
Specific speed / Suction specific speed	: 6,135 / 8,462 US units	Maximum allowable suction pressure	: 50.00 psi.g
MCSF	: 35,722.8 USgpm	Hydrostatic test pressure	: 49.00 psi.g
Head, maximum, rated diameter	: 74.98 ft	**Driver & Power Data**	
Head rise to shutoff	: 108.29 %	Driver sizing specification	: Rated power
Flow, best eff. point (BEP)	: 54,919.2 USgpm	Margin over specification	: 0.00 %
Flow ratio (rated / BEP)	: 107.43 %	Service factor	: 1.00
Diameter ratio (rated / max)	: 94.54 %	Power, hydraulic	: 535 hp
Head ratio (rated dia / max dia)	: 84.49 %	Power (bowl / pump)	: 622 / -
Viscous coefficients (CQ / CH / CE)	: 1.00 / 1.00 / 1.00	Power, maximum, rated diameter	: 754 hp
Selection status	: Acceptable	Minimum recommended motor rating	: 800 hp

Pump performance. Corrected for construction, viscosity, friction and power losses of lineshaft and thrust bearings.



Audrey Thompson

From: Scolfaro, Juliano (GE Indust, ConsInd) [Juliano.Scolfaro@ge.com]
Sent: Tuesday, October 02, 2007 3:45 PM
To: Sue Polyak
Cc: Leveritte, Boris (GE Indust, ConsInd)
Subject: RE: PSNH/Merrimack Station - Circulating Water Pump Motors/VFD's: MACAPT # 21044
Attachments: P21044Rev00.doc

Dear Sue,

Please find attached our revised proposal including the 600HP motor.

Best Regards,

Juliano.

GE Consumer & Industrial

Proposal # 21044

Customer:	**Enercon Services, Inc.**	Date:	**10/2/2007**
Cust. Ref.	**PSNH/Merrimack Station - Circulating Water Pump Motors/VFD's**	Folder:	
End User:	**PSNH/Merrimack Station**	MAC T:	**Juliano Scolfaro**
Cust spec:	**See Comments**	Project:	**PSNH/Merrimack Station**

Item 1 of 3 - VERTICAL 3-PHASE ADJUSTABLE SPEED MOTOR - SOLID SHAFT

Qty: **1** x **700 HP**; **16** poles; **450** rpm; **460** volts; **60 Hz**, **1.15** S.F., **DP**; estimated frame: **8557** ; application: **Circulating water pump**

NET PRICE - each motor, including accessories and tests as listed on datasheet **US$ 198,818.00**

DELIVERY - delivery time is subject to confirmation after receipt of order **45 weeks**

Item 2 of 3 - VERTICAL 3-PHASE ADJUSTABLE SPEED MOTOR - SOLID SHAFT

Qty: **1** x **300 HP**; **14** poles; **514** rpm; **460** volts; **60 Hz**, **1.15** S.F., **DP**; estimated frame: **8339** ; application: **Circulating water pump**

NET PRICE - each motor, including accessories and tests as listed on datasheet **US$ 133,897.00**

DELIVERY - delivery time is subject to confirmation after receipt of order **40 weeks**

Item 3 of 3 - VERTICAL 3-PHASE ADJUSTABLE SPEED MOTOR - SOLID SHAFT

Qty: **1** x **600 HP**; **16** poles; **450** rpm; **460** volts; **60 Hz**, **1.15** S.F., **DP**; estimated frame: **8557** ; application: **Circulating water pump**

NET PRICE - each motor, including accessories and tests as listed on datasheet **US$ 191,908.00**

DELIVERY - delivery time is subject to confirmation after receipt of order **45 weeks**

COMMERCIAL TERMS

T & C's:	**Conditions of sale in GEP-973G apply.**
Price policy:	**Net cash 30 days from date of invoice.**
Proposal validity:	**Price clause 1Q applies. Price valid for 30 days.**
Delivery:	**FOB Norfolk VA. Freight Inland freight the responsibility of the customer.**
Codes/Stds:	**ANSI/NEMA M.G.1; IEEE 1/85/112/115.**

UNLESS SPECIFIED OTHERWISE, ALL VALUES ARE NOMINAL AT RATED VOLTAGE AND FREQUENCY

GE Consumer & Industrial

- DATA SHEET -

Customer: **Enercon Services, Inc.** Proposal # **21044** Date: **10/2/2007** Item # **1**

Output Power	**700 HP**	Type	**KV**
Number of Poles	**16**	Mounting	**Vertical**
Voltage	**460 V**	Frame (estimated)	**8557**
Frequency	**60 Hz**	Enclosure	**DP**
Number of Phases	**3**	Service Factor	**1.15**
Synchronous Speed	**450**	Insulation Class	**F**
Rated Speed	**440**	Altitude (ft)	**3300**
Ambient Temperature (°C)	**40**	Efficiency (%) - Rated Load	**93.3**
Method of Temperature Measurement	**Resistance**	Efficiency (%) - 3/4 Load	**92.8**
Temperature Rise at S.F. 1.15 (°C)	**90**	Efficiency (%) - 1/2 Load	**91.8**
Noise (sound) Level (dBA)	**85**		
Starting Method	**Across the line**	Power Factor (%) - Rated Load	**70**
Minimum Starting Voltage (%V)	**90**	Power Factor (%) - 3/4 Load	**62**
Maximum Consecutive Starts (Cold/Hot)	**2/1**	Power Factor (%) - 1/2 Load	**50**
Rated Current (Amps)	**1003**		
Locked Rotor Current (% Rated Current)	**550%**		
Locked Rotor Torque (% Rated Torque)	**60**		
Breakdown Torque (% Rated Torque)	**175**		
Bearing Type	**Antifriction**	Rotation View from ODE	**Dual**
Lubrication	**Oil Bath**	Maximum Load WK2 (lb-ft²)	**76949**
Rotor Bar Construction	**Copper**	Rated Torque (lb-ft)	**8355**
Continuous External Down Thrust (lb)	**20000**	Thrust Bearing Type	**Natural cooling**
Momentary External Down Thrust (lb)	**17500**	Thrust Bearing L10 Life (hours)	**50000**
Momentary External Up Thrust (lb)	**3000**		

ACCESSORIES AND SPECIAL FEATURES

Bearing - Temperature Detector - Thermocouple - Qty: 2
Space Heaters - Space Heaters - Standard Temperature
Stator - Temperature Detector - Stator Platinum RTD (100 Ohm) - Qty: 6
Installation in non hazardous location
Standard warranty terms: 18 months from shipment / 12 months operational whichever occurs first

TESTS

Non-witnessed Routine test

- DATA SHEET -

Customer: **Enercon Services, Inc.** Proposal # **21044** Date: **10/2/2007** Item # **2**

Output Power	**300 HP**	Type	**KV**
Number of Poles	**14**	Mounting	**Vertical**
Voltage	**460 V**	Frame (estimated)	**8339**
Frequency	**60 Hz**	Enclosure	**DP**
Number of Phases	**3**	Service Factor	**1.15**
Synchronous Speed	**514**	Insulation Class	**F**
Rated Speed	**505**	Altitude (ft)	**3300**
Ambient Temperature (°C)	**40**	Efficiency (%) - Rated Load	**92.0**
Method of Temperature Measurement	**Resistance**	Efficiency (%) - 3/4 Load	**91.5**
Temperature Rise at S.F. 1.15 (°C)	**90**	Efficiency (%) - 1/2 Load	**90.3**
Noise (sound) Level (dBA)	**85**		
Starting Method	**Across the line**	Power Factor (%) - Rated Load	**68**
Minimum Starting Voltage (%V)	**90**	Power Factor (%) - 3/4 Load	**60**
Maximum Consecutive Starts (Cold/Hot)	**2/1**	Power Factor (%) - 1/2 Load	**48**
Rated Current (Amps)	**449**		
Locked Rotor Current (% Rated Current)	**550%**		
Locked Rotor Torque (% Rated Torque)	**60**		
Breakdown Torque (% Rated Torque)	**175**		
Bearing Type	**Antifriction**	Rotation View from ODE	**Dual**
Lubrication	**Oil Bath**	Maximum Load WK2 (lb-ft^2)	**25561**
Rotor Bar Construction	**Copper**	Rated Torque (lb-ft)	**3119**
Continuous External Down Thrust (lb)	**10000**	Thrust Bearing Type	**Natural cooling**
Momentary External Down Thrust (lb)	**17500**	Thrust Bearing L10 Life (hours)	**50000**
Momentary External Up Thrust (lb)	**3000**		

ACCESSORIES AND SPECIAL FEATURES

Bearing - Temperature Detector - Copper BTD (10 ohm) - Qty: 2
Space Heaters - Space Heaters - Standard Temperature
Stator - Temperature Detector - Stator Platinum RTD (100 Ohm) - Qty: 6
Installation in non hazardous location
Standard warranty terms: 18 months from shipment / 12 months operational whichever occurs first

TESTS

Non-witnessed Routine test

EXCEPTIONS AND COMMENTS

Budgetary proposal.
The new motor will meet mounting and shaft dimensions of existing motor. All other dimensions will be different.
We need to receive the load inertia and speed torque curve in order to confirm price, delivery and product availability.

- DATA SHEET -

Customer: **Enercon Services, Inc.** Proposal # **21044** Date: **10/2/2007** Item # **3**

Output Power	**600 HP**	Type	**KV**
Number of Poles	**16**	Mounting	**Vertical**
Voltage	**460 V**	Frame (estimated)	**8557**
Frequency	**60 Hz**	Enclosure	**DP**
Number of Phases	**3**	Service Factor	**1.15**
Synchronous Speed	**450**	Insulation Class	**F**
Rated Speed	**440**	Altitude (ft)	**3300**
Ambient Temperature (°C)	**40**	Efficiency (%) - Rated Load	**93.1**
Method of Temperature Measurement	**Resistance**	Efficiency (%) - 3/4 Load	**92.6**
Temperature Rise at S.F. 1.15 (°C)	**90**	Efficiency (%) - 1/2 Load	**91.6**
Noise (sound) Level (dBA)	**85**		
Starting Method	**Across the line**	Power Factor (%) - Rated Load	**68**
Minimum Starting Voltage (%V)	**90**	Power Factor (%) - 3/4 Load	**60**
Maximum Consecutive Starts (Cold/Hot)	**2/1**	Power Factor (%) - 1/2 Load	**48**
Rated Current (Amps)	**887**		
Locked Rotor Current (% Rated Current)	**550%**		
Locked Rotor Torque (% Rated Torque)	**60**		
Breakdown Torque (% Rated Torque)	**175**		
Bearing Type	**Antifriction**	Rotation View from ODE	**Dual**
Lubrication	**Oil Bath**	Maximum Load WK2 (lb-ft²)	**66842**
Rotor Bar Construction	**Copper**	Rated Torque (lb-ft)	**7162**
Continuous External Down Thrust (lb)	**10000**	Thrust Bearing Type	**Natural cooling**
Momentary External Down Thrust (lb)	**17500**	Thrust Bearing L10 Life (hours)	**50000**
Momentary External Up Thrust (lb)	**3000**		

ACCESSORIES AND SPECIAL FEATURES

Bearing - Temperature Detector - Copper BTD (10 ohm) - Qty: 2
Space Heaters - Standard Temperature
Stator - Temperature Detector - Stator Platinum RTD (100 Ohm) - Qty: 6
Installation in non hazardous location
Standard warranty terms: 18 months from shipment / 12 months operational whichever occurs first

TESTS

Non-witnessed Routine test

EXCEPTIONS AND COMMENTS

Budgetary proposal.
The new motor will meet mounting and shaft dimensions of existing motor. All other dimensions will be different.
We need to receive the load inertia and speed torque curve in order to confirm price, delivery and product availability.

Audrey Thompson

From: Scolfaro, Juliano (GE Indust, ConsInd) [Juliano.Scolfaro@ge.com]
Sent: Tuesday, October 02, 2007 4:22 PM
To: Sue Polyak
Cc: Leveritte, Boris (GE Indust, ConsInd)
Subject: RE: PSNH/Merrimack Station - Circulating Water Pump Motors/VFD's: MACAPT # 21044

Sue,

No problem. I'm here for that.

As this motors are a low voltage motor the drives are not so expensive.
Considering the above and also considering that a dual speed / dual winding motor is about 70% more expensive then the regular single speed motor my guess is that the option with drive is less expensive.
Also the option with drive is more simple in terms of control.

Best Regards,

Juliano.

From: Sue Polyak [mailto:spolyak@enercon.com]
Sent: Tuesday, October 02, 2007 5:17 PM
To: Scolfaro, Juliano (GE Indust, ConsInd)
Cc: Leveritte, Boris (GE Indust, ConsInd)
Subject: RE: PSNH/Merrimack Station - Circulating Water Pump Motors/VFD's: MACAPT # 21044

Thanks, Juliano.

My Project Manager is really questioning the idea that variable speed drives and new motors would be less expensive than two speed motors. He wants to make sure we can answer the plant's questions when asked why this is true. I've talked to other engineers here who are also surprised by that. Is there anything particular to this application that is causing this to be so?

Thanks! I know you've already assisted me a lot today, but I'm really getting push back on this.

Sue

Audrey Thompson

From: Leveritte, Boris (GE Indust, ConsInd) [Boris.Leveritte@ge.com]
Sent: Wednesday, October 03, 2007 1:41 AM
To: Sue Polyak
Cc: Scolfaro, Juliano (GE Indust, ConsInd)
Subject: RE: PSNH/Merrimack Station - Circulating Water Pump Motors/VFD's: MACAPT # 21044

Sue,

I completely agree with Juliano. This scenario would be dramatically different if the motors and drives in question were medium voltage. The cost of the drives would likely be more expensive by a factor of 2 - 3X. I recently quoted a 700 HP, 4160V drive for a customer, and the price was in the $150K range.

Regards,

Boris

Audrey Thompson

From: Leveritte, Boris (GE Indust, ConsInd) [Boris.Leveritte@ge.com]
Sent: Tuesday, October 02, 2007 8:57 AM
To: Sue Polyak
Cc: Scolfaro, Juliano (GE Indust, ConsInd)
Subject: Budgetary VFD Pricing for Merrimack Station - Circ Water Pump Motor Replacements

Sue,

I will be traveling and out of pocket most of the day. Thus I have asked Juliano Scolfaro, our motor application engineer who is working on the proposal to send the proposal directly to your attention with a copy to me. You will receive the motor quotes later today.

Shown below are the budgetary VFD prices and lead times you requested:

Item 1) VFD suitable for controlling 300 HP, 514 RPM Motor with estimated Full Load Amps = 477 A
Net Price Each = $ 24,960
Delivery = 20 weeks

Item 2) VFD suitable for controlling 700 HP, 450 RPM Motor with estimated Full Load Amps = 1077 A
Net Price Each = $ 59,650
Delivery = 24 weeks

Best Regards,

Boris Leveritte
Regional End User Account Mgr.
GE Motors & Controls
20 Technology Pkwy, Suite 380
Norcross, Ga. 30092
O (770) 662-4957
F (770) 447-7218
C (404) 556-2804

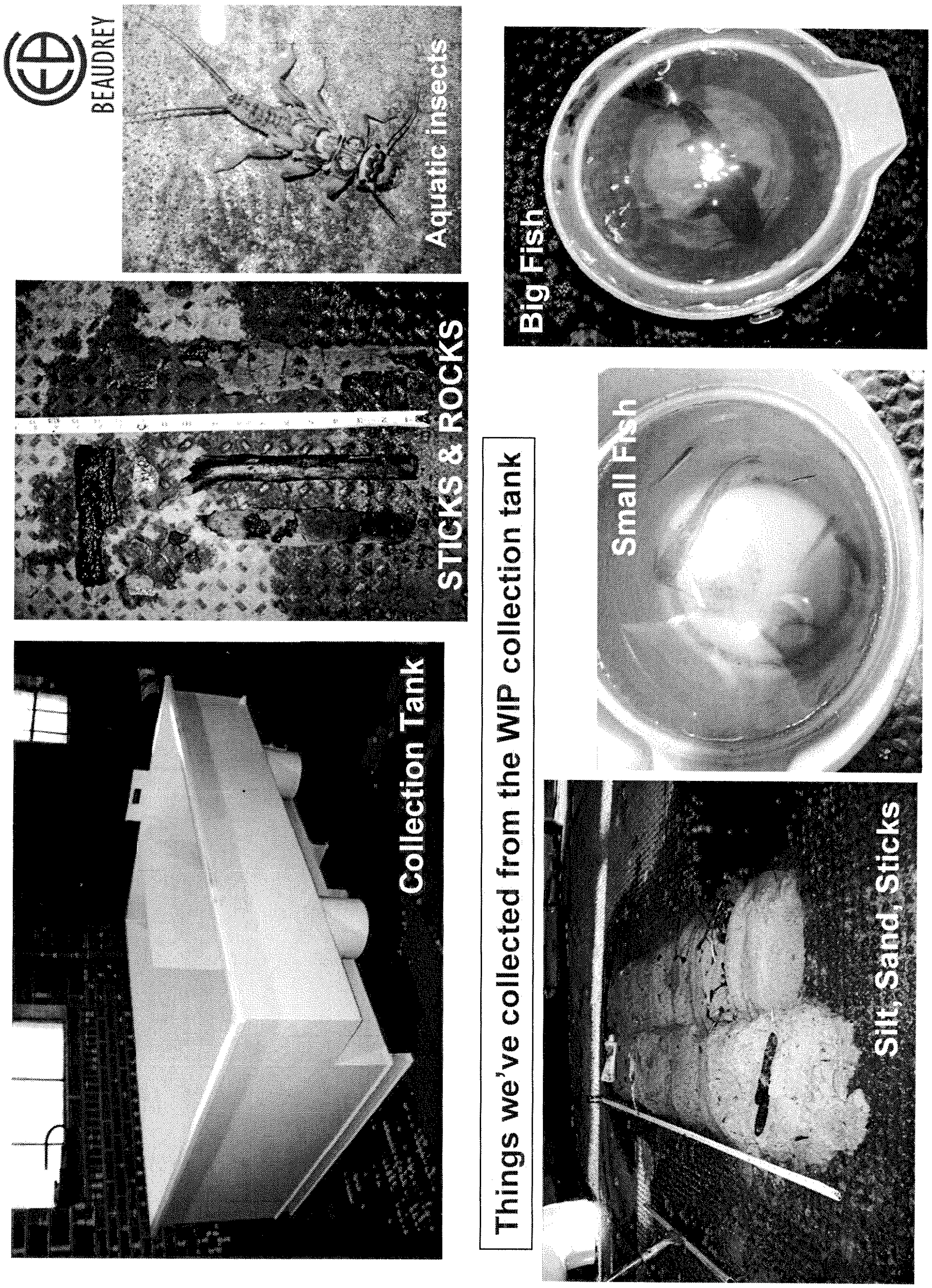
Audrey Thompson

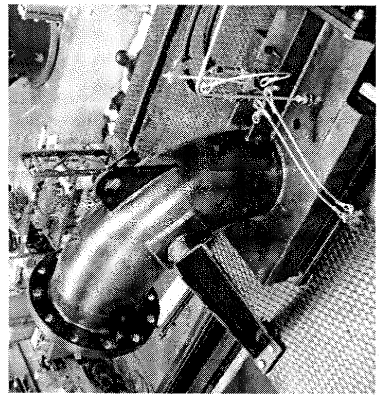
From: Brian Hittle [brian.hittle@beaudreyusa.com]
Sent: Wednesday, August 22, 2007 12:14 PM
To: 'Sue Polyak'
Subject: RE: Vendor Information Packet - PART 3 of 3
Attachments: Beaudrey - WIP screen on Missouri River.pdf

Sue,

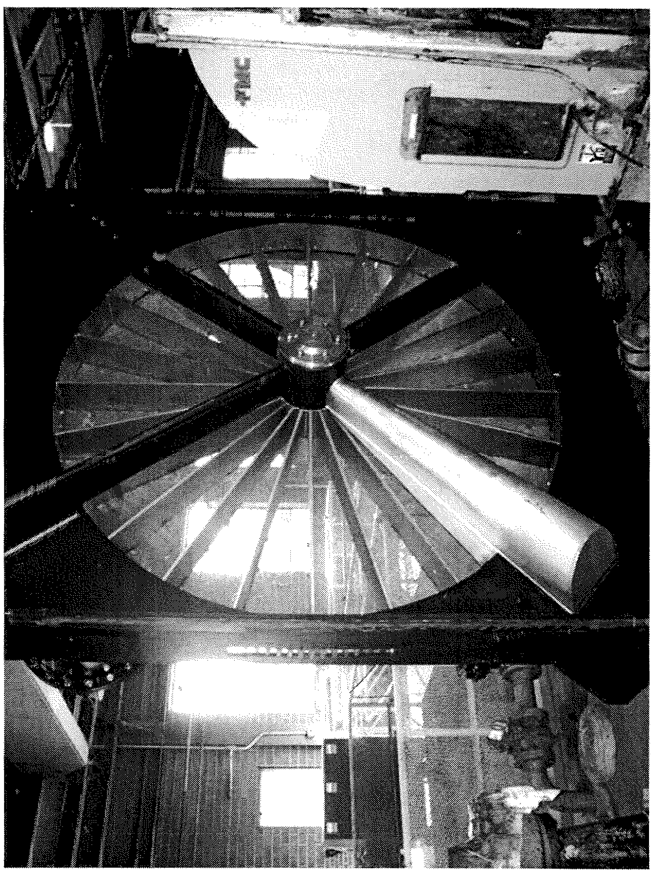
Attached are some pictures of one of our new concept screens I was telling you about on the phone.

Brian


BEAUDREY
Things we've collected from the WIP collection tank
Collection Tank
STICKS & ROCKS
Aquatic insects
Big Fish
Small Fish
Silt, Sand, Sticks

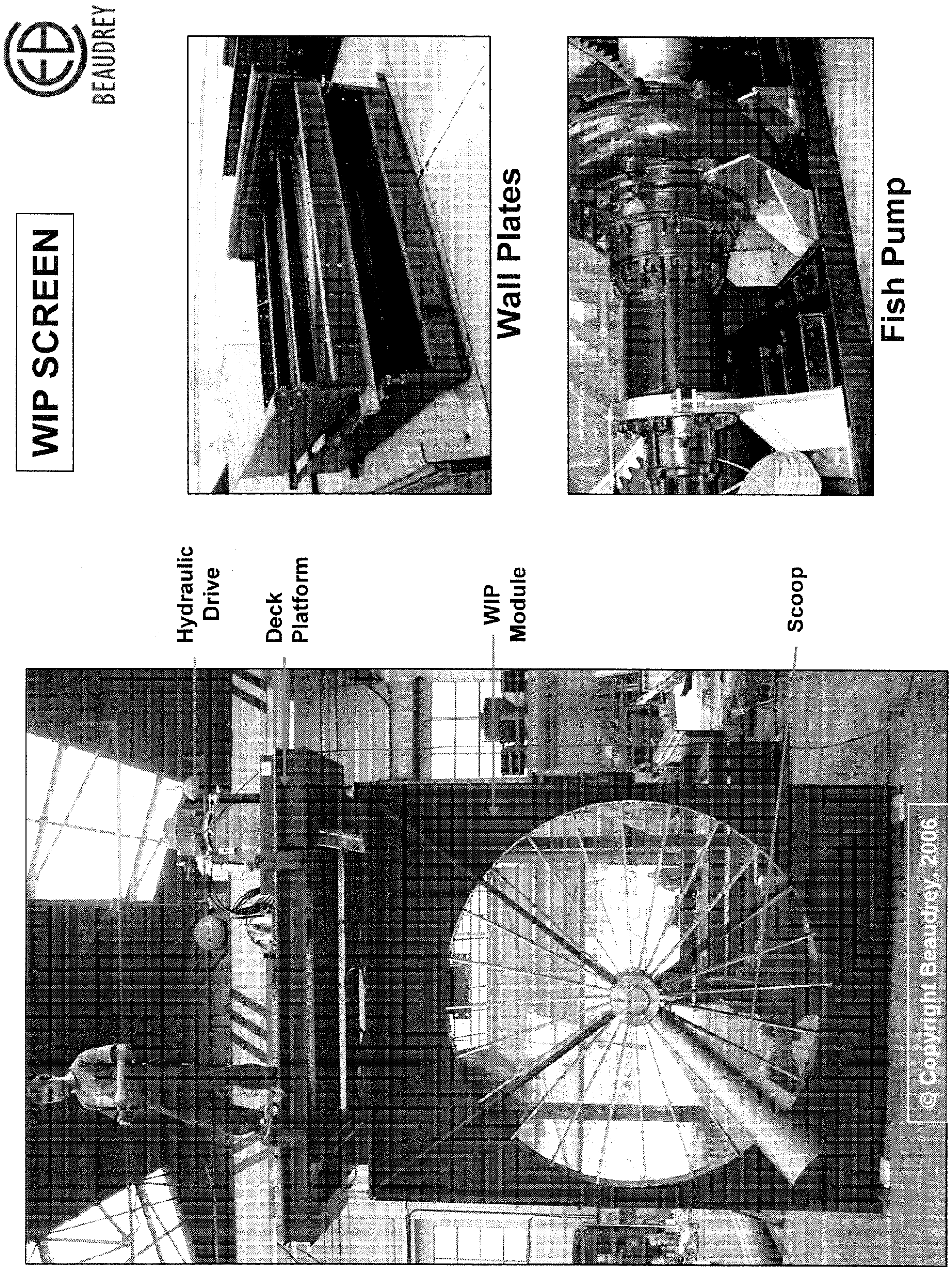


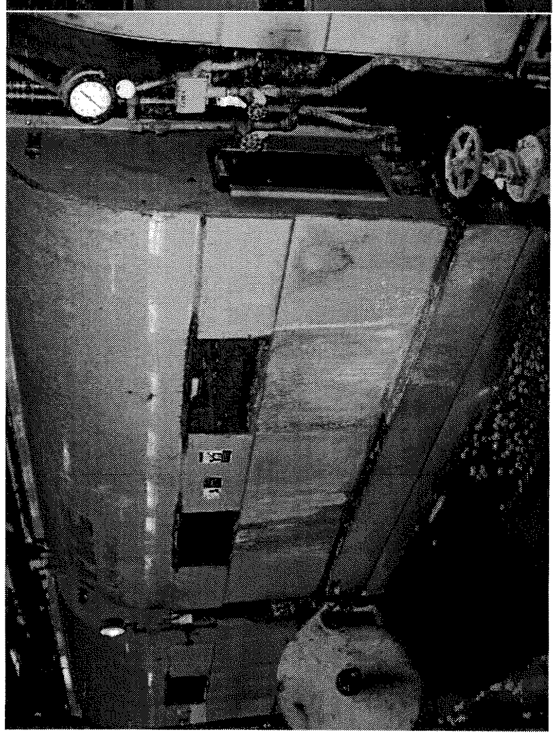
Discharge Elbow



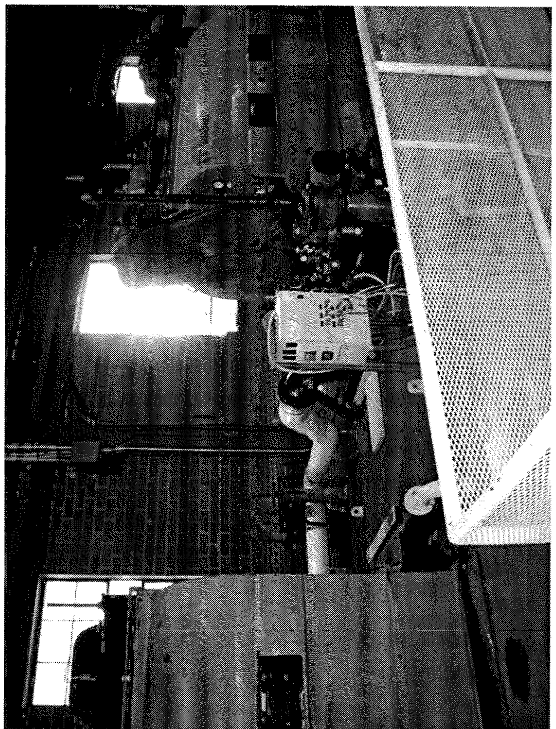
WIP pulled up for inspection

BEAUDREY


WIP SCREEN
BEAUDREY
Wall Plates
Fish Pump
Hydraulic Drive
Deck Platform
WIP Module
Scoop
© Copyright Beaudrey, 2006



Traveling Screen (Before)



WIP Deck Platform (After)

Audrey Thompson

From: Brian Hittle [brian.hittle@beaudreyusa.com]
Sent: Friday, September 21, 2007 4:08 PM
To: 'Sue Polyak'
Subject: Beaudrey: Merrimack Proposal Unit 1 (WIP Screen)
Attachments: 18105-Merrimack1-10071-R01-Rev 1.pdf

Sue,

Thanks for your patience. Please find attached your proposal for Merrimack Unit 1 WIP Screen option.

Best regards,

Brian

Brian Hittle
Beaudrey USA
Office: 913 390 5227
Fax: 913 390 5228
Mobile: 913 568 2668
Email: brian.hittle@beaudreyusa.com

BEAUDREY USA
25055 W Valley Pkwy 203
Olathe, KS. 66061

Tel. 913 390 5227
Fax 913 390 5228
Email info@beaudreyusa.com

PUBLIC SERVICE CO. OF NEW HAMPSHIRE

for

MERRIMACK STATION - UNIT 1

COMMERCIAL PROPOSAL FOR THE SUPPLY OF "WIP" TYPE SCREENING SYSTEMS

Beaudrey reference	:	EXXXX-Merrimack-unit 1-10071-R01-Rev 1
Date	:	20 September 2007
Project Director	:	Brian Hittle

1 SCOPE OF SUPPLY

1.1 EQUIPMENT

QUANTITY	EQUIPMENT
2	"WIP" screen modules each consisting of :
	• One screening wheel
	• One set of wheel "Nocling" panels (Not segmented)
	• One wheel spur gears in segments
	• One drive pinion
	• One (1) hydraulic drive motor
	• One (1) jack-up stand with guide rails
	• One fabricated support plates that include the suction scoop. They are slid into the existing wall guides
2	Vertical backwash water pipes
2	Hydraulic drive pumps, tanks and accessories
2	Hydraulic drive feed pipes
2 sets	Grease pipes for the wheels
2 sets	Ultrasonic differential level measuring systems with two probes
1	Electrical switchgear control cabinet
2	Submerged fish pump

1.2 PACKING AND DELIVERY

DDU site

2 COMMERCIAL TERMS

2.1 PRICE OF EQUIPMENT

EQUIPMENT	PRICES US dollar
"WIP" SYSTEMS as per preceding scope of supply	**$ 488,190.00**
Fish Safe Pumps	**$ 67,00.00**
Delivery (DDU As per Incoterm 2000)	Included

The above prices are considered subject to the conditions hereafter. They include no taxes, whether value-added, corporate or personal, nor any duties, excises of any sort that might be due past delivery point as per Incoterms 2000.

2.2 SPARE PARTS FOR TWO YEARS OPERATION

Later.

2.3 PRICES ARE FIRM

The prices are firm for an order placed within the tender validity period for delivery as stated below.

2.4 VALIDITY OF TENDER

This tender is valid for three months from date of proposal.

2. "WIP" SYSTEM (BEAUDREY PATENT)

3.3 PURPOSE

All water intakes using through-flow travelling screens suffer from debris carry-over. Such screens are not well suited to sea-life protection. Retrofitting dual-flow screens is not always possible for hydraulic flow pattern reasons. Dual-flow retrofits offer no fish conservation advantage.

The Beaudrey "WIP" screen has been developed to overcome all these problems. It is a development of the well-proven "Fish Protection System" system applied to the equally proven Beaudrey "W" filter.

3.4 HOW IT WORKS

The water flows through a rotating screening disk. The debris and sea-life are arrested by the fish-friendly Nocling panel. They are stored in the deep radial compartments ahead of the Nocling mesh.

When water-life preservation is paramount, the fish friendly designed pump is continuously pumping as the disk(s) rotate slowly. The scoop backwashes all the debris from the mesh and debris compartment. The backwash flow and debris are pumped up to deck level. The backwash water is returned via pipes or flumes to a safe location, to avoid recirculation..

When fish are not a concern, the washing cycle of wheel only start when one of the following signal is triggered (increase of pressure drop, clock or manual star). The pump start pumping while the wheel disk is rotating slowly. After 1 ½ rotations, the disk is cleaned and rotation stopped. The backwash water goes through a debris concentrator. The debris-free water returns to the screen pit. The debris and a small quantity of water is discharged into the existing deck debris trough at the end of the cleaning cycle. Continuous rotation can be used in this case for critical periods

3.5 MAIN COMPONENTS

- The screening wheel(s)
- The "Nocling" screening panels secured to the wheel
- The spur gear segments of each wheel
- The drive pinion bolted onto the pinion hub
- The drive motor
- The wheel support plate(s) slid into the wall guides.

  The support plate comprises :

  - The suction scoop
  - The shaft hub and radial support members
  - The drive securing flange
  - The pump supports
- The submerged backwash debris pump of the volumetric, centrifugal Hidrostal type
- The control skid at deck level, which includes :
  - The hydraulic drive pump, tank and accessories
  - The differential head-loss measuring system
  - The concentrator which comprises the shell, the screening cartridge, the water return valve and the down-load valve.

3.6 OPERATION

- The wheel is rotating continuously. The backwash pump is also running continuously.

- The wheel drive is overload protected by a hydraulic pressure switch which will reverse rotation in case of blockage. If rotation is reversed again, an alarm will sound but the screen will remain in service.

- When rotation stops, the backwash pump is also stopped.
- A high head-loss alarm is also provided.
- In case of excessive head-loss that could permanently damage the screen, a
- "Stop Main Pump" signal is made.

3.7 ADVANTAGES

3.7.1 Main advantages

- NO DEBRIS CARRYOVER
- Best available water-life protection (both for swimmers and non-swimmers).
- Combination of the time-proven "Scoop-a-fish" system, the Nocling panel and the "W" debris filter (all patented Beaudrey systems).
- Fibrous build-up-free and jelly-fish proof Nocling panels.
- Low head-loss and smooth outlet flow pattern.
- Low maintenance cost.
- Fits all through-flow screen pits with NO CIVIL engineering modification.
- Fully automatic.
- Low investment cost.
- Easy maintenance, the screen & pump can be lifted to the deck for inspection.
- Smooth outlet flow pattern.

3.7.2 Advantages of "WIP" SCREENS versus Through-flow travelling screens

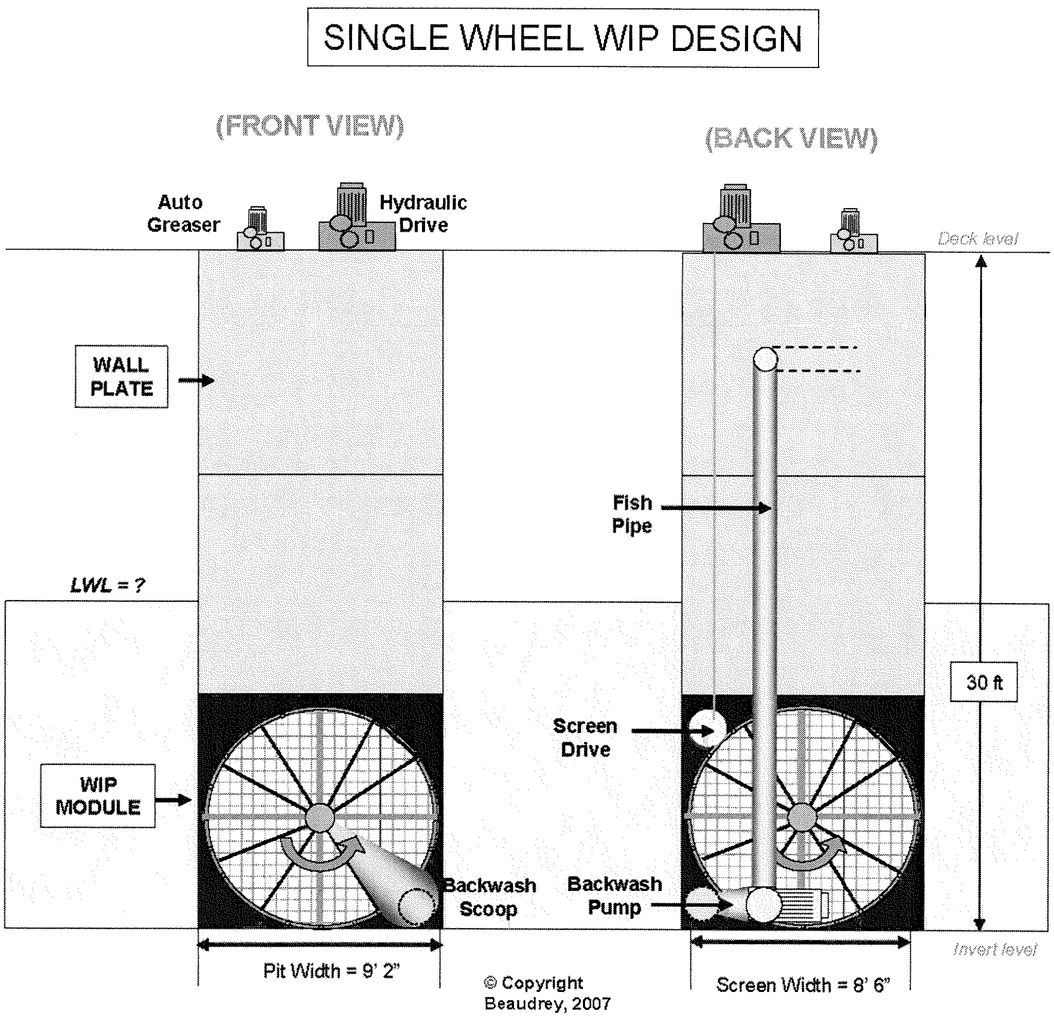
CHARACTERISTIC	COMPARAISON
Screening area at LWL	Net mesh area reduction negligible
Debris-handling capacity	One "WIP" module has the same debris-handling capacity as the screen it replaces. Two modules have twice the debris-handling capacity of the replaced travelling screen
Debris fall-off before cleaning	None with the "WIP" system.
Measured fish survival	"WIP" offers up to two-fold increase in fish saving as compared to an LP spray system.
Maintenance : • Chain tensioning	None in "WIP"
• Chain wear and change	None in "WIP"
• Boot shaft bearings and boot plate	None in "WIP"
• Nozzle cleaning	None in "WIP"
• Drive tensioning	None in "WIP"
Screening performance : • Carry-over	None in "WIP"
• Fibrous build-up on mesh	None in "WIP" (Nocling panel)
• Jelly-fish riveting	None in "WIP" (Nocling panel)
Crane capacity for installation and maintenance	• "WIP" lifting weight requirement at least 6 times less • Lifting height requirement limited to 1.7 times the pit width.
Lift tray capacity	Over twice that of a travelling screen
Head-loss clean at LWL	"WIP" offers 40 to 50 percent reduction as compared to the screen it replaces.

3.8 MAIN DATA

CHARACTERISTICS	VALUES	
WIP Type	8.5'- 1W- fish protecting	
Width of pit	9'-2"	ft - inches
Height of pit	30-0	ft - inches
Wheel diameter	8.6'	ft – inches
Number of wheel module per WIP	1	NA
Height of one wheel module	8.6'	ft – inches
Number of "WIP" modules	1	
Number of wall-plate elements	3	
Flow rate per line	28 000	GPM
Mesh aperture size	0.24 x 0.24	Inch
Mesh type	Nocling	
Head-loss, filter clean	2	in H_2O
Head-loss starting low speed	Continuous rotation	in H_2O
Alarm head-loss	30	in H_2O
Stop main pump signal	40	in H_2O
Number of backwash pumps per WIP	1	
Backwash pump flow rate	1600	gpm
Backwash pump total added head	35	ft
Backwash pump power	35	Hp
Structural design head-loss	10	ft H_2O
"WIP" rotation speed (low speed / high speed)	1 & 2	rpm

BEAUDREY USA	Document n° : 18105-Merrimack1-10071-R01-Rev 1.doc Page : 10 / 12 Date : 20 September 2007
MERRIMACK STATION – UNIT 1 WIP SCREENING SYSTEM	

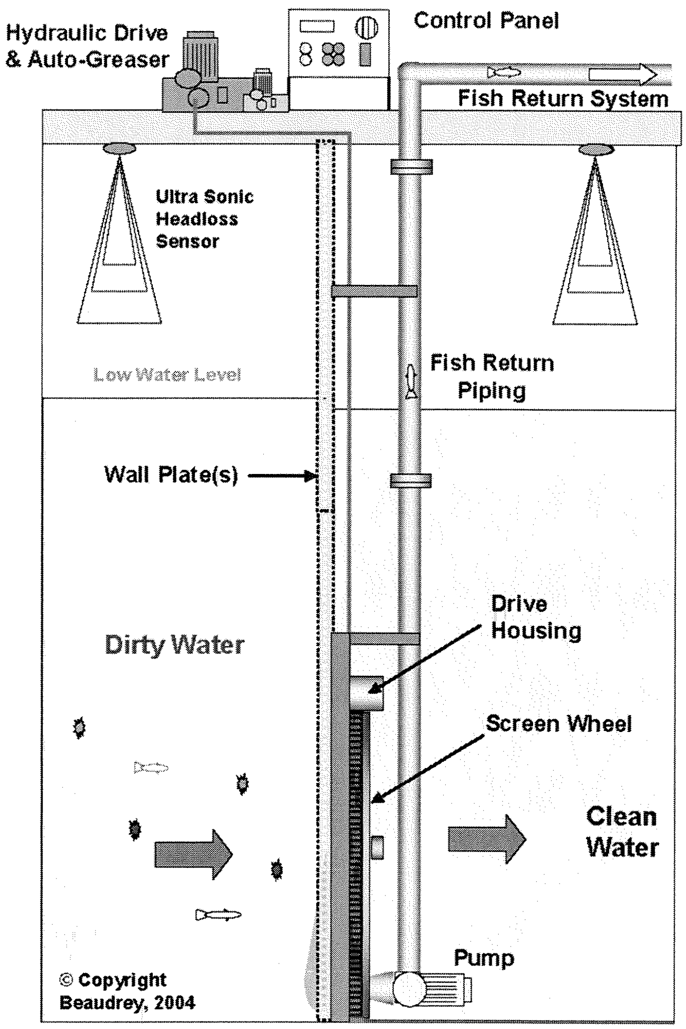
GENERAL DIAGRAM



MERRIMACK STATION – UNIT 1
WIP SCREENING SYSTEM

SECTION VIEW

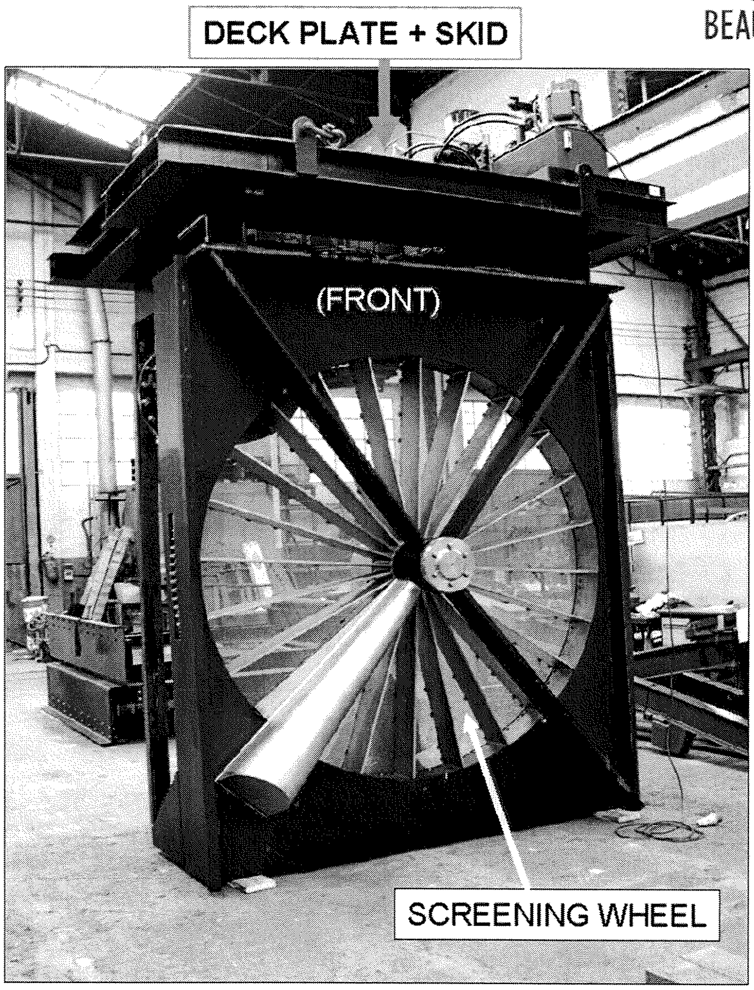
Beaudrey W Intake Protection Screen



BEAUDREY USA	Document n° : 18105-Merrimack1-10071-R01-Rev 1.doc Page : 12 / 12 Date : 20 September 2007
MERRIMACK STATION – UNIT 1 WIP SCREENING SYSTEM	

W Intake Protection Screen

BEAUDREY



Audrey Thompson

From: Brian Hittle [brian.hittle@beaudreyusa.com]
Sent: Friday, September 21, 2007 4:08 PM
To: 'Sue Polyak'
Subject: Beaudrey: Merrimack Proposal Unit 1 (WIP Screen)
Attachments: 18105-Merrimack1-10071-R01-Rev 1.pdf

Sue,

Thanks for your patience. Please find attached your proposal for Merrimack Unit 1 WIP Screen option.

Best regards,

Brian

Brian Hittle
Beaudrey USA
Office: 913 390 5227
Fax: 913 390 5228
Mobile: 913 568 2668
Email: brian.hittle@beaudreyusa.com

BEAUDREY USA
25055 W Valley Pkwy 203
Olathe, KS. 66061

Tel. 913 390 5227
Fax 913 390 5228
Email info@beaudreyusa.com

PUBLIC SERVICE CO. OF NEW HAMPSHIRE

for

MERRIMACK STATION - UNIT 2

COMMERCIAL PROPOSAL FOR THE SUPPLY OF "WIP" TYPE SCREENING SYSTEMS

Beaudrey reference	:	EXXXX-Merrimack-unit 1-10071-R01-Rev 1
Date	:	21 September 2007
Project Director	:	Brian Hittle

1 SCOPE OF SUPPLY

1.1 EQUIPMENT

QUANTITY	EQUIPMENT
2	"WIP" screen modules each consisting of :
	• One screening wheel
	• One set of wheel "Nocling" panels (Not segmented)
	• One wheel spur gears in segments
	• One drive pinion
	• One (1) hydraulic drive motor
	• One (1) jack-up stand with guide rails
	• One fabricated support plates that include the suction scoop. They are slid into the existing wall guides
2	Vertical backwash water pipes
2	Hydraulic drive pumps, tanks and accessories
2	Hydraulic drive feed pipes
2 sets	Grease pipes for the wheels
2 sets	Ultrasonic differential level measuring systems with two probes
1	Electrical switchgear control cabinet
2	Submerged fish pump

1.2 PACKING AND DELIVERY

DDU site

2 COMMERCIAL TERMS

2.1 PRICE OF EQUIPMENT

EQUIPMENT	PRICES US dollar
"WIP" SYSTEMS as per preceding scope of supply	**$ 531,965.00**
Fish Safe Pumps	**$121,000.00**
Delivery (DDU As per Incoterm 2000)	Included

The above prices are considered subject to the conditions hereafter. They include no taxes, whether value-added, corporate or personal, nor any duties, excises of any sort that might be due past delivery point as per Incoterms 2000.

2.2 SPARE PARTS FOR TWO YEARS OPERATION

Later.

2.3 PRICES ARE FIRM

The prices are firm for an order placed within the tender validity period for delivery as stated below.

2.4 VALIDITY OF TENDER

This tender is valid for three months from date of proposal.

BEAUDREY	Document n° : 18105-Merrimack2-10071-R01-Rev 1.doc Page : 3 / 12 Date : 21 September 2007
MERRIMACK STATION – UNIT 2 WIP SCREENING SYSTEM	

1. PLANT MAIN DATA

Country of installation	USA
Type of plant	Coal fired
Type of water	Fresh-water
Number of lines	2
Flow rate per line • Minimum • Normal • Maximum	 Unknown GPM 70 000 GPM Unknown GPM
Flange standard	ANSI 150 Lbs
Electrical motor standard	NEMA
Area classification	Non hazardous

3.8 MAIN DATA

CHARACTERISTICS	VALUES
WIP Type	10.4'- 1W- fish protecting
Width of pit	11.2 ft
Height of pit	35-0 ft - inches
Wheel diameter	10.4 ft
Number of wheel module per WIP	1 NA
Height of one wheel module	10.4' ft
Number of "WIP" modules	1
Number of wall-plate elements	3
Flow rate per line	70 000 GPM
Mesh aperture size	0.24 x 0.24 Inch
Mesh type	Nocling
Head-loss, filter clean	3 in H_2O
Head-loss starting low speed	Continuous rotation in H_2O
Alarm head-loss	30 in H_2O
Stop main pump signal	40 in H_2O
Number of backwash pumps per WIP	1
Backwash pump flow rate	2400 gpm
Backwash pump total added head	35 ft
Backwash pump power	80 Hp
Structural design head-loss	10 ft H_2O
"WIP" rotation speed (low speed / high speed)	1 & 2 rpm

Audrey Thompson

From:	Shields Paul [Paul.Shields@glv.com]
Sent:	Monday, October 01, 2007 9:53 AM
To:	Sue Polyak
Subject:	EIMCO Budgtary proposal
Attachments:	BPR for FHTFBS.FHDFC.BP07-142.doc; FHDFCS.CB.doc; Typ.Fish.DFC.pdf; SIMPLE Fish Screen Package.pdf

Sue,

Please find attached our revised proposal for PSNH. We are confident with the size screen listed for Unit 1 we can get their thru-screen velocities to ½ ft/sec. For unit 2, we have looked at the largest screens we have done (14 foot wide) to explore potential thru-screen velocities. Obviously this size screen would require major modifications to the intake and we still are not at ½ ft/sec. You may want to use the unit 1 pricing as a potential guide for screens between 10-14 foot wide.

Thanks Sue for this opportunity to be of service and please call with any questions. Hope you are feeling better this week!

Best Regards,

Paul Shields
Regional Sales Manager
EIMCO Water Technologies
215-260-0786

EIMCO
WATERTECHNOLOGIES
BRACKETT GREEN • CAIRD & RAYNER CLARK • DORR-OLIVER
EIMCO PROCESS • JONES-ATTWOOD • WEMCO
1335 Regents Park Dr., Ste 260, Houston, Tx 77058
PH: (281) 480-7955 -- FAX: (281) 480-8225

BUDGET PROPOSAL

TO:	Enercon	DATE:	12 Sep 2007
Attn:	Ms. Susan MacPhetres Polyak	Email Address:	spolyak@enercon.com
CC:	EWT		
Attn:	Mr. Paul Shields	Email Address:	Paul.Shields@glv.com
FROM:	Trent T. Gathright	NO. OF PAGES:	Four (4) + Attachments

SUBJECT: BUDGET PROPOSAL

CUSTOMER REFERENCE INFORMATION:	Email of 17th August 2007
CUSTOMER/SITE REFERENCE:	PSNH – Merrimack Station U 1 & 2
EQUIPMENT RECOMMENDED:	Fish Handling Thru Flow Band Screens & Fish Handling Dual Flow Conversion
EWT FILE REFERENCE NUMBER:	BP07-142

We are pleased to provide the following Budget Proposal based on the above customer reference information and the following conditions/considerations:

I. EQUIPMENT INCLUDED IN BUDGET PRICE BY (X)

X	Fish Handling Thru Flow Band Screens & Fish Handling Dual Flow Conversion	X	Factory Coating
	Controls	X	Factory Testing
X	Anchor Bolts	X	Shipment Loading
X	O & M Manuals	X	Freight to Site (separate)
X	Warranty	X	Field Service (separate)

II. ITEMS NORMALLY SUPPLIED BY OTHERS

Unloading at Site / Field Touch-up
Removal or Disposal of the Existing Screens
Installation / Erection / Mounting
Civil Works / Grouting / Anchor Installation
Motor Control Center
Conduit / Wiring / Cables & Glands
Access Ladders / Handrails / Flooring
Site Protection / Storage
State, Federal, Local Taxes or Use Taxes

III. TYPICAL DELIVERY AND SHIPMENT

The Equipment can be typical delivered in 30-32 weeks based on:

		WEEKS
A.	General Drawings for Review	6-8
B.	Review by Client/User	4-6
C.	Details, Fabrication Shipment	18-20
	TOTAL	30-32*

*** Based on delivery of first pair of screens. For multiple screens add 3 weeks for each additional pair thereafter.**

IV. VALIDITY AND PAYMENT

A. VALIDITY

This Budget Proposal should be considered as valid for approximately three (3) months based on normal industry circumstances. After such time, please check with us for changes such as material/labor rates continued validity.

B. NORMAL PAYMENT TERMS

The budget prices are based on our standard payment terms.

V. NORMAL TERMS AND CONDITIONS

The following budget prices are based on our standard terms and conditions, available on request.

VI. BUDGET PRICES

A. **Fish Handling Thru Flow Band Screens – U1 –** Two (2) Fish Handling Thru Flow Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 8'-0" Effective width for a channel 30'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts.

Total Budget Price: $ 265,500.00 USD Each x 2 = $ 531,000.00

(Five hundred thirty one thousand dollars)

B. **Fish Handling Thru Flow Band Screens – U2 –** Two (2) Fish Handling Thru Flow Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 10'-0" Effective width for a channel 35'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts.

Total Budget Price: $ 315,500.00 USD Each x 2 = $ 631,000.00

(Six hundred thirty one thousand dollars)

C. **Fish Handling Dual Flow Conversion Band Screens – U1 –** Two (2) Fish Handling Dual Flow Conversion Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 4'-0" Effective width for a channel 30'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts including flow deflectors, nose cone, transition troughs and flood box (for fish trough)

Total Budget Price: $ 360,500.00 USD Each x 2 = $ 721,000.00

(Seven hundred twenty one thousand dollars)

D. **Fish Handling Dual Flow Conversion Band Screens – U2 –** Two (2) Fish Handling Dual Flow Conversion Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 5'-0" Effective width for a channel 35'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts including flow deflectors, nose cone, transition troughs and flood box (for fish trough)

Total Budget Price: $ 410,500.00 USD Each x 2 = $ 821,000.00

(Eight hundred twenty one thousand dollars)

E. One (1) lot Fish Return Troughing (of required length) of fiberglass trough with epoxy coated carbon steel supports. **This is NOT the entire fish return trough as other appropriations should be made for the final return back to the source water.**

Total Budget Price: $ 250.00 **Per Foot**

(Two hundred fifty dollars per foot)

F. We recommend including the following for freight to the site of the above equipment.

Total Budget Price: $ 7,500.00 USD Total Suggested **(Per Screen)**

(Seven thousand five hundred dollars)

G. Field Service

We suggest including for one (1) trip and five (5) days of Field Service for approximately $ 7,000.00 USD total **per screen**. If additional days are required, our Field Service Technicians are available for $ 1,000.00 USD/Day plus all travel, living and per diem at cost.

Total Budget Price: 1 Trip & 5 Days = $ 7,000.00 Total Suggested **(Per Screen)**

(Seven thousand dollars)

VII. INFORMATION ATTACHED

X	Typical Specification Reference	Thru Flow & Dual Flow Conversion Typical Specifications
	Outline Drawing Reference	
	Brochure Reference	
X	Data/Calculations Reference	

If you have any further questions, please contact the undersigned directly at 281-480-7955.

Best Regards,
EIMCO Water Technologies LLC

Trent T. Gathright
Group Product Manager
Screening Products

REF:

SPECIFICATION

FOR A

FISH HANDLING

DUAL FLOW CONVERSION BAND SCREEN

A. DESCRIPTION

The Fish Handling Dual Flow Conversion Band Screen will be designed to fit the existing concrete intake chamber profile and replace a thru flow type traveling screen.

Fish recovery shall be via the **S. I. M. P. L. E.**® method,(**S**tabilized **I**ntegral **M**arine **P**rotective **L**ifting **E**nvironment).

The screen will consist of an endless band of baskets contained within a vertical self-supporting frame designed to rest on the chamber invert. The Fish Handling Dual Flow Conversion Screen shall be positioned in line with the water flow such that the ascending and descending panels are parallel to the flow. As raw water passes through the baskets, floating and suspended debris larger than the mesh opening shall be retained on the upstream side of the mesh and juvenile marine life shall be captured in the hydraulically stabilized fish recovery bucket. Raw water shall pass through both ascending and descending baskets and screened water shall exit through a common opening located at the rear of the screen. The flow shall be guided toward the baskets by specially designed curved "gull wings" with flanges which shall fit into the existing guide ways.

The screen shall be provided with a totally enclosed head section constructed of sheet, formed structural shapes and splash housings. The head section will be rigidly attached to the main frame so that the entire screen may be removed as a unit with a lifting frame.

The main frame shall be manufactured from plate and formed or rolled shapes. Structural members of the main frame shall be a minimum 3/8" thick. The roller tracks shall include overlapping upstream and downstream flanges and separate track wear bars on the ascending and descending sides. The exit side roller track shall also include a special thrust bar to prevent premature wear. High-density plastic frame seals shall be incorporated on the main frame mounted parallel to the seal plates [as determined by the mesh opening]. Frame seals mounted perpendicular to the seal plates and wood, neoprene, and/or rubber shall not be allowed. The frame shall be rigidly braced and capable of withstanding the required static differential headloss. The main frame shall also include curved gull wings to divert flow into baskets and flanges for mounting in the wall guides. Gull wings shall be a minimum of ¼" thick and shall transfer loading back to the main frame by specially designed adjustable struts. Gull wings must be of a semi-circular design to direct water flow into baskets. Designs employing square, rectangular or flat gull wings shall not be allowed. The bottom of the frame shall incorporate specially designed semi-circular tracks and wear bars for rotation of screen band. Designs employing foot shafts or other submerged rotating devices shall not be allowed.

The head section will incorporate a horizontal head shaft fitted with two (2) sprockets, over which the carrier chains will pass. The head shaft shall be designed to withstand the full NEMA rated stall torque of the motor without damage. The shaft shall be journeled on each end to accommodate the head sprockets and prevent lateral movement. The head sprockets shall be either six (6) or eight (8) sided, (depending on well width) and shall include replaceable corner wear rims to drive the carrier chain. Designs employing sprockets, which drive the chain rollers via tooth inserts, shall not be allowed. The shaft shall rotate in **split roller type bearings**, (COOPER or equal) and shall be supported **BELOW** the bearing by two (2) chain tensioning screws. Chain tensioning shall be via adjusting nuts and thrust bearings accessible form the operating floor. Designs employing overhead take-up screws shall not be allowed for personnel safety considerations.

Each screen shall consist of a series of interchangeable modular baskets having a pitch of ___" x ___"long (Well widths 15'-3" to 8'-2" shall normally use 24" pitch, 11'-2" to 6'-2" shall use 18" pitch, 7'-2" to 3'-2" shall use 12" pitch). Each basket shall consist of a formed frame designed to withstand the required static differential. To maximize screening area, the structural cross members of the basket frame shall be specially designed to also serve as the marine recovery lifting device, (i.e. Fish Bucket). Designs employing additional bolted fish buckets shall not be allowed. The structural members shall also be designed to provide a hydraulically stabilized sheltered area for marine life to reduce mortality.

Each basket shall be equipped with a smooth top mesh insert securely fastened to the basket frame with rigid hydraulically stabilized clamping bars, bolts and nuts with nylon locking inserts. Designs utilizing pre-cast fiberglass rails that cannot be modified with clamp bars to attain optimum "still flow" within the rail shall not be considered. The mesh shall provide a clear, unobstructed discharge for marine life on the descending side of the screen. Designs employing forced removal by pulsating water blasts on the ascending side shall not be allowed.

[Each basket shall be equipped with a flexible synthetic seal to completely seal the gap between each panel to prevent the passage of debris/marine life. The seal shall be designed for long life and shall be bolted to the leading edge of the basket only so that any basket may be opened for quick spray nozzle access.]

The carrier chain shall be __" pitch to match the baskets comprised of links, connected by pins and bushings, fitted with rollers which run on the roller track wear bars. The sidebars shall be (3/8" thick x 3" wide for 24" pitch, 3/8" thick x 2-½" wide for 18" pitch, and ¼" thick x 1-¾" wide for 12" pitch). Rollers shall be oversized and a minimum of (5-½" diameter for 24" pitch and 18" pitch, 4" diameter for 12" pitch) of corrosion resistant cast nylon for long life. The chain will be supported and driven by specially designed replaceable corner wear rims mounted to the inside and outside of each head sprocket and shall allow the rollers to turn freely while supported. The chain will be water lubricated. Chain attachment shall be by two (2) bolts passing directly through the sidebars reinforced by spacers. Except for master links, offset sidebars shall not be permitted.

The spray system shall consist of three (3) sub-systems including an outside fish spray, inside fish spray and debris spray. Each system shall consist of dual headers each independently adjustable. The spray system shall be fed by one primary high pressure line thus supplying the debris spray lines first then pass through adjustable pressure reducing valves for the fish spray. Each sub-system shall include quickly replaceable direct spray nozzles to provide a minimum 150 percent overlapping pattern. Designs employing fan or deflector type nozzles shall **NOT** be allowed.

The debris spray shall be designed for operation between 60-100 psi. The inside and outside fish sprays shall operate between 5-10 psi. The recovered marine life shall be discharge on the descending side with aid from the inside and outside fish sprays, into a fish trough located above the debris trough. The baskets shall then pass the high-pressure debris spray where the debris shall wash into the transition debris trough located above deck level. Each trough shall be furnished with a deflector to direct marine life/debris into the appropriate trough.

The ascending and descending sides of the head section shall be totally enclosed with lightweight housings. The ascending side housing shall be split into two (2) approximately equal halves with the upper housing bolted to the head section and lower housing equipped with quick release latches for inspection/maintenance access. The descending side shall include a bolted upper section to cover the transition debris trough and a bolted lower section to cover the fish trough.

The screen shall include an upper fish trough and lower transition debris trough. The fish and transition debris troughs shall be a minimum of 4" deep and minimum of 1'-8" wide and shall each slope a minimum of 1/16" per foot towards the discharge point.

Each screen trough's discharge end shall extend out a minimum of 1'-0" past the housing. The discharge ends of the troughs shall be flanged for connection by customer to customer's final discharge/return troughs.

The screens shall be equipped with an external drive assembly mounted directly on the head shaft. The drive assembly shall consist of a motor, reducer and torque arm and must be easily removable as a unit. The unit shall be of sufficient size to start and operate the screen under the indicated differential headloss and withstand the full NEMA rated stall torque of the motor without damage. The drive shall be protected from overload by a current sensing monitor located in the control panel. Designs employing shear pin sprockets, fluid couplings, drive chains, drive/driven sprockets and chain guards shall not be allowed for maintenance and inventory considerations.

The drive shall include a two (2) speed with two (2) winding motor and shall be designed to operate continuously at low speed during normal plant operations and change to high speed during period of high headloss or heavy debris loading [as determined by the existing/new control system].

B. SITE DATA

Site	
Equipment Location	Indoors or Outdoors
Liquid Being Screened	Fresh – Brackish - Saltwater
Operating Deck Level	
Maximum Water Level	
Minimum Water Level	
Channel Base Level	
Channel Depth	
Channel Width	
Minimum Immersion	

B. HYDRAULIC DATA

Screen Capacity	
Velocity through Entrance Openings	
Velocity through Mesh	
Velocity through Exit Opening	
Headloss across Entrance Openings	
Headloss across Mesh	
Headloss across Exit Opening	
Total Headloss across Screen	
(Data based on minimum immersion and clean screen conditions.)	

C. SCREEN DATA

Number of Screens	
Effective Screening (Basket) Width	
Exit Opening Width	
Design Start Differential	
Design Run Differential	
Frame Static Differential	
Basket Static Differential	
Mesh Opening Size (Clear) And Wire Size	
Number of Baskets	
Carrier Chain Pitch	
Number of Main Frame Sections	
Height of Screen Above Deck	

Overall Screen Width (Parallel to Flow)	
Overall Screen Breadth (Perpendicular to Flow)	

D. SPRAY SYSTEM DATA

Number of Debris Spray Headers	Two (2)
Debris Spray Header Diameter	
Spray Nozzles per Debris Spray Header	
Debris Spray Nozzles Type	Vee-Jet
Debris Spray Header Pressure	
Debris Wash Water Required	
Wash Water Entrance Connection	
Number of Outside Fish Spray Headers	Two (2)
Outside Spray Header Diameter	
Spray Nozzles per Outside Spray Header	
Outside Spray Nozzle Type	Vee-Jet
Outside Operating Pressure	
Outside Wash Water Required	
Number of Inside Fish Spray Headers	Two (2)
Inside Spray Header Diameter	
Spray Nozzles per Inside Spray Header	
Inside Spray Nozzle Type	Vee-Jet
Inside Operating Pressure	
Inside Wash Water Required	
Pressure Reducing Valve Type	
Total System Wash Water Required	

E. DRIVE DATA

Gear Unit Type	Helical
Motor Size	
Motor Speed(s)	
Number of Windings	
Motor Type	Induction
Motor Enclosure	TEFC
Motor Insulation	Class "F"
Motor Power Supply	Volts Phase Hertz
Space Heater Supply	Volts Phase Hertz
Screen Nominal Speed(s)	
Screen Estimated Weight	

II. SPECIFICATIONS

A. ACCESSORIES

The following item will be supplied:

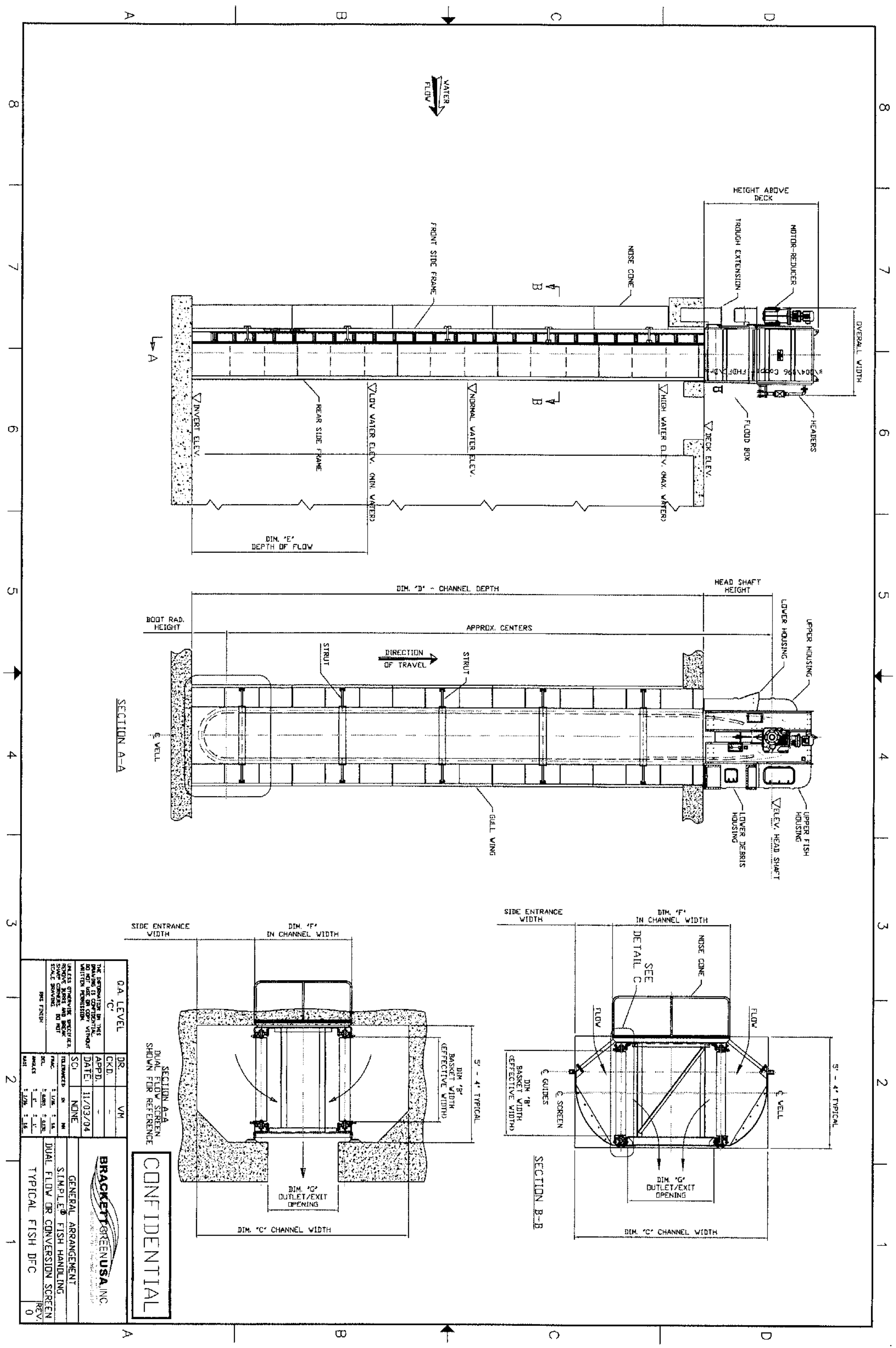
- Initial Quantity of lubricants

B. PROTECTION

See separate specification [Contact Brackett Green to suit each application].

C. MATERIAL OF CONSTRUCTION [Choose one of the columns on the right]

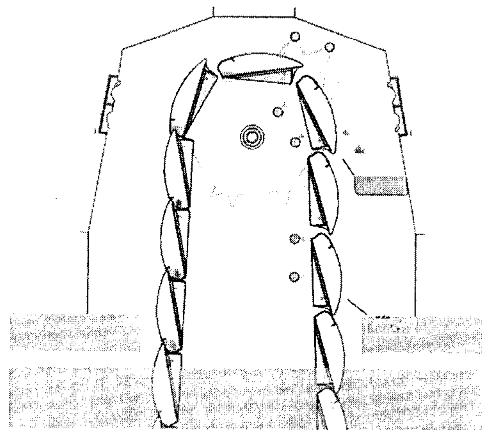
Component	Stainless Design	Carbon/Stainless	Carbon Design
Main Frame	Stainless Steel, Gr. 316	Carbon Steel, A-36	Carbon Steel, A-36
Roller Tracks	Stainless Steel, Gr. 316	Carbon Steel, A-36	Carbon Steel, A-36
Track Wear Bar (if used)	Stainless Steel, Gr. 316	Carbon Steel, A-36	Carbon Steel, A-36
Main Frame Seals	Low Friction Plastic	Low Friction Plastic	Low Friction Plastic
Head Shaft	Carbon Steel, 1045	Carbon Steel, 1045	Carbon Steel, 1045
Bearing Housing	Carbon Steel, A-36	Carbon Steel, A-36	Carbon Steel, A-36
Head Sprockets	Cast Iron, ASTM A-48	Cast Iron, ASTM A-48	Cast Iron, ASTM A-48
Head Sprocket Corner Wear Rims	Cast Iron, ASTM A-48	Cast Iron, A-536 H. T.	Cast Iron, A-536 H. T.
Chain Tensioning Screws	Stainless Steel, Gr. 303	Stainless Steel, Gr. 303	Stainless Steel, Gr. 303
Chain Tensioning Nuts	Brass or Bronze	Brass or Bronze	Brass or Bronze
Carrier Chain Sidebars	Stainless Steel, Gr. 316	Carbon Steel, 1040	Carbon Steel, 1040
Carrier Chain Pins	Stainless Steel, Gr. 316	Stainless Steel, Gr. 431	Carbon Steel, 8620
Carrier Chain Bushings	Stainless Steel, Gr. 316	Stainless Steel, Gr. 431	Carbon Steel, 8620
Carrier Chain Rollers	Nylon No. 6	Nylon No. 6	Nylon No. 6
Basket Frames	Stainless Steel, Gr. 316	Carbon Steel, A-36	Carbon Steel, A-36
Mesh Inserts	Stainless Steel, Gr. 316	Stainless Steel, Gr. 304	Electro Galvanized
Mesh Insert Construction	Woven Wire	Woven Wire	Woven Wire
Basket to Basket Seal Strip	Neoprene	Neoprene	Neoprene
Clamping Bars	Stainless Steel, Gr. 316	Carbon Steel, A-36	Carbon Steel, A-36
Lifting Lips	Stainless Steel, Gr. 316	Carbon Steel, A-36	Carbon Steel, A-36
Spray Headers (Debris/Fish)	Stainless Steel, Gr. 316	Red Brass or 304 SS	Galvanized Steel
Spray Nozzles (Debris/Fish)	Stainless Steel, Gr. 316	Brass or 304 SS	Brass
Splash Housings	Fiberglass	Fiberglass	Fiberglass
Debris Trough	Fiberglass	Fiberglass	Fiberglass
Fish Trough	Fiberglass	Fiberglass	Fiberglass
Main Frame Fasteners	Stainless Steel, Gr. 316	Stainless Steel, Gr. 18-8	Zinc Plated Steel
Mesh Insert Fasteners	Stainless Steel, Gr. 316	Stainless Steel, Gr. 18-8	Zinc Plated Steel
Basket Attachment Fasteners	Stainless Steel, Gr. 316	Stainless Steel, Gr. 18-8	Zinc Plated Steel
Splash Housing Fasteners	Stainless Steel, Gr. 316	Stainless Steel, Gr. 18-8	Zinc Plated Steel

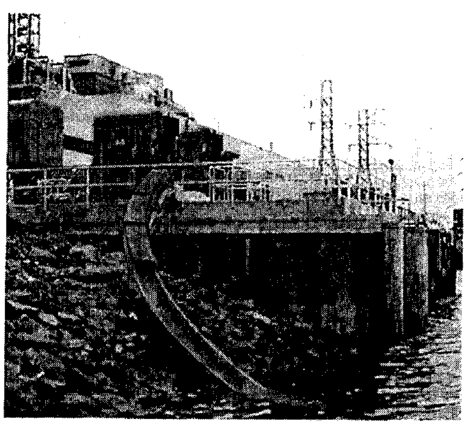

SECTION A-A
SECTION B-B
CONFIDENTIAL
GENERAL ARRANGEMENT
SIMPLE® FISH HANDLING
DUAL FLOW OR CONVERSION SCREEN
TYPICAL FISH DFC

EIMCO
WATERTECHNOLOGIES

S.I.M.P.L.E.® FISH HANDLING BAND SCREENS

Eimco Water Technologies manufacturers the Brackett Green Fish Handling Band Screens using the S.I.M.P.L.E.® Process for marine life recovery to help meet the new 316(b) requirements to reduce environmental impacts of cooling water withdrawal on existing (and new) intakes. Juvenile fish that encounter the traveling screens naturally seek the shelter of the integrated Fish Bucket due to the stabilized flow. The traveling screen rotates and elevates the fish in their natural water to deck level where a series of gentle sprays slice them into the Fish Trough. The fish and other marine life are then sluiced back to their source water via a return trough.

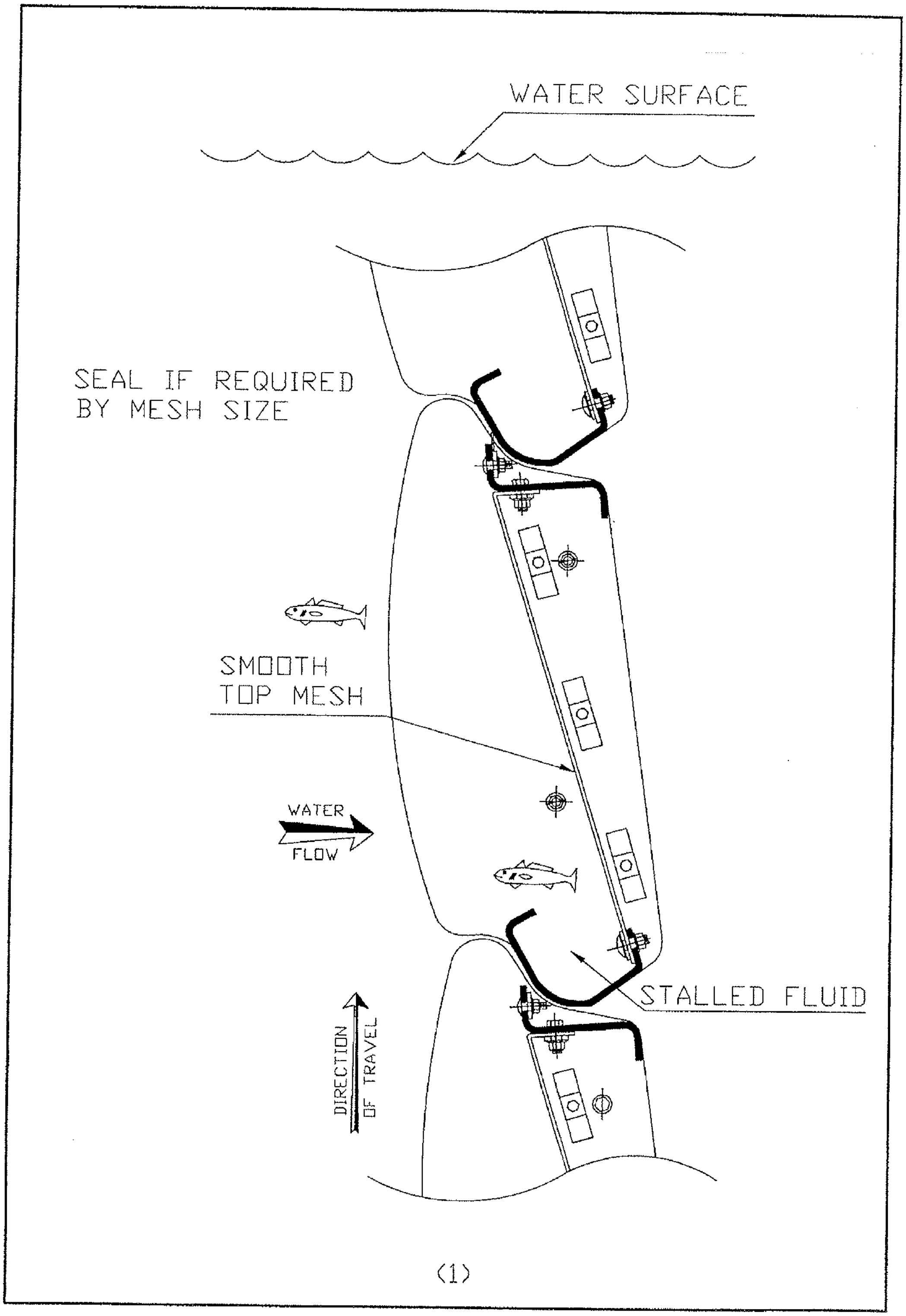


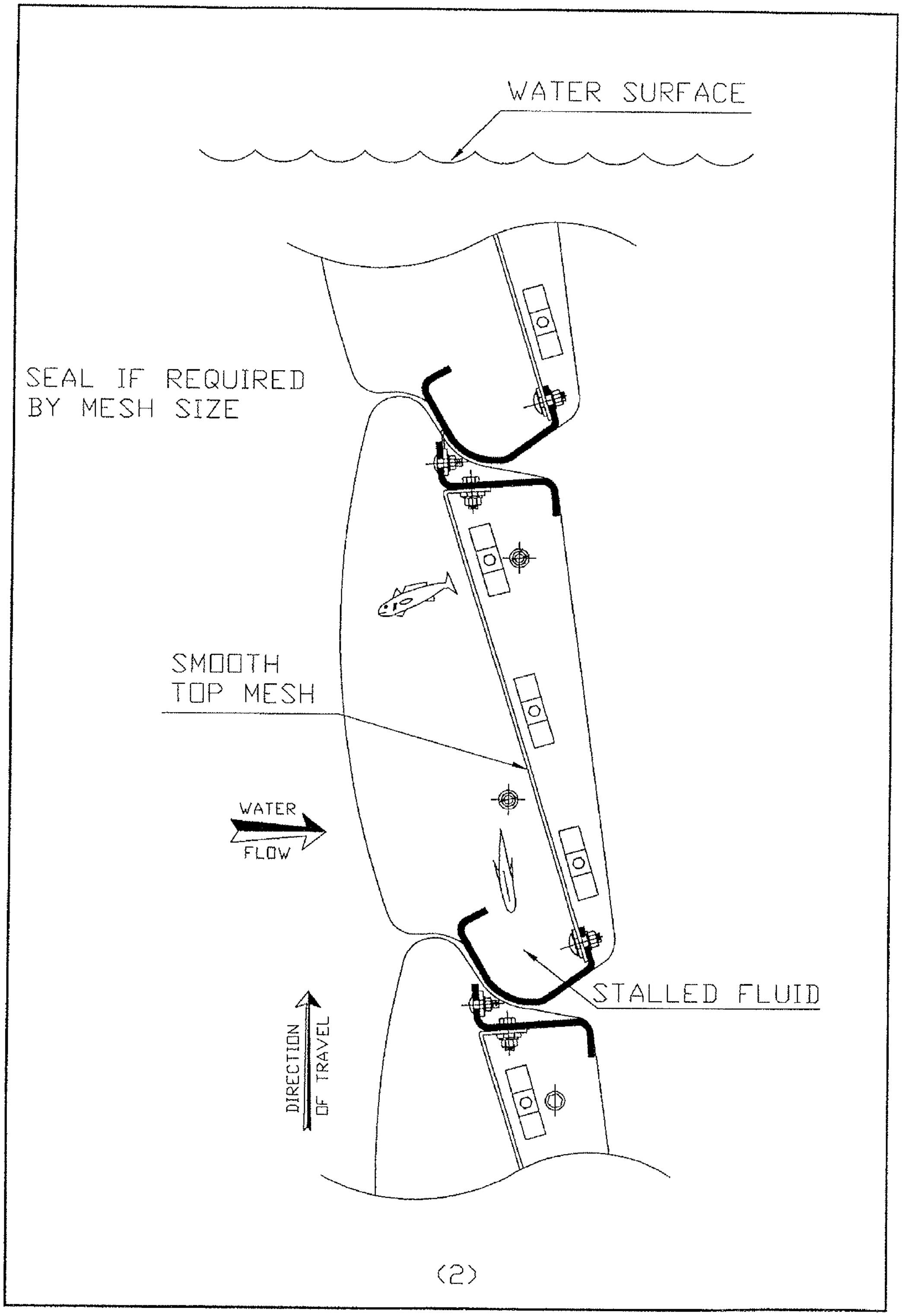


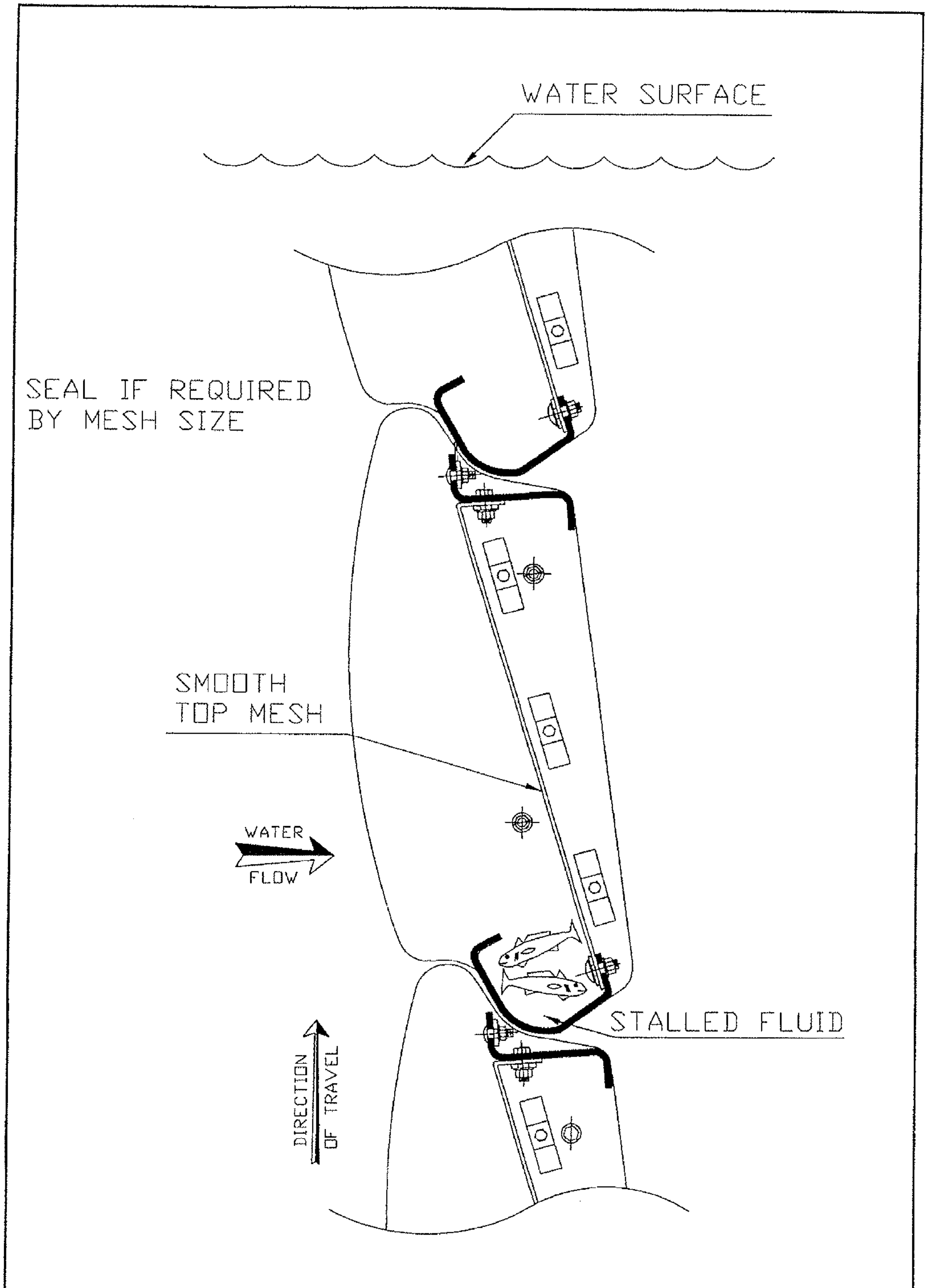
S.I.M.P.L.E. Fish Screens have been supplied in Dual Flow, Dual Flow Conversion and Thru Flow models and can be retrofit into almost any intake. S.I.M.P.L.E. Fish Screens are available in a multitude of materials including epoxy coated or galvanized carbon steel, stainless steel, with stainless-smooth top or non-metallic mesh and are suitable for fresh, brackish or salt water. For Inquiries please include flow rate, desired mesh opening, elevations or heights of deck, high water, low water and invert, desired materials of construction and quantity of screens. A complete General Information package including survival reports is available upon request.

BRACKETT GREEN   CARD & RAYNER CLARK   DORR-OLIVER   EIMCO PROCESS   JONES+ATTWOOD   WEMCO

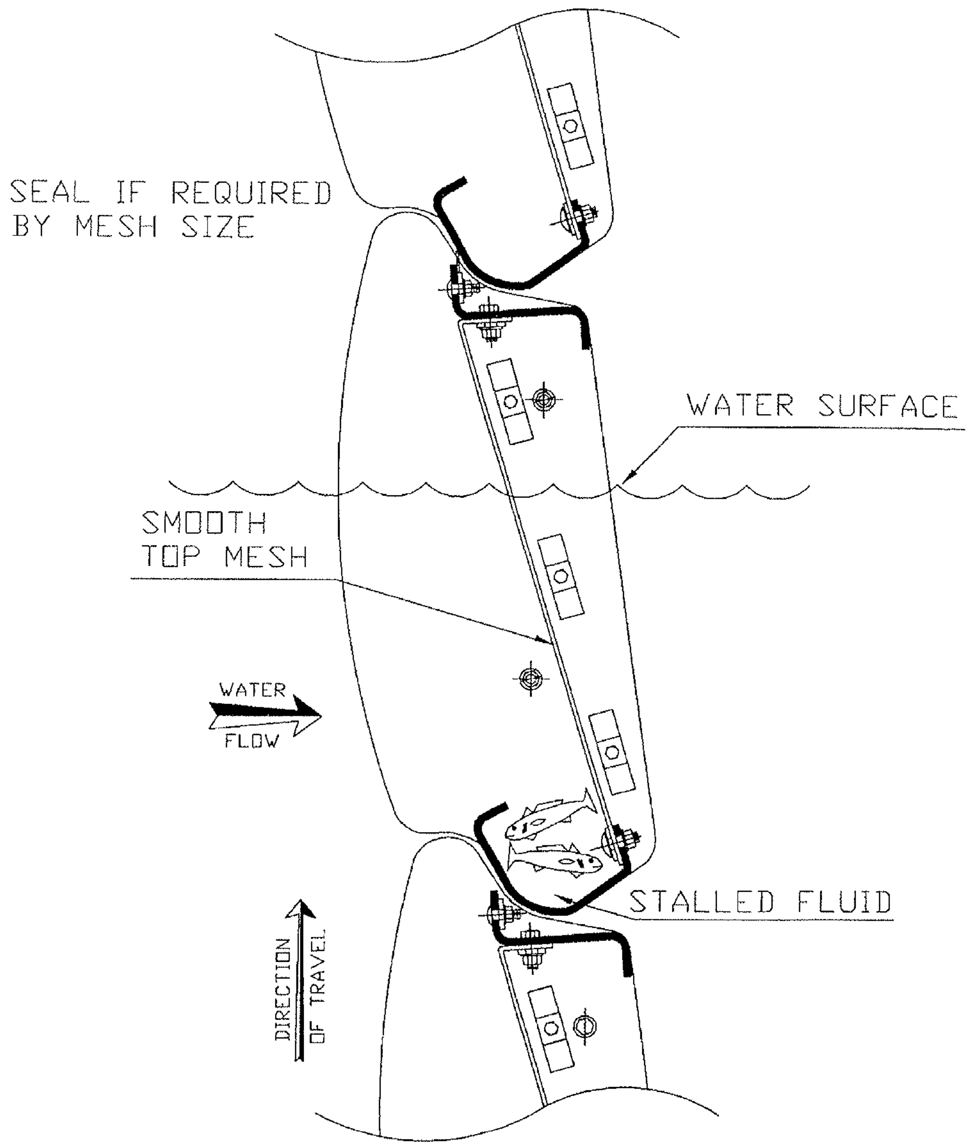
EIMCO Water Technologies LLC
2850 South Decker Lake Drive
Salt Lake City, Utah 84119
www.glv.com
Tel: 801-526-2025
Fax: 801-526-2426
A GLV COMPANY


WATER SURFACE
SEAL IF REQUIRED
BY MESH SIZE
SMOOTH
TOP MESH
WATER
FLOW
STALLED FLUID
DIRECTION
OF TRAVEL
(1)


WATER SURFACE
SEAL IF REQUIRED
BY MESH SIZE
SMOOTH
TOP MESH
WATER
FLOW
STALLED FLUID
DIRECTION
OF TRAVEL
(2)


WATER SURFACE
SEAL IF REQUIRED BY MESH SIZE
SMOOTH TOP MESH
WATER FLOW
STALLED FLUID
DIRECTION OF TRAVEL

(3)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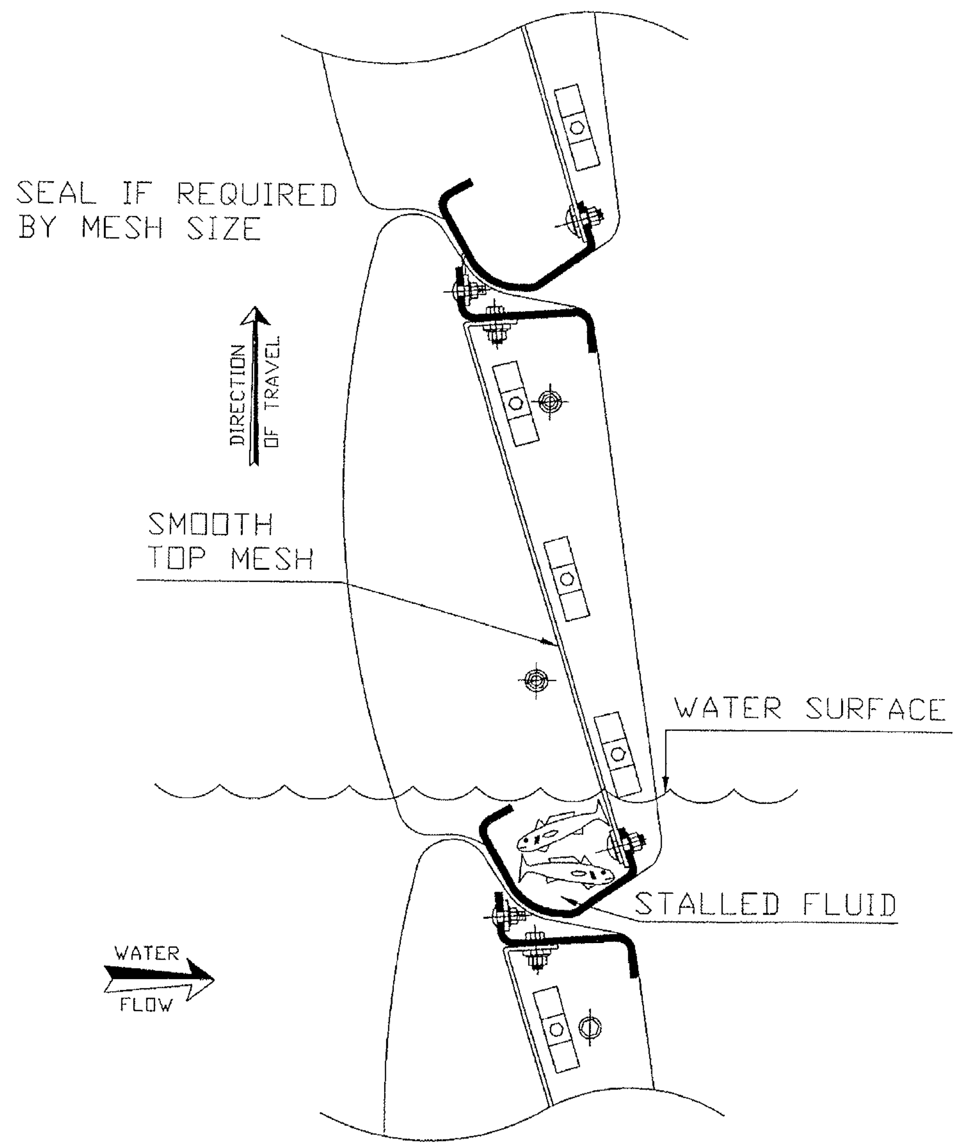
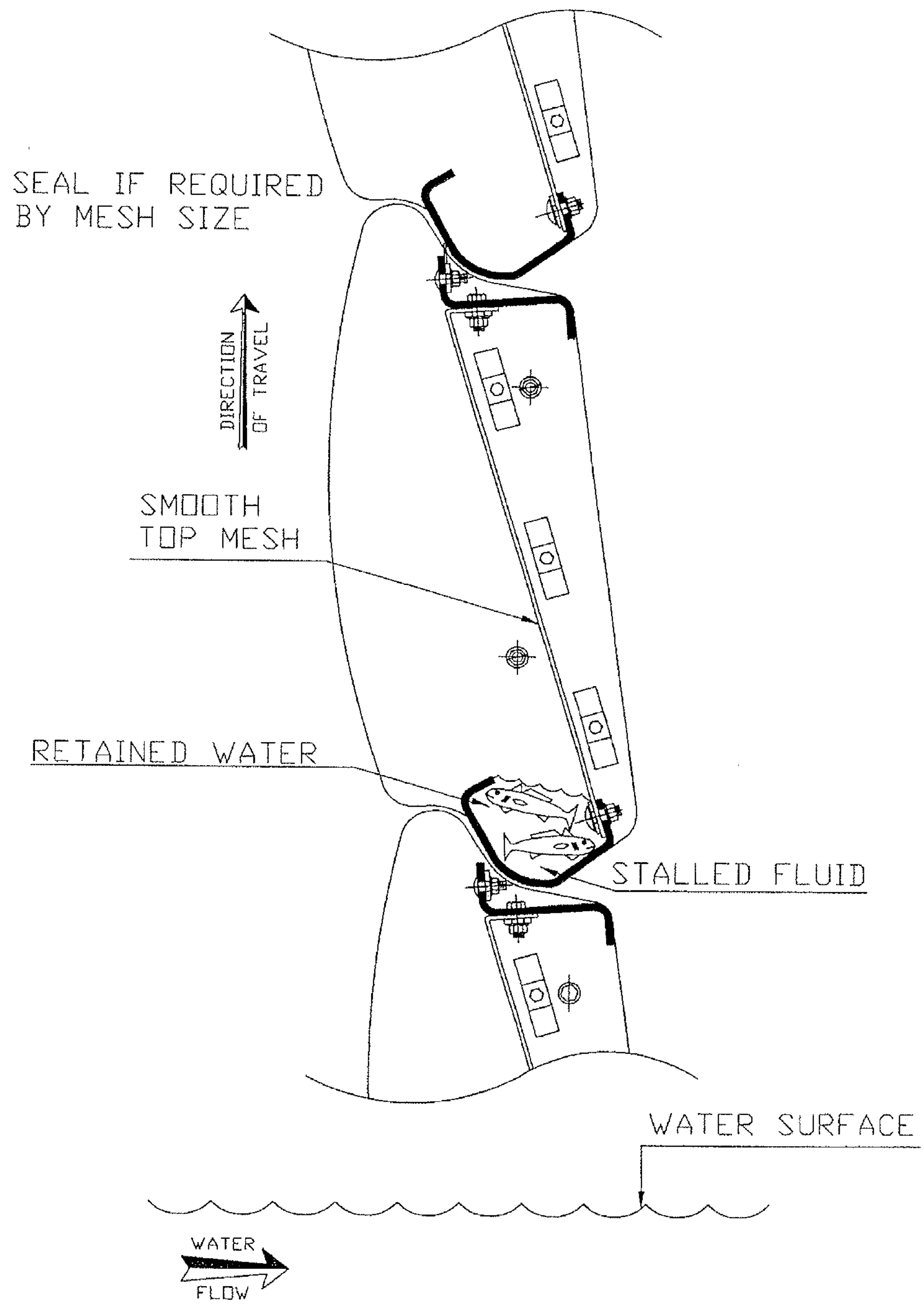
BY MESH SIZE
WATER SURFACE
SMOOTH
TOP MESH
WATER
FLOW
STALLED FLUID
DIRECTION
OF TRAVEL

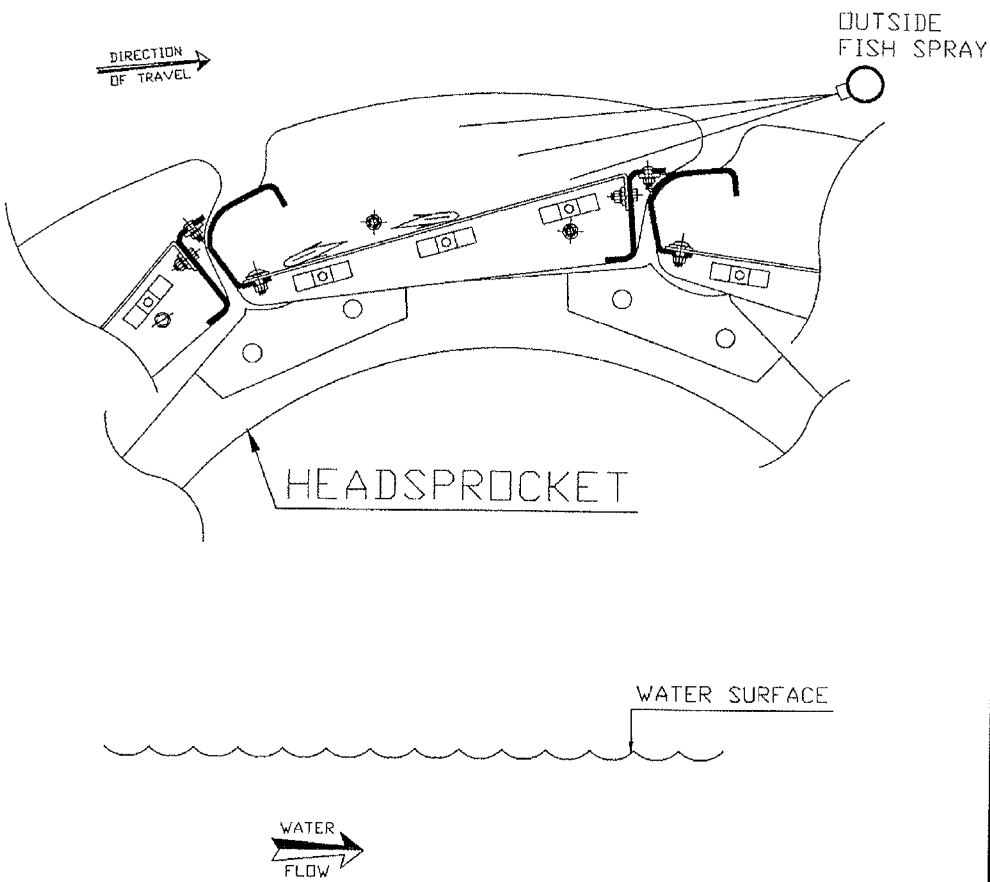
(4)


SEAL IF REQUIRED
BY MESH SIZE
DIRECTION
OF TRAVEL
SMOOTH
TOP MESH
WATER SURFACE
STALLED FLUID
WATER
FLOW

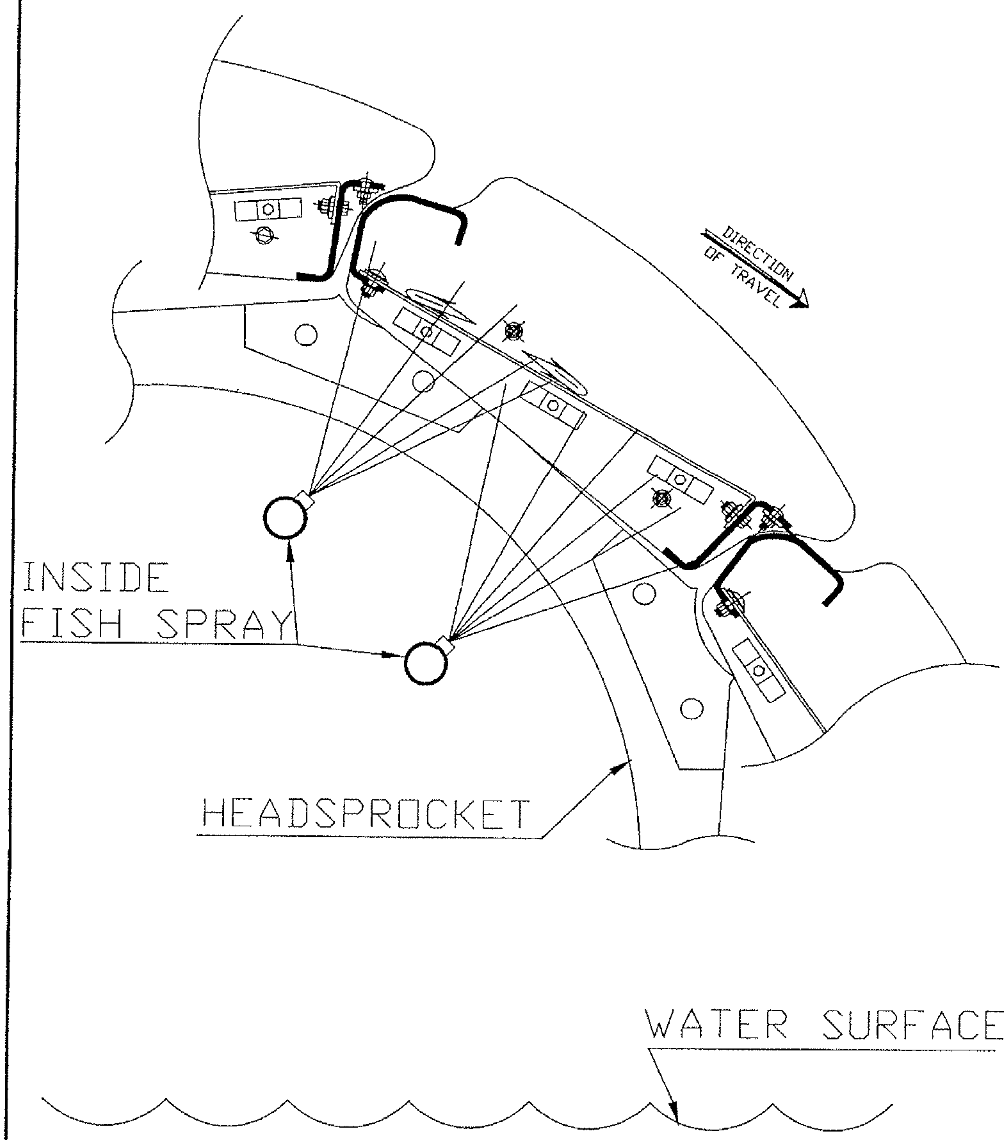
(5)


SEAL IF REQUIRED
BY MESH SIZE
DIRECTION
OF TRAVEL
SMOOTH
TOP MESH
RETAINED WATER
STALLED FLUID
WATER SURFACE
WATER
FLOW

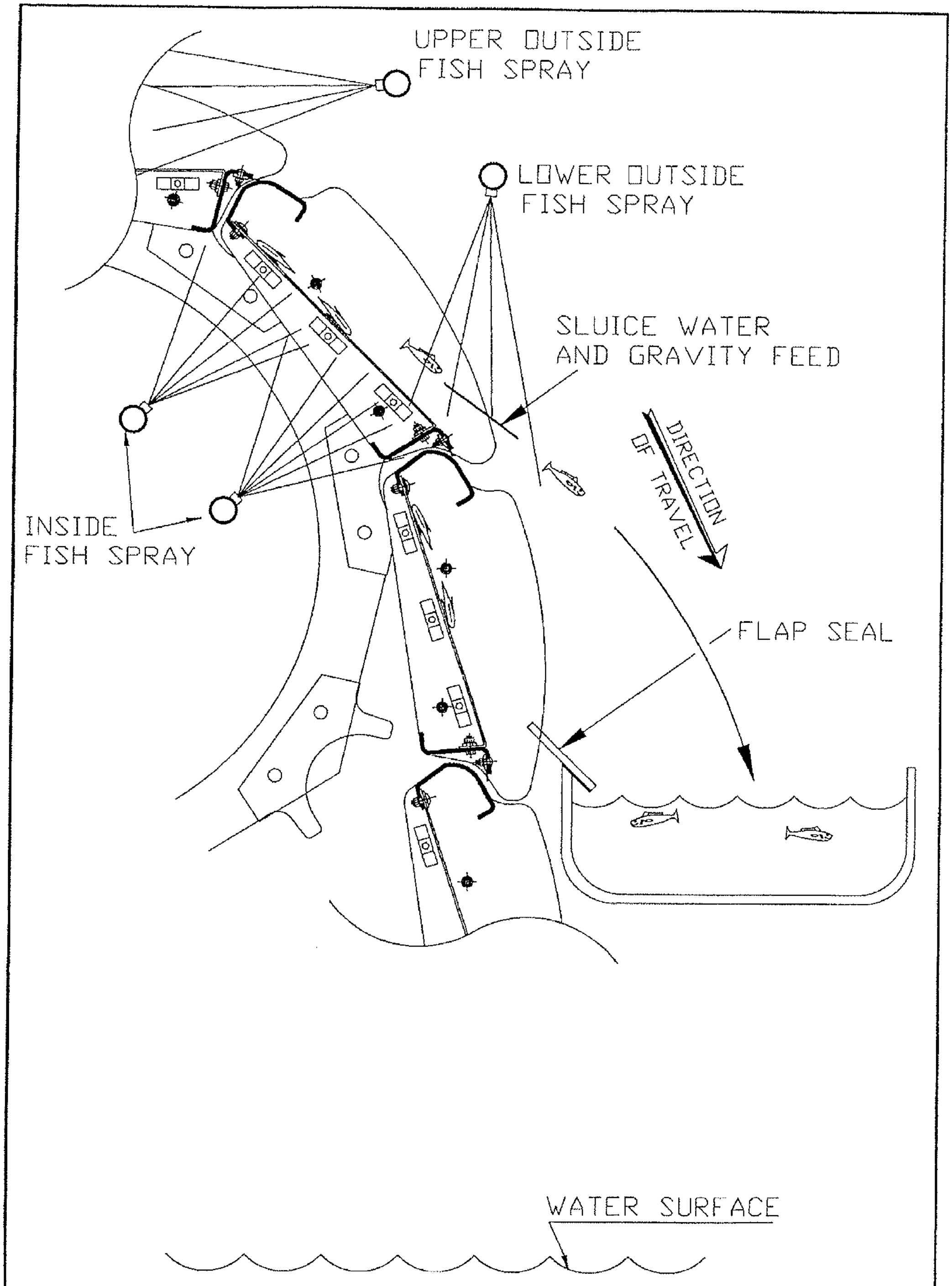
(6)


OUTSIDE
FISH SPRAY
DIRECTION
OF TRAVEL
HEADSPROCKET
WATER SURFACE
WATER
FLOW

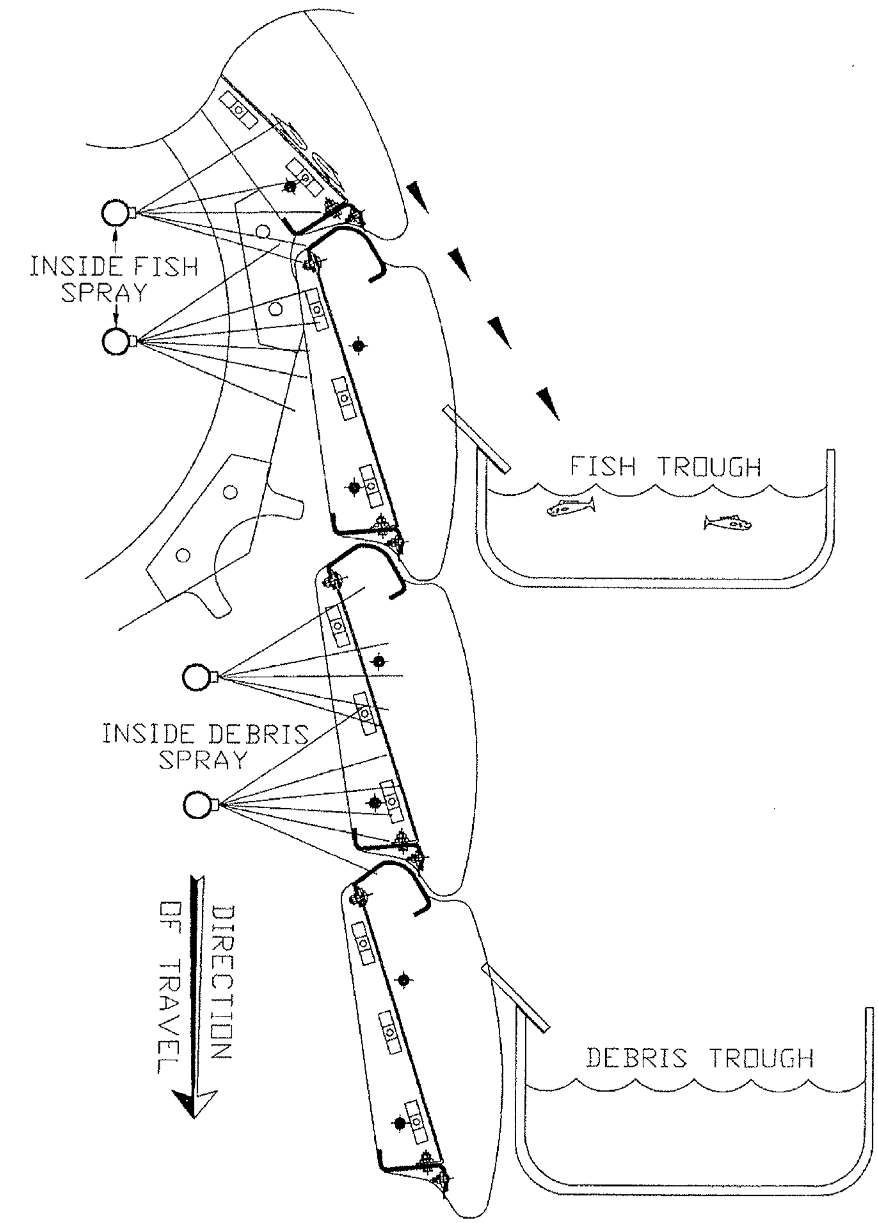
(7)


DIRECTION OF TRAVEL
INSIDE FISH SPRAY
HEADSPROCKET
WATER SURFACE

(8)


UPPER OUTSIDE
FISH SPRAY
LOWER OUTSIDE
FISH SPRAY
SLUICE WATER
AND GRAVITY FEED
DIRECTION
OF TRAVEL
INSIDE
FISH SPRAY
FLAP SEAL
WATER SURFACE

(9)


INSIDE FISH
SPRAY
FISH TROUGH
INSIDE DEBRIS
SPRAY
DIRECTION
OF TRAVEL
DEBRIS TROUGH

(10)

From: Shields Paul [Paul.Shields@glv.com]
Sent: Wednesday, September 12, 2007 5:15 PM
To: spolyak@enercon.com
Cc: athompson@enercon.com
Subject: FW: Budget Proposal for Fish Handling Thru Flow and Dual Flow Conversion Screens, PSNH - Merrimack, EWT Ref. BP07-142
Attachments: Typ.Fish.TFBS.pdf; FHTFBS.CB.doc; FHDFCS.CB.doc; BPR for FHTFBS.FHDFC.BP07-142.doc; Typ.Fish.DFC.pdf

Sue,

Please find attached our proposal for Merrimack. Audrey had called about the proposal earlier this week and I informed her that it would be a little longer before we got this to you, glad I was wrong. Please see our notes below in regards to some pricing and other issues.

I will be at Merrimack tomorrow. Thanks and please contact me with any questions.

Best Regards,
Paul Shields
215-260-0786

From: Gathright, Trent
Sent: Wed 9/12/2007 2:51 PM
To: Shields Paul; Someah Kaveh
Cc: Norman, Charles - Houston
Subject: Budget Proposal for Fish Handling Thru Flow and Dual Flow Conversion Screens, PSNH - Merrimack, EWT Ref. BP07-142

Paul,

Please find our budget proposal attached for the PSNH – Merrimack station per the request from Enercon.

Please also note the following:

- **We have based the prices on epoxy coated carbon steel with 316 SS mesh and fasteners. The data sheet they filled out indicated all 316 SS construction but we assume they were only wanting the mesh in SS as this is fresh water and the price for all 316 SS would be 2 X that shown.**

- **We have only supplied "typical" specifications and drawings at this stage and can certainly proved complete detailed specifications upon their further interest in the fish handling screens.**

10/4/2007

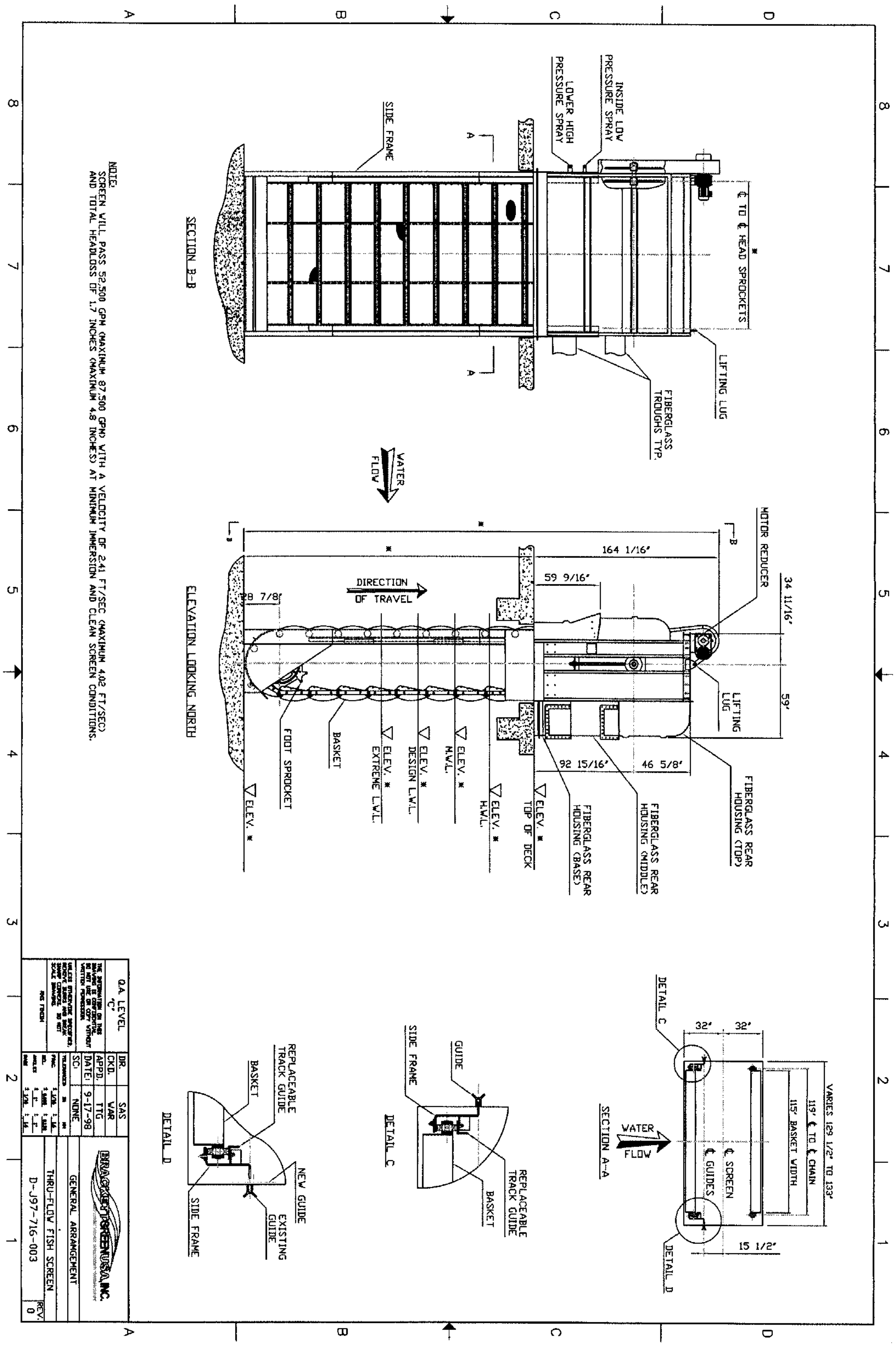
- **We have offered Dual Flow Conversion screens to provide similar velocities as the thru flow screens (i.e. 4' DFC for the 8' TF wells and 5' DFC for the 10' TF wells). The channels in unit 2 may have to be altered to accept the 5' DFC.**

- **We can also provide further details on the final fish return trough if this continues to develop but the current price shown per foot should provide them what they need for now.**

Please confirm your receipt of this and that you will forward this and copy the above notes to Enercon.

Trent T. Gathright
Group Product Manager
Screen Products

EIMCO Water Technologies
1335 Regents Park Dr., Suite 260
Houston, TX 77058


SECTION B-B
ELEVATION LOOKING NORTH
SECTION A-A
DETAIL C
DETAIL D
NOTE:
SCREEN WILL PASS 52,500 GPM (MAXIMUM 87,500 GPM) WITH A VELOCITY OF 2.41 FT/SEC (MAXIMUM 4.02 FT/SEC)
AND TOTAL HEADLOSS OF 1.7 INCHES (MAXIMUM 4.8 INCHES) AT MINIMUM IMMERSION AND CLEAN SCREEN CONDITIONS.
SIDE FRAME
INSIDE LOW PRESSURE SPRAY
LOWER HIGH PRESSURE SPRAY
℄ TO ℄ HEAD SPROCKETS
LIFTING LUG
FIBERGLASS TROUGHS TYP.
WATER FLOW
MOTOR REDUCER
164 1/16"
59 9/16"
34 11/16"
59"
28 7/8"
DIRECTION OF TRAVEL
92 15/16"
46 5/8"
FIBERGLASS REAR HOUSING (TOP)
FIBERGLASS REAR HOUSING (MIDDLE)
FIBERGLASS REAR HOUSING (BASE)
ELEV. * TOP OF DECK
ELEV. * H.W.L.
ELEV. * N.W.L.
ELEV. * DESIGN L.W.L.
ELEV. * EXTREME L.W.L.
ELEV. *
BASKET
FOOT SPROCKET
VARIES 129 1/2" TO 133"
119" ℄ TO ℄ CHAIN
115" BASKET WIDTH
℄ SCREEN
℄ GUIDES
32"
15 1/2"
GUIDE
REPLACEABLE TRACK GUIDE
NEW GUIDE
EXISTING GUIDE
GENERAL ARRANGEMENT
THRU-FLOW FISH SCREEN
D-J97-716-003
DATE: 9-17-98
SC: NONE

REF:

SPECIFICATION

FOR A

FISH HANDLING

THRU FLOW BAND SCREEN

A. DESCRIPTION

The Fish Handling Thru-Flow Band Screen shall be designed to fit the new concrete intake chamber and remove juvenile fish and other marine organisms as they are drawn into the screen.

Fish recovery shall be via the superior BTA **S.I.M.P.L.E.®** method (**S**tabilized **I**ntegral **M**arine **P**rotective **L**ifting **E**nvironment).

The screen shall consist of an endless band of baskets contained within a vertical self-supporting frame designed to rest on the chamber invert. The Fish Handling Thru-Flow Screen shall be positioned in line with the general water flow such that the baskets on the ascending side are facing raw water. As raw water passes through the baskets, floating and suspended debris larger than the mesh opening shall be retained on the upstream side of the mesh and juvenile marine life shall be captured in the hydraulically stabilized fish recovery basket. Raw water shall pass through the ascending baskets and screened water shall exit through the descending baskets on the downstream side.

The screen shall be provided with a totally enclosed head section constructed of sheet, formed structural shapes and splash housings. The head section will be rigidly attached to the main frame so that the entire screen may be removed as a unit.

The main frame shall be manufactured from plate and formed or rolled shapes. Structural members of the main frame shall be a minimum of 3/8" thick. The roller tracks shall include overlapping upstream (and downstream) flanges and separate track wear bars on the ascending (descending) side(s). High-density plastic frame seals shall be incorporated on the main frame mounted parallel to the seal plates [as determined by the mesh opening]. Frame seals mounted perpendicular to the seal plates and wood, neoprene, and/or rubber shall not be allowed. The frame shall be rigidly brace and capable of withstanding the required static differential headloss. The bottom of the main frame shall incorporate a curved boot plate and seal to prevent debris/marine life from passing under the screen. The bottom of the frame shall also be designed with foot sprockets in the boot section to accommodate the radial transition from descending to ascending sides.

The head section will incorporate a horizontal head shaft fitted with two (2) sprockets, over which the carrier chain will pass. The head shaft shall be designed to withstand the full NEMA rated torque of the motor without damage. The shaft shall be journeled on each end to accommodate the head sprockets and prevent lateral movement. The head sprockets will be six (6) sided and shall include replaceable corner wear rims to drive the carrier chain. Designs employing sprockets, which drive the chain rollers via tooth inserts, shall not be allowed. The shaft shall rotate in **split roller type bearings**, (Cooper of equal) and shall be supported **BELOW** the bearing by two (2) chain tensioning screws. Chain tensioning shall be via adjusting nuts and thrust bearings accessible from the operating floor. Designs employing overhead take-up screws shall not be allowed for personnel safety considerations.

The foot shaft assembly will incorporate a fixed shaft fitted with two (2) foot sprockets, over which the carrier chain will pass. The foot sprockets will have water lubricated bushings and sleeves that will be firmly held in place by set collars.

Each screen shall consist of a series of interchangeable modular baskets. Each basket shall consist of a die formed frame designed to withstand the required static differential. To maximize screening area, the structural cross members of the basket frame shall be specially designed to also serve as the marine recovery lifting device, (i.e. Fish Bucket). The structural members shall also be designed to provide a hydraulically stabilized sheltered area for marine life to reduce mortality.

Each basket shall be equipped with a smooth top mesh insert securely fastened to the basket frame with rigid hydraulically stabilized clamping bars, bolts and nuts with nylon locking inserts. Designs utilizing pre-cast fiberglass rails that cannot be modified with clamp bars to attain optimum "still flow" within the rail shall not be considered. The mesh shall provide a clear, unobstructed discharge for marine life on the descending side of the screen. Designs employing forced removal by pulsating water blasts on the ascending side shall not be allowed.

[Each basket shall be equipped with a flexible synthetic seal to completely seal the gap between each panel to prevent the passage of debris/marine life. The seal shall be designed for long life and shall be bolted to the leading edge of each basket only so that any basket may be opened for quick spray nozzle access.]

The carrier chain shall be 24" pitch to match the baskets comprised of links, connected by pins and bushings, fitted with rollers which run on the roller track wear bars. The chain shall have minimum 3/8" thick x 3" wide sidebars, 1 1/4" diameter pins and 1 3/4" diameter bushings designed for water lubricated service. Rollers shall be oversized and a minimum of 5 ½" diameter of corrosion resistant cast nylon for long life. The chain will be supported and driven by specially designed replaceable corner wear rims mounted to the inside and outside of each head sprocket and shall allow the rollers to turn freely while supported. Chain attachment shall be by two (2) bolts passing directly through the sidebars reinforced by spacers. Except for master links, offset sidebars shall not be permitted.

The spray system shall consist of three (3) sub-systems including an outside fish spray, inside fish spray and debris spray. Each system shall consist of dual headers each independently adjustable. The spray system shall be fed by one primary high pressure line thus supplying the debris spray lines first then passing through adjustable pressure reducing valves for the fish spray. Each sub-system shall include quickly replaceable direct spray nozzles to provide a minimum 150 percent overlapping pattern. Design employing fan or deflector type nozzles shall **NOT** be allowed.

The debris spray shall be designed for operation between 60-100 psi. The inside and outside fish sprays shall operate between 5-10 psi. The recovered marine life shall be discharged on the descending side wide aid from the inside and outside fish sprays, into a fish trough located above the debris trough. The baskets shall then pass the high-pressure debris spray where the debris shall wash into a debris trough located above deck level. Each trough shall be furnished with a deflector to direct marine life/debris into the appropriate trough.

The ascending and descending sides of the head section shall be totally enclosed with lightweight housings. The ascending side housing shall be split into two (2) approximately equal halves with the upper housing bolted to the head section and the lower housing equipped with quick release latches for inspection/maintenance access. The descending side shall include a bolted upper section to cover the debris trough and a bolted lower section to cover the fish trough.

The screen shall include an upper fish trough and lower debris trough. The fish and debris trough shall be minimum of 4" deep and minimum of 1'-8" wide and each shall slope a minimum of 1/16" per foot towards the discharge point.

Each screen's trough discharge end shall extend out a minimum of 1'-0" past the housing. The discharge ends of the troughs shall be flanged for connection by customer to customer's final discharge/return troughs.

The screens shall be equipped with an external drive assembly mounted directly on the head section. The drive assembly shall consist of a motor, reducer, drive sprocket, drive chain, driven sprocket, and chain guard. The unit shall be of sufficient size to start and operate the screen under the indicated differential headloss and withstand the full NEMA rated torque of the motor without damage. The drive shall be protected from overload by a current sensing monitor located in the control panel. Designs employing shear pins and fluid couplings shall not be allowed.

Power shall be introduced by means of an electric motor driving a helical gear speed reducer through a coupling. Power shall be transmitted to the head shaft through a steel roller chain drive assembly operating over a drive and driven sprockets.

OR

The screens shall be equipped with an external drive assembly mounted directly on the head shaft. The drive assembly shall consist of a motor, reducer and torque arm and must be easily removable as a unit. The unit shall be of sufficient size to start and operate the screen under the indicated differential headloss and withstand the full NEMA rated stall torque of the motor without damage. The drive shall be protected from overload by a current sensing monitor located in the control panel. Designs employing shear pin sprockets, fluid couplings, drive chains, drive/driven sprockets and chain guards shall not be allowed for maintenance and inventory considerations.

The drive shall be two (2) speed with two (2) winding motor and shall be designated to operate continuously at low speed during normal plant operations and change to high speed during periods of head low or heavy debris loading.

B. SITE DATA

Site	
Equipment Location	Indoors or Outdoors
Liquid Being Screened	Fresh - Brackish - Saltwater
Operating Deck Level	
Maximum Water Level	
Minimum Water Level	
Channel Base Level	
Channel Depth	
Channel Width	
Minimum Immersion	

C. HYDRAULIC DATA

Screen Capacity	
Velocity through Mesh	
Headloss across Mesh	
(Data based on minimum water level and clean screen conditions.)	

D. SCREEN DATA

Number of Screens	
Effective Screening (Basket) Width	
Design Start Differential	
Design Run Differential	
Frame Static Differential	
Basket Static Differential	
Mesh Opening Size (Clear) And Wire Size	
Number of Baskets	
Carrier Chain Pitch	

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D. **SCREEN DATA - Continued**

Number of Main Frame Sections	
Height of Screen Above Deck	
Overall Screen Width	

E. **SPRAY SYSTEM DATA**

Number of Debris Spray Headers	Two (2)
Debris Spray Header Diameter	
Nozzles Per Debris Spray Header	
Debris Spray Nozzle Type	Vee-Jet
Debris Spray Header Pressure	
Debris Wash Water Required	
Wash Water Entrance Connection	
Number of Outside Fish Spray Header	Two (2)
Outside Spray Header Diameter	
Spray Nozzles Per Outside Spray Header	
Outside Spray Nozzle Type	Vee-Jet
Outside Operating Pressure	
Outside Wash Water Required	
Number of Inside Fish Spray Headers	Two (2)
Inside Spray Header Diameter	
Spray Nozzles Per Inside Spray Header	
Inside Spray Nozzles Type	Vee-Jet
Inside Operating Pressure	
Inside Wash Water Required	
Pressure Reducing Valve Type	
Total System Wash Water Required	

F. **DRIVE DATA**

Gear Unit Type	Helical
Gear Unit Ratio	
Motor Size	
Motor Speed(s)	
Number of Windings	
Motor Type	Induction
Motor Enclosure	TEFC
Motor Insulation	Class "F"
Motor Power Supply	Volts Phase Hertz
Space Heater Supply	Volts Phase Hertz
Screen Nominal Speed(s)	
Screen Estimated Weight	

II. SPECIFICATIONS

A. **ACCESSORIES**

The following items will be supplied:

REF:

SPECIFICATION

FOR A

FISH HANDLING

DUAL FLOW CONVERSION BAND SCREEN

A. DESCRIPTION

The Fish Handling Dual Flow Conversion Band Screen will be designed to fit the existing concrete intake chamber profile and replace a thru flow type traveling screen.

Fish recovery shall be via the **S. I. M. P. L. E.**® method,(**S**tabilized **I**ntegral **M**arine **P**rotective **L**ifting **E**nvironment).

The screen will consist of an endless band of baskets contained within a vertical self-supporting frame designed to rest on the chamber invert. The Fish Handling Dual Flow Conversion Screen shall be positioned in line with the water flow such that the ascending and descending panels are parallel to the flow. As raw water passes through the baskets, floating and suspended debris larger than the mesh opening shall be retained on the upstream side of the mesh and juvenile marine life shall be captured in the hydraulically stabilized fish recovery bucket. Raw water shall pass through both ascending and descending baskets and screened water shall exit through a common opening located at the rear of the screen. The flow shall be guided toward the baskets by specially designed curved "gull wings" with flanges which shall fit into the existing guide ways.

The screen shall be provided with a totally enclosed head section constructed of sheet, formed structural shapes and splash housings. The head section will be rigidly attached to the main frame so that the entire screen may be removed as a unit with a lifting frame.

The main frame shall be manufactured from plate and formed or rolled shapes. Structural members of the main frame shall be a minimum 3/8" thick. The roller tracks shall include overlapping upstream and downstream flanges and separate track wear bars on the ascending and descending sides. The exit side roller track shall also include a special thrust bar to prevent premature wear. High-density plastic frame seals shall be incorporated on the main frame mounted parallel to the seal plates [as determined by the mesh opening]. Frame seals mounted perpendicular to the seal plates and wood, neoprene, and/or rubber shall not be allowed. The frame shall be rigidly braced and capable of withstanding the required static differential headloss. The main frame shall also include curved gull wings to divert flow into baskets and flanges for mounting in the wall guides. Gull wings shall be a minimum of ¼" thick and shall transfer loading back to the main frame by specially designed adjustable struts. Gull wings must be of a semi-circular design to direct water flow into baskets. Designs employing square, rectangular or flat gull wings shall not be allowed. The bottom of the frame shall incorporate specially designed semi-circular tracks and wear bars for rotation of screen band. Designs employing foot shafts or other submerged rotating devices shall not be allowed.

The head section will incorporate a horizontal head shaft fitted with two (2) sprockets, over which the carrier chains will pass. The head shaft shall be designed to withstand the full NEMA rated stall torque of the motor without damage. The shaft shall be journeled on each end to accommodate the head sprockets and prevent lateral movement. The head sprockets shall be either six (6) or eight (8) sided, (depending on well width) and shall include replaceable corner wear rims to drive the carrier chain. Designs employing sprockets, which drive the chain rollers via tooth inserts, shall not be allowed. The shaft shall rotate in **split roller type bearings**, (COOPER or equal) and shall be supported **BELOW** the bearing by two (2) chain tensioning screws. Chain tensioning shall be via adjusting nuts and thrust bearings accessible form the operating floor. Designs employing overhead take-up screws shall not be allowed for personnel safety considerations.

Each screen shall consist of a series of interchangeable modular baskets having a pitch of ___" x ___"long (Well widths 15'-3" to 8'-2" shall normally use 24" pitch, 11'-2" to 6'-2" shall use 18" pitch, 7'-2" to 3'-2" shall use 12" pitch). Each basket shall consist of a formed frame designed to withstand the required static differential. To maximize screening area, the structural cross members of the basket frame shall be specially designed to also serve as the marine recovery lifting device, (i.e. Fish Bucket). Designs employing additional bolted fish buckets shall not be allowed. The structural members shall also be designed to provide a hydraulically stabilized sheltered area for marine life to reduce mortality.

Each basket shall be equipped with a smooth top mesh insert securely fastened to the basket frame with rigid hydraulically stabilized clamping bars, bolts and nuts with nylon locking inserts. Designs utilizing pre-cast fiberglass rails that cannot be modified with clamp bars to attain optimum "still flow" within the rail shall not be considered. The mesh shall provide a clear, unobstructed discharge for marine life on the descending side of the screen. Designs employing forced removal by pulsating water blasts on the ascending side shall not be allowed.

[Each basket shall be equipped with a flexible synthetic seal to completely seal the gap between each panel to prevent the passage of debris/marine life. The seal shall be designed for long life and shall be bolted to the leading edge of the basket only so that any basket may be opened for quick spray nozzle access.]

The carrier chain shall be __" pitch to match the baskets comprised of links, connected by pins and bushings, fitted with rollers which run on the roller track wear bars. The sidebars shall be (3/8" thick x 3" wide for 24" pitch, 3/8" thick x 2-½" wide for 18" pitch, and ¼" thick x 1-¾" wide for 12" pitch). Rollers shall be oversized and a minimum of (5-½" diameter for 24" pitch and 18" pitch, 4" diameter for 12" pitch) of corrosion resistant cast nylon for long life. The chain will be supported and driven by specially designed replaceable corner wear rims mounted to the inside and outside of each head sprocket and shall allow the rollers to turn freely while supported. The chain will be water lubricated. Chain attachment shall be by two (2) bolts passing directly through the sidebars reinforced by spacers. Except for master links, offset sidebars shall not be permitted.

The spray system shall consist of three (3) sub-systems including an outside fish spray, inside fish spray and debris spray. Each system shall consist of dual headers each independently adjustable. The spray system shall be fed by one primary high pressure line thus supplying the debris spray lines first then pass through adjustable pressure reducing valves for the fish spray. Each sub-system shall include quickly replaceable direct spray nozzles to provide a minimum 150 percent overlapping pattern. Designs employing fan or deflector type nozzles shall **NOT** be allowed.

The debris spray shall be designed for operation between 60-100 psi. The inside and outside fish sprays shall operate between 5-10 psi. The recovered marine life shall be discharge on the descending side with aid from the inside and outside fish sprays, into a fish trough located above the debris trough. The baskets shall then pass the high-pressure debris spray where the debris shall wash into the transition debris trough located above deck level. Each trough shall be furnished with a deflector to direct marine life/debris into the appropriate trough.

The ascending and descending sides of the head section shall be totally enclosed with lightweight housings. The ascending side housing shall be split into two (2) approximately equal halves with the upper housing bolted to the head section and lower housing equipped with quick release latches for inspection/maintenance access. The descending side shall include a bolted upper section to cover the transition debris trough and a bolted lower section to cover the fish trough.

The screen shall include an upper fish trough and lower transition debris trough. The fish and transition debris troughs shall be a minimum of 4" deep and minimum of 1'-8" wide and shall each slope a minimum of 1/16" per foot towards the discharge point.

Each screen trough's discharge end shall extend out a minimum of 1'-0" past the housing. The discharge ends of the troughs shall be flanged for connection by customer to customer's final discharge/return troughs.

The screens shall be equipped with an external drive assembly mounted directly on the head shaft. The drive assembly shall consist of a motor, reducer and torque arm and must be easily removable as a unit. The unit shall be of sufficient size to start and operate the screen under the indicated differential headloss and withstand the full NEMA rated stall torque of the motor without damage. The drive shall be protected from overload by a current sensing monitor located in the control panel. Designs employing shear pin sprockets, fluid couplings, drive chains, drive/driven sprockets and chain guards shall not be allowed for maintenance and inventory considerations.

The drive shall include a two (2) speed with two (2) winding motor and shall be designed to operate continuously at low speed during normal plant operations and change to high speed during period of high headloss or heavy debris loading [as determined by the existing/new control system].

B. SITE DATA

Site	
Equipment Location	Indoors or Outdoors
Liquid Being Screened	Fresh – Brackish - Saltwater
Operating Deck Level	
Maximum Water Level	
Minimum Water Level	
Channel Base Level	
Channel Depth	
Channel Width	
Minimum Immersion	

B. HYDRAULIC DATA

Screen Capacity	
Velocity through Entrance Openings	
Velocity through Mesh	
Velocity through Exit Opening	
Headloss across Entrance Openings	
Headloss across Mesh	
Headloss across Exit Opening	
Total Headloss across Screen	
(Data based on minimum immersion and clean screen conditions.)	

C. SCREEN DATA

Number of Screens	
Effective Screening (Basket) Width	
Exit Opening Width	
Design Start Differential	
Design Run Differential	
Frame Static Differential	
Basket Static Differential	
Mesh Opening Size (Clear) And Wire Size	
Number of Baskets	
Carrier Chain Pitch	
Number of Main Frame Sections	
Height of Screen Above Deck	

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Overall Screen Width (Parallel to Flow)	
Overall Screen Breadth (Perpendicular to Flow)	

D. SPRAY SYSTEM DATA

Number of Debris Spray Headers	Two (2)
Debris Spray Header Diameter	
Spray Nozzles per Debris Spray Header	
Debris Spray Nozzles Type	Vee-Jet
Debris Spray Header Pressure	
Debris Wash Water Required	
Wash Water Entrance Connection	
Number of Outside Fish Spray Headers	Two (2)
Outside Spray Header Diameter	
Spray Nozzles per Outside Spray Header	
Outside Spray Nozzle Type	Vee-Jet
Outside Operating Pressure	
Outside Wash Water Required	
Number of Inside Fish Spray Headers	Two (2)
Inside Spray Header Diameter	
Spray Nozzles per Inside Spray Header	
Inside Spray Nozzle Type	Vee-Jet
Inside Operating Pressure	
Inside Wash Water Required	
Pressure Reducing Valve Type	
Total System Wash Water Required	

E. DRIVE DATA

Gear Unit Type	Helical
Motor Size	
Motor Speed(s)	
Number of Windings	
Motor Type	Induction
Motor Enclosure	TEFC
Motor Insulation	Class "F"
Motor Power Supply	Volts Phase Hertz
Space Heater Supply	Volts Phase Hertz
Screen Nominal Speed(s)	
Screen Estimated Weight	

II. SPECIFICATIONS

A. ACCESSORIES

The following item will be supplied:

- Initial Quantity of lubricants

B. PROTECTION

See separate specification [Contact Brackett Green to suit each application].

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EIMCO
WATERTECHNOLOGIES
1335 Regents Park Dr., Ste 260, Houston, Tx 77058
PH: (281) 480-7955 -- FAX: (281) 480-8225

BUDGET PROPOSAL

TO:	Enercon	DATE:	12 Sep 2007
Attn:	Ms. Susan MacPhetres Polyak	Email Address:	spolyak@enercon.com
CC:	EWT		
Attn:	Mr. Paul Shields	Email Address:	Paul.Shields@glv.com
FROM:	Trent T. Gathright	NO. OF PAGES:	Four (4) + Attachments

SUBJECT: BUDGET PROPOSAL

CUSTOMER REFERENCE INFORMATION:	Email of 17th August 2007
CUSTOMER/SITE REFERENCE:	PSNH – Merrimack Station U 1 & 2
EQUIPMENT RECOMMENDED:	Fish Handling Thru Flow Band Screens & Fish Handling Dual Flow Conversion
EWT FILE REFERENCE NUMBER:	BP07-142

We are pleased to provide the following Budget Proposal based on the above customer reference information and the following conditions/considerations:

I. EQUIPMENT INCLUDED IN BUDGET PRICE BY (X)

X	Fish Handling Thru Flow Band Screens & Fish Handling Dual Flow Conversion	X	Factory Coating
	Controls	X	Factory Testing
X	Anchor Bolts	X	Shipment Loading
X	O & M Manuals	X	Freight to Site (separate)
X	Warranty	X	Field Service (separate)

II. ITEMS NORMALLY SUPPLIED BY OTHERS

Unloading at Site / Field Touch-up
Removal or Disposal of the Existing Screens
Installation / Erection / Mounting
Civil Works / Grouting / Anchor Installation
Motor Control Center
Conduit / Wiring / Cables & Glands
Access Ladders / Handrails / Flooring
Site Protection / Storage
State, Federal, Local Taxes or Use Taxes

III. TYPICAL DELIVERY AND SHIPMENT

The Equipment can be typical delivered in 30-32 weeks based on:

		WEEKS
A.	General Drawings for Review	6-8
B.	Review by Client/User	4-6
C.	Details, Fabrication Shipment	18-20
	TOTAL	30-32*

*** Based on delivery of first pair of screens. For multiple screens add 3 weeks for each additional pair thereafter.**

IV. VALIDITY AND PAYMENT

A. VALIDITY

This Budget Proposal should be considered as valid for approximately three (3) months based on normal industry circumstances. After such time, please check with us for changes such as material/labor rates continued validity.

B. NORMAL PAYMENT TERMS

The budget prices are based on our standard payment terms.

V. NORMAL TERMS AND CONDITIONS

The following budget prices are based on our standard terms and conditions, available on request.

VI. BUDGET PRICES

A. **Fish Handling Thru Flow Band Screens – U1** – Two (2) Fish Handling Thru Flow Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 8'-0" Effective width for a channel 30'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts.

Total Budget Price: $ 265,500.00 USD Each x 2 = $ 531,000.00

(Five hundred thirty one thousand dollars)

B. **Fish Handling Thru Flow Band Screens – U2 –** Two (2) Fish Handling Thru Flow Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 10'-0" Effective width for a channel 35'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts.

Total Budget Price: $ 315,500.00 USD Each x 2 = $ 631,000.00

(Six hundred thirty one thousand dollars)

C. **Fish Handling Dual Flow Conversion Band Screens – U1** – Two (2) Fish Handling Dual Flow Conversion Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 4'-0" Effective width for a channel 30'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts including flow deflectors, nose cone, transition troughs and flood box (for fish trough)

Total Budget Price: $ 360,500.00 USD Each x 2 = $ 721,000.00

(Seven hundred twenty one thousand dollars)

D. **Fish Handling Dual Flow Conversion Band Screens – U2** – Two (2) Fish Handling Dual Flow Conversion Band Screens to include the S.I.M.P.L.E. Fish Handling design, Approx. 5'-0" Effective width for a channel 35'-0" deep of mainly epoxy coated carbon steel with 316 SS mesh and fasteners, 1/8" x ½" smooth top mesh for normal operation and interchangeable 1mm mesh inserts including flow deflectors, nose cone, transition troughs and flood box (for fish trough)

Total Budget Price: $ 410,500.00 USD Each x 2 = $ 821,000.00

(Eight hundred twenty one thousand dollars)

E. One (1) lot Fish Return Troughing (of required length) of fiberglass trough with epoxy coated carbon steel supports. **This is <u>NOT</u> the entire fish return trough as other appropriations should be made for the final return back to the source water.**

Total Budget Price: $ 250.00 **Per Foot**

(Two hundred fifty dollars per foot)

F. We recommend including the following for freight to the site of the above equipment.

Total Budget Price: $ 7,500.00 USD Total Suggested **(Per Screen)**

(Seven thousand five hundred dollars)

G. Field Service

We suggest including for one (1) trip and five (5) days of Field Service for approximately $ 7,000.00 USD total **per screen**. If additional days are required, our Field Service Technicians are available for $ 1,000.00 USD/Day plus all travel, living and per diem at cost.

Total Budget Price: 1 Trip & 5 Days = $ 7,000.00 Total Suggested **(Per Screen)**

(Seven thousand dollars)

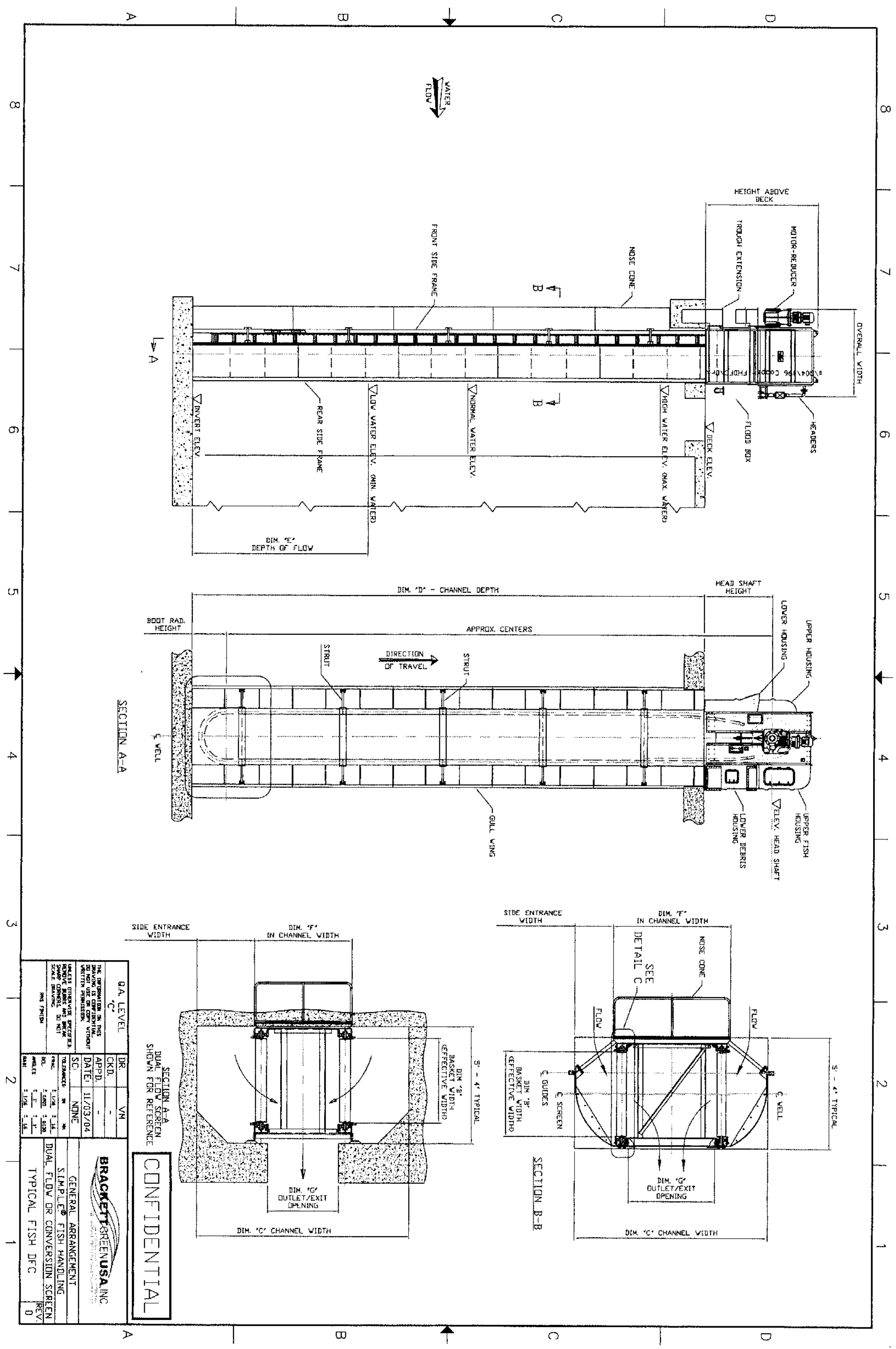
VII. INFORMATION ATTACHED

X	Typical Specification Reference	Thru Flow & Dual Flow Conversion Typical Specifications
	Outline Drawing Reference	
	Brochure Reference	
X	Data/Calculations Reference	

If you have any further questions, please contact the undersigned directly at 281-480-7955.

Best Regards,
EIMCO Water Technologies LLC

Trent T. Gathright
Group Product Manager
Screening Products


WATER FLOW
HEIGHT ABOVE DECK
TROUGH EXTENSION
MOTOR-REDUCER
NOSE CONE
FRONT SIDE FRAME
OVERALL WIDTH
HEADERS
FLOOD BOX
DECK ELEV.
HIGH WATER ELEV. (MAX. WATER)
NORMAL WATER ELEV.
LOW WATER ELEV. (MIN. WATER)
REAR SIDE FRAME
INVERT ELEV.
DIM. "E" DEPTH OF FLOW
DIM. "D" - CHANNEL DEPTH
HEAD SHAFT HEIGHT
BOOT RAD. HEIGHT
APPROX. CENTERS
DIRECTION OF TRAVEL
STRUT
LOWER HOUSING
UPPER HOUSING
SECTION A-A
℄ WELL
GULL WING
LOWER DEBRIS HOUSING
ELEV. HEAD SHAFT
UPPER FISH HOUSING
SIDE ENTRANCE WIDTH
DIM. "F" IN CHANNEL WIDTH
SECTION A-A DUAL FLOW SCREEN SHOWN FOR REFERENCE
DIM. "B" BASKET WIDTH (EFFECTIVE WIDTH)
5' - 4" TYPICAL
DIM. "G" OUTLET/EXIT OPENING
DIM. "C" CHANNEL WIDTH
SEE DETAIL C
NOSE CONE
FLOW
℄ GUIDES
℄ SCREEN
℄ WELL
SECTION B-B
CONFIDENTIAL
BRACKETT GREEN USA, INC
GENERAL ARRANGEMENT
S.I.M.P.L.E® FISH HANDLING
DUAL FLOW OR CONVERSION SCREEN
TYPICAL FISH DFC
REV 0
Q.A. LEVEL "C"
DR. VM
DATE 11/03/04
SC. NONE

From: David Anderson [dlanderson@optonline.net]
Sent: Thursday, August 30, 2007 2:03 PM
To: Sue Polyak
Subject: Re: Debris Carryover at Merrimack Station
Attachments: Merrimack Budget Proposal 28788 E1.pdf; _AVG certification_.txt

Sue,

With this message is a copy of a proposal we have made for the Merrimack Station.

Let me know if you have any questions.

Thanks,

Dave

At 03:50 PM 8/23/2007, Sue Polyak wrote:

> PRIVILEGED & CONFIDENTIAL,
> ATTORNEY-CLIENT COMMUNICATION,
> ATTORNEY WORK PRODUCT,
> PREPARED IN ANTICIPATION OF LITIGATION
>
> Dave,
>
> I just received the following information about debris carryover from Merrimack Station:"For periods of time without any outages, we will typically take a load drop every couple months to clean leaves, sticks, etc., from the condenser water boxes. More frequently in the fall. The effect is typically a gain of 0.2- 0.5 in hg condenser pressure, which is significant. The cooling water heat exchangers are also cleaned periodically due to leaves, sticks, etc., clogging the tube sheet." Obviously, we'll want to look into the MultiDisc screens - your specialty!
>
> Did you receive the Vendor Information Packet? If not, let me know and I can send it in pieces. If you did, let me know if you have any questions.
>
> Thanks!
> Sue

PASSAVANT GEIGER

Passavant-Geiger GmbH
Business Unit Geiger
Hardeckstraße 3
76185 Karlsruhe, Germany
Phone: + 49 721 5001 - 0
Telefax: + 49 721 5001 - 213
www.passavant-geiger.de
info@passavant-geiger.de

Headquarters
Passavant-Roediger-Straße 1
65326 Aarbergen, Germany

Passavant-Geiger GmbH · Hardeckstraße 3 · 76185 Karlsruhe

Enercon Services Inc.
500 Town Park Lane Suite275
Kennesaw, GA 30144

USA

Our reference:	e-mail:	phone: +49 721 5001-351	Karlsruhe,
Christian Stohlmann	Christian.Stohlmann@passavant-geiger.de	telefax: +49 721 5001-370	August 29, 2007

Subject: **Merrimack Station**
MultiDisc® - Water Intake Screens

Our Ref.: **Our Budget Offer No. 28 788 E 1**

Dear Sirs,

We refer to the above mentioned project and take pleasure in providing our budget quotation for the replacement of the existing travelling band screens with our MultiDisc® screens.

The MultiDisc® provides the unique solution for a zero carry-over design, which can be easily retrofit, and does not disrupt a plants intended flow pattern.

We are offering the MultiDisc® with perforated plastic panels. With regard to the cleaning of the panels by means of the spray water device, this type of screen material shows a much better performance compared to panels using wire mesh cloth, especially fibrous debris, which tends to wrap around the wire crossings.

On Request the machines can be shipped completely assembled and can be installed in a one-piece assembly except some minor parts like e.g. spray hood, thus decreasing installation expenditures to a minimum.

It should be noted that with our fish return design, you will be able to use the existing debris trough without modification. For comparison purposes if you were to use any other fish return design you would have to add a new trough on the downstream side of the screens. Likewise our fish return design requires only our normal spray wash system. All other fish return designs require the addition of two additional spray wash headers per screen, and may require additional spray wash pumps.

../2

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The stated US-Dollar prices are based on the ECB daily USD/EURO exchange rate 1.367 plus an offset of 0.016. As soon as we come to an agreement on the delivery and payment terms, the final exchange rate will be fixed. However, in view of the present tense situation on the steel market it is not possible for us to make a long term prediction of future prices. Therefore the stated prices are valid until 31/10/07 only.

For further commercial as well as technical details please refer to the following quotation.

We trust you will find our offer of interest and we appreciate your interest in Passavant-Geiger products. We further hope to have provided a technically and commercially attractive quotation and look forward to work with you on this project. Please feel free to contact us or Mr. Dave Anderson if you have any questions.

Best Regards

Passavant-Geiger GmbH
Business Unit Geiger

i.A. Christian Stohlmann

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MERRIMACK STATION
PASSAVANT-GEIGER BUDGET OFFER NO. 28 788 E1

PRICE SCHEDULE

Item	Qty	Designation	Unit price in USD	Lot price in USD
		Unit 1		
1.1	2	GEIGER MultiDisc® Screen, Type MDS 550 with 9.5 mm (3/8") perforation and Fish Protection Provisions	267,000.00	535,000.00
		Unit 2		
1.2	2	GEIGER MultiDisc® Screen, Type MDS 700 with 9.5 mm (3/8") perforation and Fish Protection Provisions	322,000.00	644,000.00
2.0	4	Electrical Operating & Control Systems	16,500.00	66,000.00
3.0	1	Estimated Freightcosts DDP free site acc. to INCOTERMS 2000		110,000.00
		Total	**USD**	**1,355,000.00**

VAT excluded
Our prices do not include customs duties and levies as well as federal, state and local tax duties and demurrage costs.

The performance and services of Passavant Geiger consist in the following major activities for the Screening Equipment:

- the design
- German statutory approvals
- the fabrication
- the shop inspection
- the shop testing
- delivery DDP free site
-

Passavant-Geiger GmbH
Business Unit Geiger

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MERRIMACK STATION
PASSAVANT-GEIGER BUDGET OFFER NO. 28 788 E1

DESIGN INFORMATION – UNIT 1

0.1 GENERAL INFORMATION

Max flow per intake channel	:	29000 gpm

0.2 MEDIUM : fresh water

0.3 MATERIAL OF MAIN COMPONENTS

Cleaning machines	:	stainless steel 304

0.4 CIVILSTRUCTURE

Operating floor level	:	EL + 207'
Invert level screens	:	EL + 177'
Width of section travelling screen	:	9'-2"

0.5 WATER LEVELS

Low Water level (L.W.L.)	:	EL + 187'
Normal Water level (N.W.L)	:	EL + 189'
Assumed High Water level (H.W.L)	:	EL + 204'

0.6 BLOCKAGE / HEADLOSS / VELOCITY

MultiDisc® Screen with perforation 9.5 mm / 3/8"
Max Flow at L.W.L

Blockage	Headloss	Velocity
clean mesh	1.39 inch WC	1.80 ft/s
10 % blocked	1.72 inch WC	2.00 ft/s
20 % blocked	2.17 inch WC	2.25 ft/s
30 % blocked	2.84 inch WC	2.57 ft/s
40 % blocked	3.86 inch WC	3.01 ft/s

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PASSAVANT-GEIGER BUDGET OFFER NO. 28 788 E1

DESIGN INFORMATION – UNIT2

0.1 GENERAL INFORMATION

Max flow per intake channel	:	70000 gpm

0.2 MEDIUM : fresh water

0.3 MATERIAL OF MAIN COMPONENTS

Cleaning machines	:	stainless steel 304

0.4 CIVILSTRUCTURE

Operating floor level	:	EL + 207'
Invert level screens	:	EL + 172'
Width of section travelling screen	:	11'-2"

0.5 WATER LEVELS

Low Water level (L.W.L.)	:	EL + 187'
Normal Water level (N.W.L)	:	EL + 189'
Assumed High Water level (H.W.L)	:	EL + 204'

0.6 BLOCKAGE / HEADLOSS / VELOCITY

MultiDisc® Screen with perforation 9.5 mm / 3/8"
Max Flow at L.W.L

Blockage	Headloss	Velocity
clean mesh	2.17 inch WC	2.25 ft/s
10 % blocked	2.67 inch WC	2.50 ft/s
20 % blocked	3.38 inch WC	2.81 ft/s
30 % blocked	4.42 inch WC	3.21 ft/s
40 % blocked	6.01 inch WC	3.75 ft/s

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MERRIMACK STATION
PASSAVANT-GEIGER BUDGET OFFER NO. 28 788 E1

TECHNICAL DESCRIPTION

ITEM 1.1

2 GEIGER MULTIDISC® SCREENS, TYPE MDS 550 FOR UNIT 1

The GEIGER MultiDisc® Screens (US Patent No. 6,719,898) are applied for screening intake water for power and desalination plants as well as for process water plants. They are used for fine screening of river or sea water where the water level is subject to fluctuation or where very large volumes of water are to be screened. They are installed in multi-stage screening and sieving plants. Their main purpose is the removal of suspended and floating matter and various sediments from pre-cleaned water.

The MultiDisc® Screen is suitable for either narrow or wide, deep or shallow chamber sections: chamber widths 1.2 – 3.5 m across flow direction and chamber depths up to 15 m. The mesh size ranges from 1.0 to 10 mm.

Design features

The MultiDisc® Screen has a *thru-flow* flow pattern. The raw water flow directly through the mesh panels without change of the flow direction. The total submerged screening area, that is, the descending and ascending mesh panels as well as mesh panels in the lower guiding section, is used to screen raw water.

The screenings are retained at the front of the mesh panels. As the screen band travels through the water body, the collected screenings will be carried upwards to the discharge position above deck level, where they will be washed off by a spray water device into a waste collecting trough. The spraying of mesh panels is with a suitable pressure to achieve a high intensity of cleaning of mesh panels.

Due to the design of circulating sickle shaped panels across the channel no carry over of debris to the clean water side can occur.

Machine construction
The main components of the MultiDisc® Screen are the sickle shaped mesh panels, one central chain guideway integrated in the supporting structure, one revolving chain, one lower guiding section, spray water device, a screenings collecting trough, drive unit, overload protection and a protective splashing guard.

The head section of the screen frame incorporates, solid main shaft, the sprocket wheel and the spray pipe as well as the splash guard. The base frame supports the rotating main shaft with flanged sprocket wheel. The spray pipe is arranged in such a way as to produce the maximum spraying efficiency.

The spray water pipe is equipped with a certain number of flat jet nozzles and can optionally be fitted with a manually operated internal rotating brush for nozzle cleaning. The splash guard of the head section is easy to be removed and on both sides provided with inspection doors.

The mesh panels are secured on one endless revolving side bar chain to form the MultiDisc® screen. The chain strand run on a large sprocket wheel and is directed through the lateral chain guideways. The mesh panels themselves are sealed by overlapping each other on the upstream side.

Debris retained in the screen mesh and on the debris carriers is sprayed off as the mesh panels reach the position of the spray pipe and is collected in the debris collecting trough.

No rotating shaft with wheels and bearings are permanently submerged and exposed to the raw water and all maintenance work can therefore be carried out on deck level without dewatering the screening chamber. This construction minimizes operation and maintenance costs.

The MultiDisc® Screen is being driven by a frequency converter controlled or 2-speed geared motor in combination with a bevel gear as speed reducer. The drive unit is directly mounted on the main shaft thus avoiding an additional chain-drive assembly. The entire drive unit is set up outside of the splash guard and therefore free from direct exposure to liquid medium.

The overload protection is effected electronically. In the event of an overload occurrence a electronic switch interrupts the electrical circuit and stops the MultiDisc Screen and a failure signal will be triggered.

Operation

The MultiDisc Screen can be operated in three modes for all possible operation situations in the foreseen praxis:

A) Automatic control
B) Local manual control
C) Adjustable timer
D) Remote control

Mode A is a function of the rate of pollution and is operated by the water level differential sensor which controls the operation of the screen via electrical operating and control system. The water level differential measuring system may be designed according to one of the following three methods: the air injection principle, hydrostatic principle or the ultrasonic principle. In the automatic control mode the MultiDisc Screen is initiated through the impulse given by the water differential measuring unit.

Mode B is activated when the selector switch at the electrical operating and control panel was set to LOCAL. In this mode the MultiDisc screen can only be switched on and off at the local push-button station. When it has been switched on, the MultiDisc screen runs in slow speed without the wash pump being switched on. This operation mode serves mainly for the inspection of the mesh panels.

Mode C is controlled by a timer relay combination. Once started the machine runs until the pre-set time will have elapsed. Then it is stopped, and restarted again by the timer or a differential water level measuring system which has an over-riding function. The timer settings can be changed at any time, approximately it is set to:

Mode D is controlled by a external PLC. Once started by setting a remote contact to on the machine runs until the remote contact is set to off.

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Technical data

Type: MDS 550

Chamber (channel) width	b:	2.794	m	/	9' – 2"	
Chamber depth	t:	9.144	m	/	30'	
Machine width	Mb:	2.65	m	/	8.70'	
Overall height above floor (approx.)	v:	3.1	m	/	10.2'	
Angle of inclination	Alfa:	90	Degree			
Discharge height of screenings (approx.)	a:	0	m			
Chain pitch		550	mm	/	21.6"	
Center distance		9.35	m	/	30.68'	
Total number of sickle shaped panels	n:	42	pcs			
Perforation of panels	W1:	9.5	mm	/	0.375"	
Free screening area	$A1_0$	74.2	%			
Min. revolving speed	N_1	0.08	m/s	/	0.26	ft/s
Max. revolving speed	n_2	0.24	m/s	/	0.79	ft/s
Design dynamic water head	$H_{delta}1$:	0.61	m		2'	
Design static water head	$H_{delta}2$:	1.52	m		5'	
Operating frequency		60	Hz			
Nominal rating of drive (approx.)		7.50	KW			
Operating voltage		460	V			
Nominal frequency		60	Hz			
Enclosure of drive		IP55				
Insulation class		F				
No. of spray nozzles – ascending side		6				
No. of spray nozzles – descending side		2				
Req. spray water flowrate (min.)		27	m^3/h	/	119	gpm
Req. spray water pressure (min.)		6.0	bar			

Each MultiDisc screen consists mainly of:

1 SCREEN FRAME made of folded steel plate with sufficient number of bracing members and integrated guideway which serve as roller tracks for the chain as well as stainless steel wear strips serving sliding surface for the mesh panels.

1 LOWER GUIDING SECTION made of stainless steel for the drive chain integrated in the screen frame.

42 MESHPANELS made of perforated polyoxymthylene plates with stainless steel carrier blade.

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1 REVOLVING CHAIN, maintenance-free design, dismountable, with heat-treated and hardened pins and bushes, lateral and rear polyamide rollers.

1 DRIVE UNIT with geared motor with electronic overload protection device, shaft with directly flanged sprocket wheel. Completely installed on a stainless steel support structure adjustable in height.

1 SPRAY WATER DEVICE, high pressure, with spray pipe, flat jet nozzles, regulating valve and waste water discharge as well as necessary valves, pressure gauges and shut-off valves.

1 BOTTOM SPARGER for the lower screen deflection as flushing pipe with nozzles located along the deflection line.

1 Discharge CHUTE with trough leading the debris into the existing debris trough.

1 SPLASH-GUARD with lockable inspection flaps and inspection windows.

Materials of construction for main parts according to DIN, AISI / ASTM Standard:

PART DESCRIPTION	MATERIAL	DIN	AISI / ASTM	FINISH
Base frame	stainless steel	1.4301	304	pickled / passivated
Lower guiding section	stainless steel	1.4301	304	pickled / passivated
Wear strips	stainless steel	1.4301	304	pickled / passivated
Chain guides	stainless steel	1.4301	304	pickled / passivated
Mesh panel	Polyoxymethylene Polyethylene	POM PE		as usual in trade
Lower guiding section	stainless steel	1.4301	304	pickled / passivated
Splash guard	stainless steel	1.4301	304	pickled / passivated
Spray pipes	stainless steel	1.4301	304	pickled / passivated
Spray nozzles	stainless steel	1.4439		as usual in trade
Main shaft	stainless steel	1.4301	304	pickled / passivated
Chain sprocket	stainless steel / polyamide	1.4301	304	pickled / passivated
Chain side bars	stainless steel	1.4301	304	pickled / passivated
Pins and bushes of chain	stainless steel	1.4122	similar to 431	
Chain rollers	Polyamide	PA 6G		pickled / passivated
Motors and gear units	As customary in trade			as usual in trade
Screws, bolts and washers	stainless steel	A4	316, 316L, 316Ti	as usual in trade

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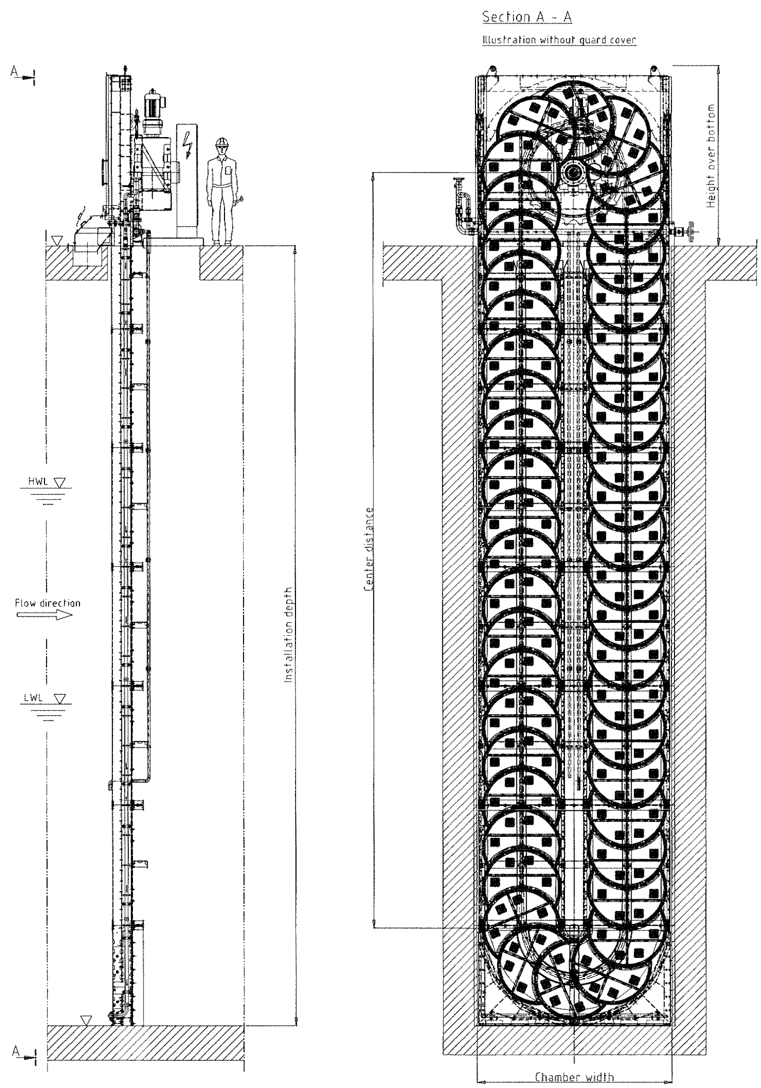
MultiDisc® Screen Typical Assembly Drawing



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1 FISH PROTECTION PROVISIONS

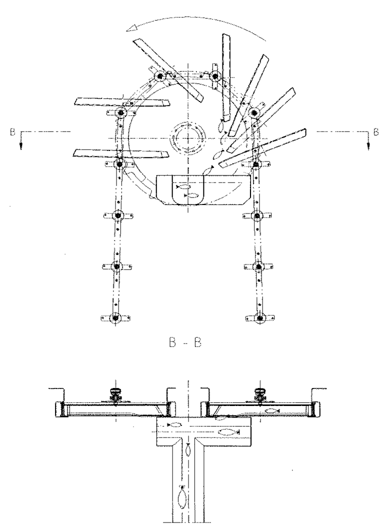
Function

The MultiDisc® Screen panels are additionally equipped with fish buckets, which are designed to retain some of the cooling water during its upward travel, thereby allowing any captured fish "to survive within the water" once the screen panels exit the water level.

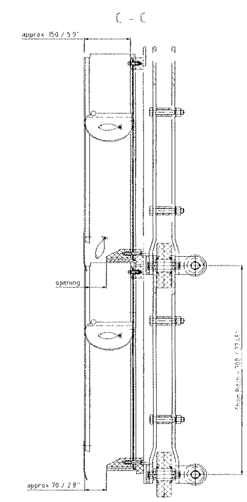
A low pressure spray header smoothly recovers impinged organisms from the screen surface into the bucket. Fish impinged on the mesh below this bucket are led via an opening in the lower panel frame into the bucket of the following mesh panel. As each screen panel turns to return down for another cleaning cycle, the retained water and fish are gently "poured" into the debris trough located at the upstream side.

Typical Assembly

Bucket Deflection Travel
(without Mesh Panels)



Mesh Panel / Fish Bucket Arrangement



Materials of construction for main parts according to DIN, AISI / ASTM Standard:

PART DESCRIPTION	MATERIAL	DIN	AISI / ASTM	FINISH
Fish buckets	stainless steel	1.4301	304	coated
Spray pipe	stainless steel	1.4301	304	pickled / passivated
Screw, bolts and washers	stainless steel	A4	316, 316L, 316Ti	as usual in trade

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ITEM 1.2

2 GEIGER MULTIDISC® SCREENS, TYPE MDS 700 FOR UNIT 2

Similar to tem 1.1 except the following:

Technical data

Type: MDS 700

Chamber (channel) width	b:	3.404	m	/ 11' – 2"	
Chamber depth	t:	10.67	m	/ 35'	
Machine width	Mb:	3.25	m	/ 10'-8"	
Overall height above floor (approx.)	v:	3.5	m	/ 11.4'	
Angle of inclination	Alfa:	90	Degree		
Discharge height of screenings (approx.)	a:	0	m		
Chain pitch		700	mm	/ 27.57"	
Center distance		10.5	m	/ 34.45'	
Total number of sickle shaped panels	n:	38	pcs		
Perforation of panels	W1:	9.5	mm	/ 0.375"	
Free screening area	$A1_0$	74.2	%		
Min. revolving speed	N_1	0.08	m/s	/ 0.26	ft/s
Max. revolving speed	n_2	0.24	m/s	/ 0.79	ft/s
Design dynamic water head	$H_{delta}1$:	0.61	m	2'	
Design static water head	$H_{delta}2$:	1.52	m	5'	
Operating frequency		60	Hz		
Nominal rating of drive (approx.)		9.20	KW		
Operating voltage		460	V		
Nominal frequency		60	Hz		
Enclosure of drive		IP55			
Insulation class		F			
No. of spray nozzles – ascending side		7			
No. of spray nozzles – descending side		3			
Req. spray water flowrate (min.)		30	m^3/h	/ 132	gpm
Req. spray water pressure (min.)		6.0	bar		

Each MultiDisc screen consists mainly of:

38 MESHPANELS wit of perforated polyethylene plates pinched between two ste0l frames, of which outline is completely seamed in a synthetic structure as mesh panel friction strip.

Materials of construction for main parts according to DIN, AISI / ASTM Standard:

PART DESCRIPTION	MATERIAL	DIN	AISI / ASTM	FINISH
Mesh panel	stainless steel Polyethylene	1.4301 PE	304	pickled / passivated

ITEM 2.0

4 ELECTRICAL OPERATING AND CONTROL SYSTEMS

for 1 MultiDisc® Screen. The panel is suitable for outdoor installation arranged NEMA 4X and made of stainless steel AISI 304. All switchgear is mounted on a galvanized mounting plate inside the cabinet and wired ready for operation. Operation/control/monitoring of MDS exclusively at VFD operator panel.The power section switchgear is not of the MCC-type (no withdrawable modules). Cabinet of the free-standing type with bottom cable access

Control philosophy:
The control modes SLOW – FAST – WATER LEVEL to be selected by the VFD Operator panel. Automatic control of operation speed by differential level measuring unit.

Control provides:
- Dry contact for "VFD Common Failure" indication to central control room (DCS)
- Inverter internal control circuits used for input for external source 4-20mA for speed control by external water level meas. system
- Voltage supply for water level measuring system incl. in the VFD

Supply voltage 460 V 60 Hz
Control voltage 24 VDC

Main switches executed as circuit breaker.

The power and control panel mainly consists of:
- Frequency converter with EMC-filter and output choke
- VFD Operator Panel
- MCB for VFD-protection and terminals for motor and controls

The electrical operating and control equipment as well as the drive motor are provided with an automatic heat exchanger to prevent condensation.

Switching and control instruments for the following drive units:

1 MULTIDISC with frequency converter controlled motor

Nominal motor rating: 7.5 kW at Unit 1 respect. 9.2 KW at Unit 2

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Operation modes: SLOW – FAST – WATER LEVEL

Frequency converter incl. EMC filter & Output choke (make ABB):

Supply voltage:	460V
Nominal frequency:	60 Hz
Enclosure:	IP 20
Max. drive rating:	15 kW
Max nominal current:	25 A
Max output frequency:	400 Hz

Overall dimensions of the sheet steel cabinets:

height:	600	mm / 1.96'
width:	600	mm / 1.96'
depth:	400	mm / 1.31'

Remarks:

- Inverter internal control used for control purpose
- Equipment (switchgear, wires, terminals) meets relevant NEMA-regulations
- Power & control panel internal wiring colours acc. to IEC-recommendations
- Power & control panel internal wiring marked with termination point numbers
- Power & control equipment panel providing dry contacts for status/failure indication in DCS
- Control section not providing signal bus modules, remote control system or redundant operation items etc; no process visualisation provided.
- Neither system alarm cables to DCS, power feeding cables nor system cables or cable pipes and ducts and trenches as well as other laying or fastening material included in our quotation

Audrey Thompson

From:	Petrovs, Henry (WT) [henry.petrovs@siemens.com]
Sent:	Tuesday, August 21, 2007 2:52 PM
To:	athompson@enercon.com
Subject:	Hello from Siemens Water Technologies - Henry Petrovs - Merrimack Generating Station 316(b)
Attachments:	Conectiv - Discharge 1.ppt; Conectiv - Discharge.ppt; Siemens Who Are We (5).doc; intake_broch_0606.pdf; Conectiv - Deepwater - 30393-103a.TIF; Conectiv - Deepwater - 30393-101a.TIF; Conectiv - Deepwater - 30393-102a.TIF

Audrey,

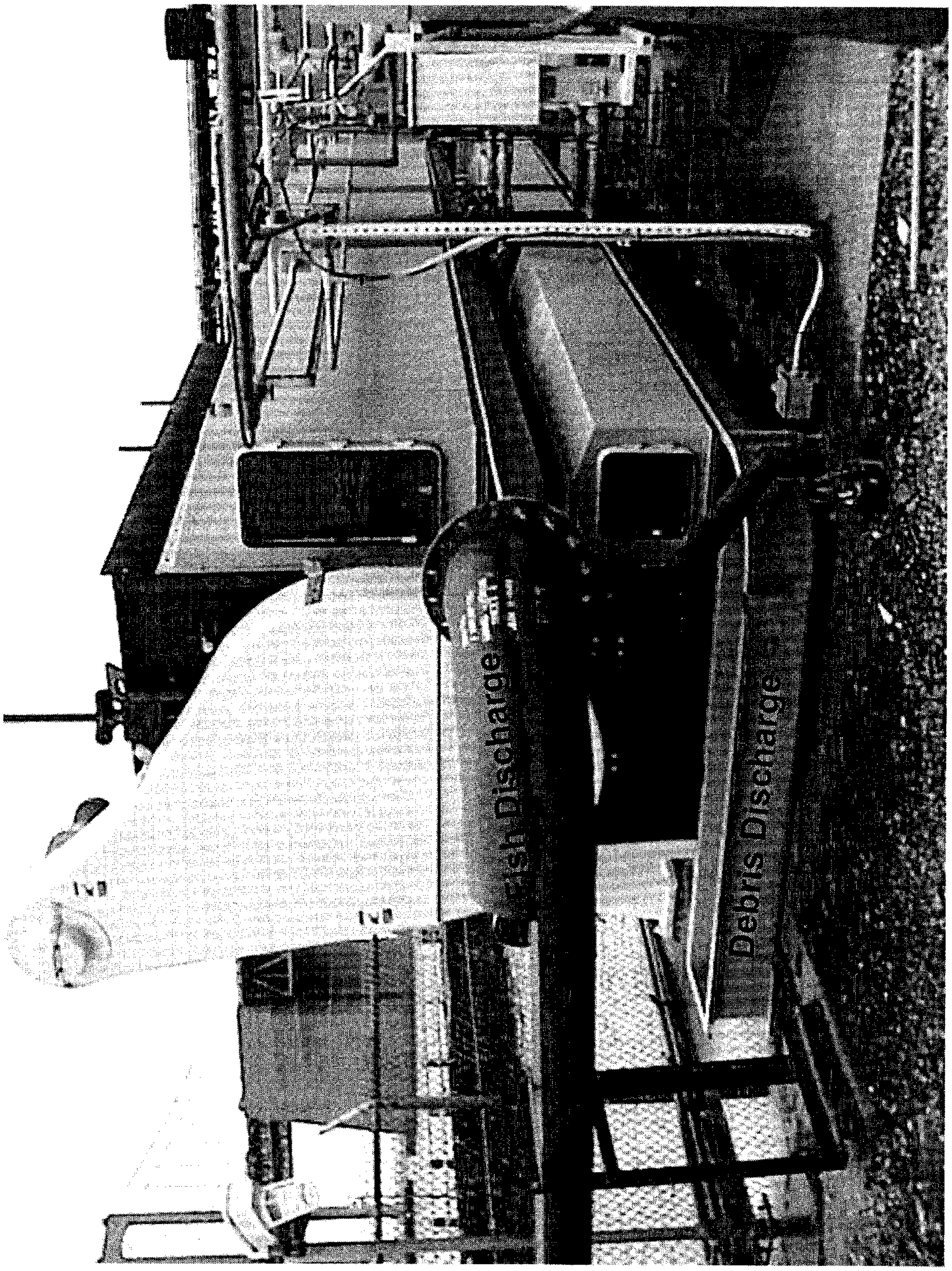
Let me know if this gets to you and I'll send you more Stuff?

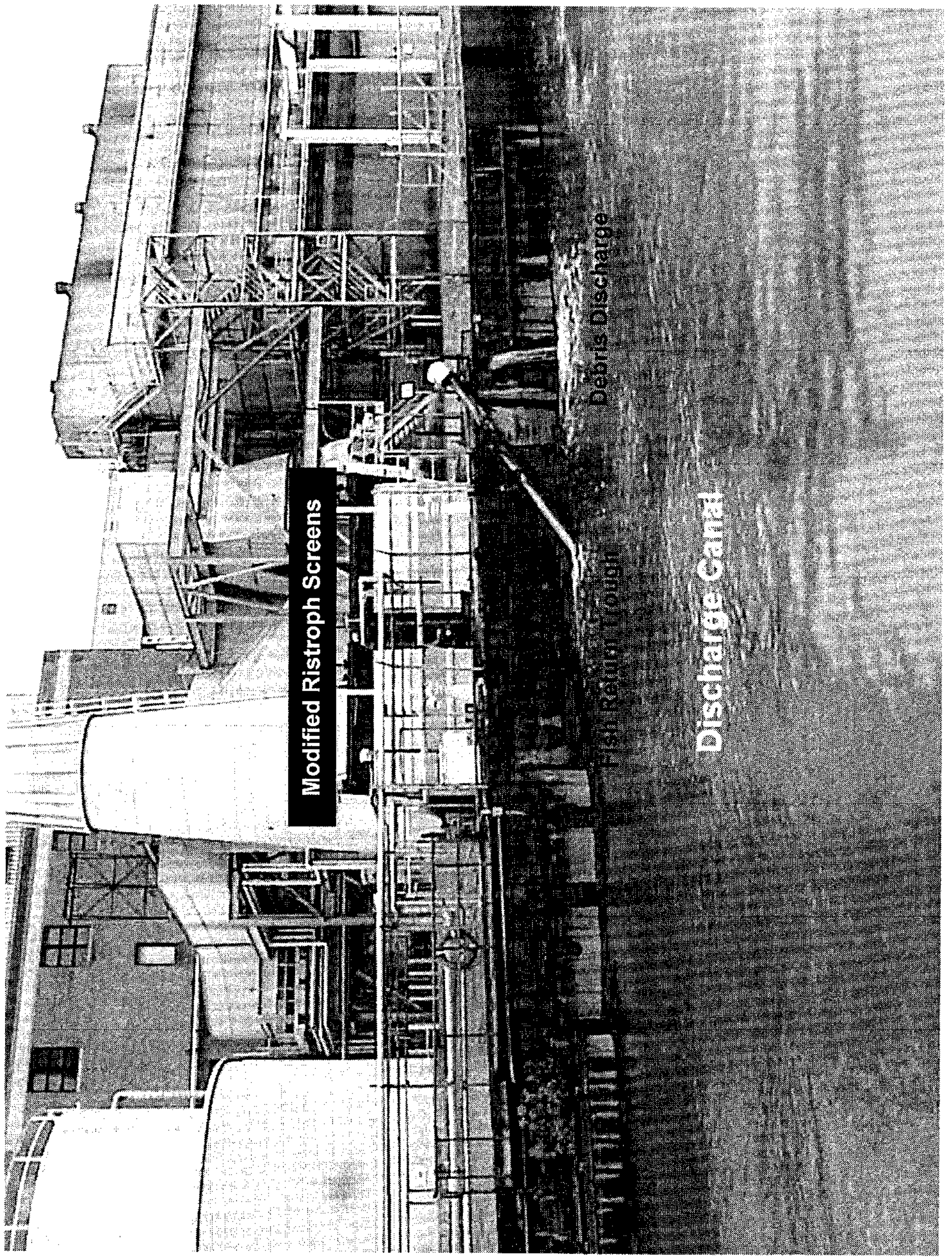
Attached is our Installation for Conectiv - Deepwater Generating Station utilizing the Siemens Modified Ristroph Traveling Water Screen that we Developed.

Regards,

Henry

Henry Petrovs
Technical Sales Manager
Midwest & Eastern Region
Engineered Products & Systems
Intake Products - Rex®, Link-Belt® & Royce® Traveling Water Screens

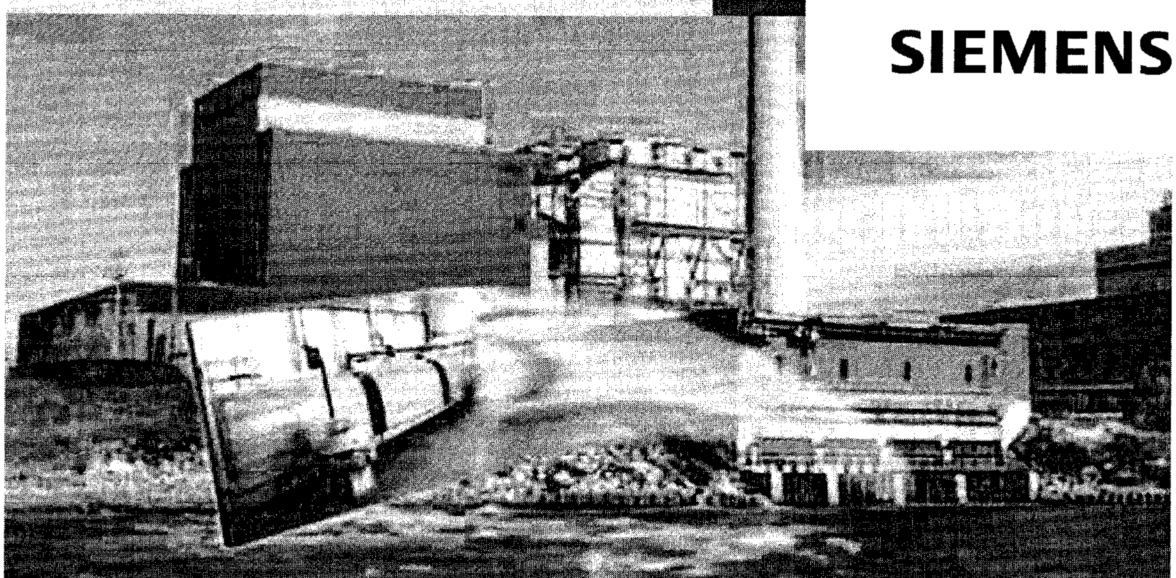

Fish Discharge
Debris Discharge


Modified Ristroph Screens
Debris Discharge
Discharge Canal

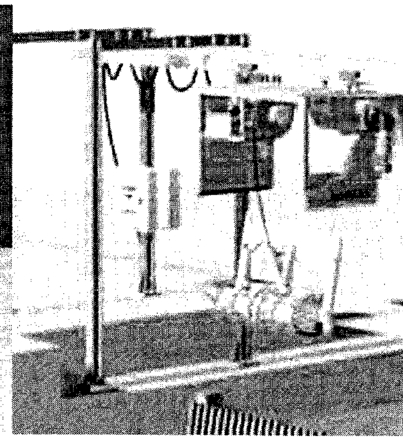
Water Technologies

Rex® and Link-Belt® Intake Systems: proven, efficient and reliable

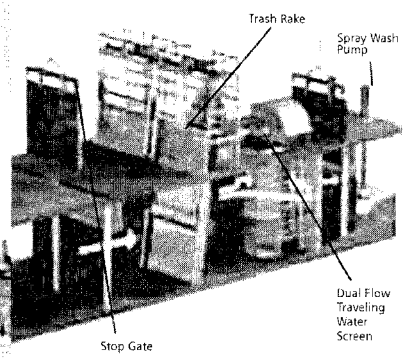
SIEMENS

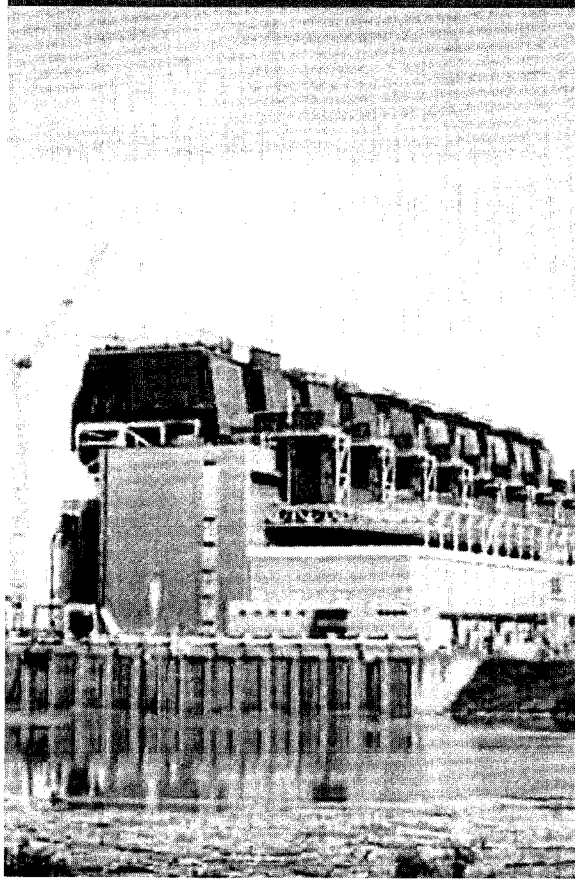


Unrivaled experience in providing dependable, efficient screening



Trash rake removes heavy debris.





We have decades of experience solving high volume water intake problems under varying site conditions.

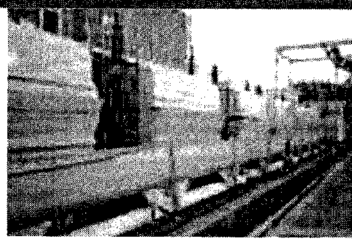
Rex® and Link-Belt® intake systems lead the industry
With thousands of our traveling water screens supplied to power generators, municipalities and other industries over the past century, we are the recognized leader in the water intake industry. Our intake screening systems provide clean, debris-free raw water while minimizing ecological impacts, reducing maintenance problems, and extending service life.

A complete system from stop gates through controls
Stop logs/gates prevent water from entering the channel during down-stream maintenance. Bar racks capture rough and larger debris to prevent it from reaching the finer mesh of the traveling water screen. These racks are cleaned by trash rakes, either stationary or traversing.

Choose from several types of traveling water screens to capture fine debris. In addition, we offer a dependable, user-friendly control system for complete and closely-calibrated control of the entire screening system.

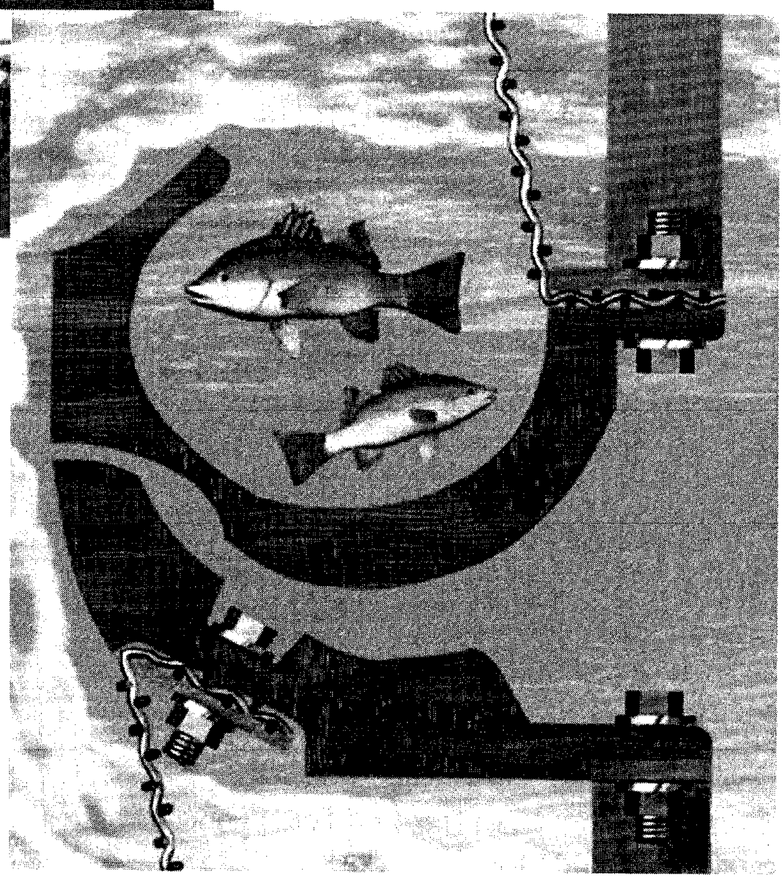
We also provide all the ancillary equipment, from pumps to auxiliary strainers, trash baskets and stationary screens. And - before we leave your site - we can arrange for training for your operating personnel.

The leader in solutions for fish-friendly screening



A Rex® fish screen installation designed with the benefit of our full-scale fish laboratory.

New technologies for fish protection such as our unique integral fish buckets are a proven way to minimize the adverse impact on marine life.



Our Modified Ristroph system meets environmental standards

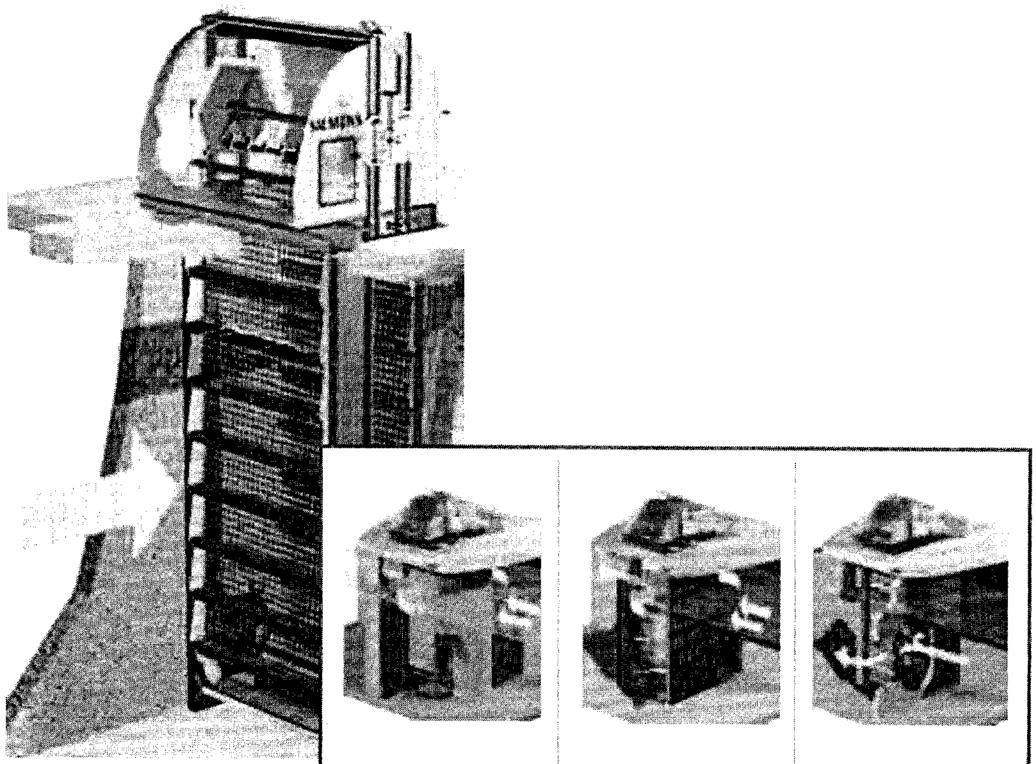
Cooling water intake systems are the highly visible object of Section 316(b) of the Clean Water Act. These standards mandate very specific requirements for all areas of intake structure operation.

We've been designing, testing and improving fish protection systems since the late 1960's; long before the current regulations were conceived.

As a result, our Modified Ristroph fish handling intake screen systems are all able to meet the new rules.

Whether you need to plan a new intake system or a retrofit, you'll benefit from our experience and our support.

A variety of screen designs for any site condition



Dual Flow Traveling Water Screens

Dual Flow Retrofits

Center Flow Screens

No matter what the site condition or specification, we have the right water screen to meet your needs.

Through Flow Traveling Water Screens
have submerged screen surfaces perpendicular to the intake flow. They collect and carry debris upward where it is flushed into a debris trough. Screen widths range from 2 to 14 feet (610 to 4267 mm) with vertical centers from 8 to 100+ feet (2440 mm to 30 m). Screen mesh openings are sized according to customer requirements and site conditions.

Dual Flow Traveling Water Screens
are essentially Through Flow systems turned 90 degrees, putting the screen surfaces parallel to the intake flow. This doubles the effective screening area and reduces possible down-stream debris carryover. It also allows the use of finer screen meshes without increasing flow velocity.

Dual Flow Retrofits
allow an existing Through Flow screen well to be easily converted to Dual Flow operation. Curved flow diverter plates on both sides of the new Dual Flow screen engage the existing embedded guideways and create the "double entry/single exit" flow pattern.

Center Flow Screens
are similar to Dual Flow traveling screens, but direct the flow from inside to the outside of the screen. Side plates block the flow along the outer edges of the channel and direct it inward to the screen. Debris is lifted to the top and flushed away by water and gravity.

Audrey Thompson

From:	Petrovs, Henry (WT) [henry.petrovs@siemens.com]
Sent:	Thursday, August 23, 2007 3:40 PM
To:	Audrey Thompson
Cc:	jim boyson; bbo5807254@aol.com; Kofeldt, Thomas J (WT)
Subject:	RE: Hello from Siemens Water Technologies - Henry Petrovs - Merrimack Generating Station 316(b)
Attachments:	95XXXHP - Enercon Services - Merrimack Units 1&2 - 316(b) 2007.doc

Audrey,

Attached is the Budget Numbers for the Merrimack Unit 1 & 2 Replacement 316(b) Traveling Water Screen for your consideration.

Regards,

Henry Petrovs

Henry Petrovs
Technical Sales Manager
Midwest & Eastern Region
Engineered Products & Systems
Intake Products - Rex®, Link-Belt® & Royce® Traveling Water Screens

SIEMENS

Water Technologies

INTAKE PRODUCTS, 1901 SOUTH PRAIRIE AVENUE, WAUKESHA, WI 53189

TELEPHONE 262-521-8414
FACSIMILE 262-521-8364
MOBILE 630-841-7944
INTERNET www.siemens.com/water

August 23, 2007

Enercon Services, Inc.
500 TownPark Lane, Suite 275
Kennesaw, GA 30144

Attention: Audrey Thompson
Email: athompson@enercon.com

Subject: Siemens Modified Ristroph Design - 316(b) Traveling Water Screen (TWS)
Budget Price for Merrimack Generating Station Replacing:
Unit 1: Two (2) FMC/Link-Belt Model 45A TWS 8'- 0" Baskets x 31'- 0" Centers – JK3231 (1958)
Unit 2: Two (2) Rex TWS 10'- 0" Baskets x 36'- 0" Centers – H50570 (1965)

Budget Proposal: 95XXXHP

Dear Ms. Thompson:

Siemens Water Technologies Corp. is pleased to present you this ***BUDGETARY PRICE QUOTATION.*** The units shall be Siemens Water Technologies 316(b) Design, replacing Units provided by Envirex/Rex under the following Contract H50470 and FMC/Link-Belt Contract JK3231:

FISH PROTECTION

The Traveling Water Screen Fish Protection System is designed to remove fish and fingerlings which are unable to escape from in front of the screen, safely transport and return them to the source water downstream of the screen intake. This system is an optional auxiliary system designed to work in conjunction with the debris removal function of the Traveling Water Screen. The system may be furnished as described in this specification on new Traveling Water Screens or modified for site specific retrofit of existing equipment. Fish survival rates are maximized when the traveling water screen fish protection system is employed as part of an overall screen intake design which allows fish to escape the intake current.

OPERATION

Fish and debris removal functions of the traveling water screen shall be separate with dedicated spray headers and toughing for each. Fish shall be removed first on the descending chain {rear} side of the screen, and then the debris is removed on the descending chain {rear} side of the screen.

The fish shall be lifted to the operating floor level in a watertight fish tray on the bottom member of each screen tray. The fish shall discharge by sliding off the tray, aided by a low pressure intermittent spray which shall gently flush the fish from the tray into a trough for sluicing to the source water.

Fish Trays

The trays are watertight and maintain a minimum water depth while transporting the fish. The contour of the pan shall facilitate complete flushing of its contents with a low pressure spray. The fish bucket shall be an integral part of the lower tray member of each tray and span the entire width of the tray.

Fish Spray Piping

The fish spray piping shall be constructed of stainless steel. The fish spray headers shall be located above the fish trough on the descending chain (rear) side of the screen.

The fish spray shall spray the fish trays with a low pressure spray so as to flush the fish from the bucket and not the debris deposited on the cloth. Operating pressure shall be 15 PSI maximum. The spray nozzles shall be brass material having replaceable orifices.

Fish Protection System Includes

- Non-Metallic Trays with Integral Fish Bucket
- Smooth-Tex Screen Cloth for Trays
- Fiberglass Fish Trough
- Auxiliary Fish Spray Header
- Dual Fish Spray Header
- Two (2) Pressure Regulating Valves Per Traveling Water Screen
- Two (2) Ball Valve Per Traveling Water Screen
- One (1) Butterfly Valve Per Traveling Water Screen

Fish Protection Screen Baskets

Baskets shall be non-metallic construction.

The baskets shall be a single piece construction designed to withstand the specified head differentials without excessive elastic and/or any permanent plastic deformation.

The rails shall be constructed out of molded fiberglass reinforced plastic of proven durability. The geometric cross section of the rails shall be totally enclosed for strength and torsional rigidity and the hollow core filled with polystyrene foam.

The rails shall be fused to the plastic compression molded curved end plates and the fused connection shall be capable of developing the full strength of the rails.

The basket width shall be selected and designed to minimize through flow velocities. Submit calculations of all through-flow velocities for Owner review and acceptance.

The basket shall be designed to maximize the screening area available and the bottom rail fish buckets shall be designed to enhance fish recovery and provide a protected area for the impinged fish. The fish bucket shall have sufficient capacity to provide a suitable environment while fish are retained in the bucket and the opening shall be sized to encourage fish to enter and to minimize damage when emptying. The exact configuration of the bucket shall be either of a "proven design" or determined by model/flume testing or computer analysis to ensure a hydraulically stable, "stalled" fluid zone which attracts the fish, prevents damage to the fish while in the bucket and prevents the fish from escaping the bucket. A "proven design" is a design substantiated by fish survival studies on actual screen installations and is preferred.

A flexible neoprene or compatible material shall be bolted to the upper rail (only) to seal between adjacent baskets if the clearances between baskets are greater than the least dimension of the wire mesh. The seal shall be designed for long life and prevent the passage of debris or fish.

The screen mesh shall be a stainless steel Type 304 Smooth-Tex construction, sufficiently rigid to preclude fatigue failure due to flexing. The mesh shall have 1/4" x 1/2" openings with the long dimension oriented in the vertical direction. The mesh shall be secured to the baskets by plastic retainer bars of sufficient number to secure the screen mesh firmly to the basket frame.

The screen mesh shall be especially designed and manufactured to minimize harm and abrasion to the impinged fish.

The screen mesh shall be canted to facilitate entry of fish into the fish bucket and the discharge of fish with minimal harm.

PAINTING

Before shipment we will clean in accordance with our general shop practice and apply 10-12 mils of High-Build Coal Tar Epoxy Paint, or equal to all carbon steel surfaces.

The chain will receive one (1) shop coat of slush oil.

The head shaft will receive one (1) shop coat of Siemens standard shop preservative.

The drive unit will remain manufacturer's standard paint.

Stainless steel, galvanized and nonferrous materials will remain unpainted.

ASSEMBLY

Standard shop assembly includes the fitting up of the head section for shipment as a unit. However, the drive sprockets, drive chain and drive chain casing are not shop assembled on an outside drive style head section. The head section assembly will include the drive unit as specified herein, and spray piping including that portion projecting through the head frame side plus the outside elbow but less the spray nozzles and feed pipes with valve.

Intermediate frame parts and chains will be shipped as unit parts to be assembled with the head and foot sections in the field. Trays will be assembled with cloth and retainer bars for field assembly to the chains.

Splash housings are shipped separately for assembly to the head section in the field.

SPRAY WATER REQUIREMENTS

198 GPM @ 80 PSI for Rear Debris Header

153 GPM @ 15 PSI for Dual Fish Spray Header

49 GPM @ 7 PSI for Auxiliary Fish Spray Header

Total Spray Wash Requirements is 400 GPM @ 80 PSI per Screen.

CLARIFICATIONS

1. Siemens will terminate spray piping one foot outside of the fiberglass splash housing.

2. All interconnecting piping between the Traveling Water Screens and the spray wash pumps is not included. Additionally, we have no provisions included for the Fish Spray Pumps.

3. As an Option, Siemens can Design and/or supply a fiberglass "Fish Trough" extending from the Traveling Water Screens to point of discharge back to the source water. The fish will be discharged into the water through a PVC Pipe.

SCOPE OF SUPPLY

Scope of Supply Unit 1:

Two (2) Siemens Design 316(b) Screen, 2-Post Design w/Back-Up Beam, 10'- 0" x 33'- 0" Sprocket Centers

- Structural Framework, Carbon Steel w/SS Hardware
- Direct Drive - Motor/Reducer – 10/2.5 FPM, 1800/450RPM
- Rex Non-Metallic 316(b) Fish Basket w/#14W&M (0.080 Dia.), 1/4" x 1/2" Smooth-Tex, 304 Stainless Steel Mesh
- Carrier Chain, Carbon Steel Design, 3/8" Side Bars, 416 Stainless Steel Pins and Rollers
- Head Shaft, Carbon Steel
- Anti-Friction Roller Bearings
- Roll-Around Boot Section
- All Spray Headers 304 Stainless Steel
- Fish Protection Valves, Pressure Switches, etc.
- Fiberglass Discharge & Fish Troughs (Ending 1ft from Splash Housing)
- Freight to Job Site

Scope of Supply Unit 2:

Two (2) Siemens Design 316(b) Screen, 2-Post Design w/Back-Up Beam, 10'- 0" x 38'- 0" Sprocket Centers

- Structural Framework, Carbon Steel w/SS Hardware
- Direct Drive - Motor/Reducer – 10/2.5 FPM, 1800/450RPM
- Rex Non-Metallic 316(b) Fish Basket w/#14W&M (0.080 Dia.), 1/4" x 1/2" Smooth-Tex, 304 Stainless Steel Mesh
- Carrier Chain, Carbon Steel Design, 3/8" Side Bars, 416 Stainless Steel Pins and Rollers
- Head Shaft, Carbon Steel
- Anti-Friction Roller Bearings
- Roll-Around Boot Section
- All Spray Headers 304 Stainless Steel
- Fish Protection Valves, Pressure Switches, etc.
- Fiberglass Discharge & Fish Troughs (Ending 1ft from Splash Housing)
- Freight to Job Site

BUDGETARY Price:

- Unit 1: Two (2) Siemens 10'- 0" x 33'- 0" - "316(b) Fish Design":...............$326,000.00
- Unit 2: Two (2) Siemens 10'- 0" x 38'- 0" - "316(b) Fish Design":...............$381,000.00

We appreciate this opportunity to serve and assist you in your upcoming traveling water screen project. Please feel free to contact this office if you require any additional information or assistance.

Regards,

Henry Petrovs

Henry Petrovs
Technical Sales Manager
Midwest & Eastern Region
Engineered Products & Systems
Intake Products - Rex®, Link-Belt® & Royce® Traveling Water Screens
E-MAIL: Henry.Petrovs@siemens.com

CC: Siemens/T. Kofeldt

From: Shields Paul [Paul.Shields@glv.com]
Sent: Wednesday, October 03, 2007 2:13 PM
To: Sue Polyak
Subject: RE: Fish Return Trough
Attachments: Estimate of System Efficiency - Merrimack Station -02-10-07.xls

Sue,

Thank you for your time today on the phone to review your questions below. As we discussed, acoustic fish deterrence system equipment would roughly cost $800,000.00. The installation is estimated at roughly $150,000.00. Actual costs would require full evaluation, but we believe this is good guidance considering our time constraints.

Attached is the survival spreadsheet that we discussed. Below are some notes from the FGS people on it. Hopefully this will give you an understanding of what the spreadsheet offers.

Thanks again Sue and please call with any other questions.

FGS: I have drawn up a table that estimates the likely efficiency of a combined acoustic fish deflection system and fish return system, which I have attached. I would stress this is a preliminary spreadsheet that I am still working on, but thought it would be useful to send it so you can see the assumed figures we have used. Some are based upon trails else where, but Andy had used his judgment to guesstimate the like deflection efficiencies for a number (most) of the fish present. As more data becomes available from audiogram / web research we can become surer of the figures. However, at this stage I would stress this is just an estimate of the likely efficiencies.

			%age of Fish /	Expected AFD Efficiency	Expected Fish Return Efficiency	Estimated AFD Efficiency: Deflected as %age	Estimated AFD Efficiency: Residual as %age	Estimated Fish Return Efficiency (No AFD Installed): Deflected as %age	Estimated Fish Return Efficiency (No AFD Installed): Residual as %age	Estimated Fish Return Efficiency (After Operational AFD): Deflected as %age	Estimated Fish Return Efficiency (After Operational AFD): Residual as %age	ESTIMATED OVERALL %AGE DEFLECTED (58+27 =)	
		Total Fish	100.1										
		Known Fish	99.4										
			99.3	Overall Expected Efficiencies		58 %	42 %	65 %	34 %	27 %	14 %		
		Unknown Fish	0.7		of total							85 %	total fish
			0.7		of known fish							85 %	known fish
'Known' Fish													
Alewife			8.4	70	65	5.9	2.5	5.5	2.9	1.6	0.9	7.5	
Anchovies			0.0	80		-	-	-	-	-	-	0.0	
Anchovy	Bay	Anchoa mitchilli	0.0	90		-	-	-	-	-	-	0.0	
Bass	Large Mouth		20.1	70	65	14.1	6.0	13.1	7.0	3.9	2.1	18.0	
Bass	Small Mouth		11.2	70	65	7.8	3.4	7.3	3.9	2.2	1.2	10.0	
Bass	Stripped		0.0	70	65	-	-	-	-	-	-	0.0	
Bass	Rock		0.4	70	65	0.3	0.1	0.3	0.1	0.1	0.0	0.4	
Bass			0.0	55	65	-	-	-	-	-	-	0.0	
Bass			0.0	81	65	-	-	-	-	-	-	0.0	
Bluegill			6.7	50	65	3.4	3.4	4.4	2.3	2.2	1.2	5.5	
Carp	Buffalo		0.0	82.5		-	-	-	-	-	-	0.0	
Carps			0.0	90		-	-	-	-	-	-	0.0	
Catfish	Channel		0.0	85		-	-	-	-	-	-	0.0	
Catfish	Flathead		0.0	85		-	-	-	-	-	-	0.0	
Clupeids			0.0	95	0	-	-	-	-	-	-	0.0	
Cod			0.0	55	65	-	-	-	-	-	-	0.0	
Crab	Blue	Callinectes sapidus	0.0	20		-	-	-	-	-	-	0.0	
Crappie	Black		0.1	50	65	0.1	0.1	0.1	0.0	0.0	0.0	0.1	
Crappie	White		0.0	50	65	-	-	-	-	-	-	0.0	
Cyprinids			0.0	80		-	-	-	-	-	-	0.0	
Dab			0.0	16	80	-	-	-	-	-	-	0.0	
Eel	American		0.4	36%	80	0.0	0.4	0.3	0.1	0.3	0.1	0.3	
Eel	European		0.0	36%		-	-	-	-	-	-	0.0	
Fallfish			3.0	70	65	2.1	0.9	2.0	1.1	0.6	0.3	2.7	
Flounder	Summer	Paralichthys dentatus	0.0	30		-	-	-	-	-	-	0.0	
Flounder	Winter	Pseudopleuronectes ame	0.0	30		-	-	-	-	-	-	0.0	
Flounder			0.0	60	80	-	-	-	-	-	-	0.0	
Goby	Round		0.0	20		-	-	-	-	-	-	0.0	
Herring			0.0	95	0	-	-	-	-	-	-	0.0	
Herring	Blueback	Alosa aestivalis	0.0	90		-	-	-	-	-	-	0.0	
Menhaden	Atlantic	Brevoortia tyrannus	0.0	80		-	-	-	-	-	-	0.0	
Minnows			0.0	70		-	-	-	-	-	-	0.0	
Minnow	Eastern silvery		1.5	70	65	1.1	0.5	1.0	0.5	0.3	0.2	1.3	
Mullet	Grey		0.0	63	65	-	-	-	-	-	-	0.0	
Paddlefish			0.0	20		-	-	-	-	-	-	0.0	
Perch	White		0.0	45	65	-	-	-	-	-	-	0.0	
Perch	Yellow		1.4	45	65	0.6	0.8	0.9	0.5	0.5	0.3	1.1	
Pipefish	Northern	Syngnathus fuscus	0.0	0		-	-	-	-	-	-	0.0	
Plaice			0.0	16	80	-	-	-	-	-	-	0.0	
Poor Cod			0.0	55	65	-	-	-	-	-	-	0.0	
Pout			0.0	55	65	-	-	-	-	-	-	0.0	
Pumpkinseed			1.5	50	65	0.8	0.8	1.0	0.5	0.5	0.3	1.2	
Salmonids			0.0			-	-	-	-	-	-	0.0	
Salmon & Sea Trout			0.0	80	80	-	-	-	-	-	-	0.0	
Shad	American		0.0	82.5		-	-	-	-	-	-	0.0	
Shad	Gizzard		0.0	82.5		-	-	-	-	-	-	0.0	
Shiners			0.0			-	-	-	-	-	-	0.0	
Shiner	Common		6.5	50	65	3.3	3.3	4.2	2.3	2.1	1.1	5.4	
Shiner	Golden		2.8	50	65	1.4	1.4	1.8	1.0	0.9	0.5	2.3	
Shiner	Spottail		28.3	50	65	14.2	14.2	18.4	9.9	9.2	5.0	23.3	
Shrimp	Grass	Palaemonetes vulgaris	0.0	20		-	-	-	-	-	-	0.0	
Shrimp	Sand	Crangon franciscorum	0.0	20		-	-	-	-	-	-	0.0	
Silverside	Atlantic	Menidia menidia	0.0	55		-	-	-	-	-	-	0.0	

			%age of Fish /	Expected AFD Efficiency	Expected Fish Return Efficiency	Estimated AFD Efficiency		Estimated Fish Return Efficiency (No AFD Installed)		Estimated Fish Return Efficiency (After Operational AFD)		ESTIMATED OVERALL %AGE DEFLECTED	
		Total Fish	100.1										
						Deflected as %age	Residual as %age	Deflected as %age	Residual as %age	Deflected as %age	Residual as %age		
		Known Fish	99.4										
			99.3	Overall Expected Efficiencies		58 %	42 %	65 %	34 %	27 %	14 %	(58+27 =)	
		Unknown Fish	0.7		of total							85 %	total fish
			0.7		of known fish							85 %	known fish
'Known' Fish													
Smelt	Sand		0.0	79	65	-	-	-	-	-	-	0.0	
Sole			0.0	16	80	-	-	-	-	-	-	0.0	
Sprat			0.0	88	0	-	-	-	-	-	-	0.0	
Suckers			0.0	15	80	-	-	-	-	-	-	0.0	
Sucker	white		1.6	15	80	0.2	1.4	1.3	0.3	1.1	0.3	1.3	
Sunfish			0.0	50	65	-	-	-	-	-	-	0.0	
Sunfish	Bluegill		0.0	50	65	-	-	-	-	-	-	0.0	
Sunfish	Redbreast		5.5	50	65	2.8	2.8	3.6	1.9	1.8	1.0	4.5	
Walleye			0.0			-	-	-	-	-	-	0.0	
Weakfish		Cynoscion regalis	0.0			-	-	-	-	-	-	0.0	
whitefish			0.0			-	-	-	-	-	-	0.0	
Whiting			0.0	55	65	-	-	-	-	-	-	0.0	
Unknown Fish													
Drum	Freshwater	these fish communicate by sound and so we assume that these will be sensitive to an acoustic system, but without further testing Andy is reluctant to provide an estimate of the likely deflection efficiency											
Muskellunge		not known, but we assume its response will be similar to the Northern pike, listed above											
Pike	Northern	Pike don't tend to respond well, but since they are often present as a predator to the other fish, if the other fish are deflected the pike will also move, and thus reduce its catch also.											
			0.0			-	-	-	-	-	-		
			0.0			-	-	-	-	-	-		
Tessellated darter			0.4			0.0	0.4	0.0	0.4	0.0	0.4		
Chain pickerel			0.3			0.0	0.3	0.0	0.3	0.0	0.3		
			0.0			-	-	-	-	-	-		

SOUNDINGS

Fish Guidance Systems

The newsletter of Fish Guidance Systems Ltd ISSUE 8

Great Lakes Trial Demonstrates Effectiveness of FGS System

Trials being carried out at the Ontario Power Generation (OPG) Lambton Generating Station (4000 MW) have shown a combined strobe light and FGS acoustic system to be very effective in excluding fish.

The system was installed in 2004 to deflect gizzard shad (*Dorosoma cepedianum*), from the intake, which were impeding the plant's cooling process, causing loss of unit efficiency and unit shutdowns. The cost to OPG was estimated to be CAD 20 million in 2003 (USD 18 million).

The acoustic system was specified and supplied by FGS after detailed modelling by FGS acoustics engineers to determine the optimum configuration for the system. The system was installed for OPG by Kinectrics Inc., an independent firm of engineers and consultants, who assessed the performance of the system over the winter of 2005-6. The overall impingement reduction was about 73%, but Dr Paul Patrick, Kinectrics' Aquatic Management Systems Manager says that this figure "is likely an underestimate due to the difficulty in estimating fish numbers during high impingement events (when the system was not operating). A true estimate of the systems effectiveness, based upon laboratory trials, is probably within **73-84%**".

The system will be in use again for the winter of 2006, and OPG is negotiating with FGS to keep the system on site until 2010.

FGS Acoustic Barriers Best Option in Fight Against Asian Carp

All possible screening solutions were extensively reviewed by FishPro, Consulting Engineers and Scientists, on behalf of Minnesota DNR, Wisconsin DNR and the US Fish and Wildlife Service, to determine the most appropriate barrier to prevent Asian carp (bighead and silver carp) migrating through the Mississippi Basin. Fish Guidance's acoustic systems came out on top, beating all of the alternatives. Subsequent trials by Illinois Natural History Survey demonstrated a **95%** deflection efficiency for the system tested and FGS is currently negotiating the installation of systems at a number of sites.

SOUNDINGS

Fish Guidance Systems

North American Fish Can Hear Too!

Following on from the successful trials at the OPG Lambton GS, Kinectrics Inc. has set up two laboratory systems at their Great Lakes Laboratory, Toronto and also at the Florida Institute of Technology Marine Laboratory at Vero Beach, Florida.

The systems are being used to evaluate the effectiveness of FGS systems on a variety of fish and aquatic species found in North America, including –

Photographs courtesy of Kinectrics Inc.

Red Drum	*Sciaenops ocellatus*
Black Drum	*Pogonias cromis*
Snook	*Centropomus undecimalis*
Gray Snapper	*Lutjanus griseus*
Striped Mullet	*Mugil cephalus*
Jack Crevalle	*Caranx hippos*
Sheepshead	*Archosargus probatocephalus*
Tarpon	*Megalops atlanticus*
Sea Turtles	
Walleye	*Sander vitreus vitreus*
Yellow Perch	*Perca flavescen*
White Bass	*Morone chrysops*
Crappie	*Pomoxis annularis*

Further details can be obtained from FGS, or directly from Kinectrics Inc.

FGS Notches Up Over 80 Installations Worldwide

More than 80 FGS systems have been installed since 1994 in the UK, Europe and more recently in North America. During this time a number of independent trials have been run to assess the performance of the systems. Copies of the results and associated published papers are available from FGS.

For more information on fish guidance systems for water intakes please contact

Telephone: +44 (0)1962 777 789 **Facsimile:** +44 (0)1962 777 123
E-mail: fgs@fish-guide.com **Web site:** www.fish-guide.com

SPA System

print

SOUND PROJECTOR ARRAY (SPA)

SPA systems are used to block / deflect fish movements at the entrance to water intakes and are harmless to fish. The SPA system uses underwater sound projectors powered by audio amplifiers and electronic signal generators, to create a repellent acoustic field ahead of a water intake. FGS supply different models of SPA system to suit different site conditions.

The SPA system is analogous to a public address or domestic hi-fi system. The signal is recorded onto an EPROM-chip and the signal generator may contain a number of these which can be manually selected or played at random or in rotation. One or more high-powered audio amplifiers that are matched and filtered to suit the sound projectors amplify the signal.

Power requirements are usually around 1kVA per amplifier and sound projector. Each sound projector will handle up to 450 W of signal power

FGS acoustic SPA systems comprise the following components:

FGS Mk II 15-100 Sound Projector
Underwater sound projectors are used to create the underwater sound field. Generally, a linear array of sound projectors is used to create a field of repulsion. We refer to this array as the 'Sound Projector Array' or SPA. This model is typically used on smaller intakes.

FGS Mk II 30-600 Sound Projector
The FGS Mk II 30-600 sound projector is used typically on larger intakes.

Deployment System
A deployment system allows the sound projectors to be lowered and raised for maintenance. Deployment systems may take many forms ranging from a simple rail to a custom-made structure, which avoids the need to use divers for maintenance.

FGS 1-08 Signal Generator (1 signal) and (8 signals)
FGS signal generators are based on solid-state digital recording technology. A single signal generator is used where the target fish species are migratory and or non-resident. An eight signal generator is used where there are resident species to avoid habituation to any one signal.

FGS Model 400 Amplifier / Monitor
The signal generator feeds into a bank of audio frequency power amplifiers that boost signal levels to the required output levels for the transducers.

FGS Model 1-03 Diagnostics/Alarm Unit
The FGS Model 1-03 Diagnostics / Alarm Unit is used to monitor the status of control equipment.

For further information, please e-mail fgs@fish-guide.com

close X

Power Station 1

print

DOEL POWER STATION - SPA SYSTEM

BACKGROUND / PROBLEM
Doel nuclear power station operated by Electrabel, approached Fish Guidance Systems Ltd in 1996 to help reduce the numbers of fish that were being drawn into their cooling water intake each year. The main species being affected were herring and sprat (clupeid family). Electrabel, were keen to respond to concerns expressed by environmental regulators and fishermen.

SOLUTION
In 1997, a SPA fish deterrent system was designed and installed on the offshore intake. In total, 20 large FGS Mk II 30-600 sound projectors were installed to create a repellent sound field close to the water intake openings causing passing fish to veer away. A multiple signal generator was used to avoid resident species habituating to any one sound signal. To allow servicing of the fish deterrent system whilst the station is still operating, a deployment frame has been installed to lower sound projectors into their optimum position and to allow them to be raised for routine inspections and maintenance.

RESULTS
The acoustic installation has subsequently undergone a number of evaluation trials by researchers from Belgium's Leuven University. Independent trials have shown a reduction in the target species by 98%. In addition, the catch of other non-target species has been reduced with the overall reduction being 81%.

For further information, please e-mail fgs@fish-guide.com

close X

Power Station 2

print

HARTLEPOOL POWER STATION - SPA SYSTEM

BACKGROUND / PROBLEM
In 1995 Nuclear Electric commissioned a trial of an acoustic fish deterrent system at 1,200 MW Hartlepool power station. Hartlepool is a nuclear power station which abstracts 34 m3/sec cooling water from the neighbouring Seaton Channel. The cooling water enters via a short (50m) dredged area connecting to the Seaton Channel.

Like all coastal power stations, marine life was becoming caught up in the flow, and had to be filtered out to prevent blockage of the fine heat exchanger tubes within the plant using large rotating band screens. The quantities involved on occasion could overpower or overwhelm the screening systems, reducing the water supply, in extreme cases causing the station to cease generation

SOLUTION
A SPA installation was designed to create a gradient of deterrent sound, increasing inshore towards the intake openings. The design involved six FGS Mk I Model 30-600 sound projectors aligned along the intake wharf. A further six sound projectors were placed in the 50 m intake channel, to ensure that under Low Water conditions when water was confined to the dredged channel, fish would be repelled before they entered the high velocity region in front of the intakes.

RESULTS
Performance trials of the acoustic deterrent system compared fish catches with sound-on and sound-off days, over a 44-day period. The results of the trials showed a marked reduction in fish catch when the acoustic deterrent system was operating. Sprat (Sprattus sprattus) and herring (Clupea harengus) formed over 80% of the fish numbers. The reduction in fish kill for herring was 80 % and 60% for sprat.

For further information, please e-mail fgs@fish-guide.com

close X

From: Sue Polyak [spolyak@enercon.com]
Sent: Thursday, August 30, 2007 9:27 AM
To: brian.hittle@beaudreyusa.com
Subject: Wedge wire screen mesh size vs. entrainment reduction
Attachments: Egg_Larvae Dimensions.pdf

PRIVILEGED & CONFIDENTIAL,
ATTORNEY-CLIENT COMMUNICATION,
PREPARED IN ANTICIPATION OF LITIGATION

Brian,

I just received this spreadsheet from my biologist. Based on this, we would like to get quotes for 1.5mm, 1mm and 0.8mm wedgewire screens. Hopefully, that will fit in with what you were already looking into.

Thanks!

Sue

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Table A. Percent reductions of selected species at Merrimack Station for a range of exclusionarly mesh widths for entrainment estimates based on actual plant flow.

Species	Egg diameter (mm) Range	Egg diameter (mm) Average	YSL Width (mm)	PYSL Width (mm)	2006 Estimated Entrainment Eggs	2006 YSL	2006 PYSL	2006 TOTAL	2007 Estimated Entrainment Eggs	2007 YSL	2007 PYSL	2007 TOTAL
White sucker	2-3.6	2.8	1.5	1.7	0	0	1,160,036	1,160,036	0	0	1,120,929	1,120,929
Yellow perch	2.3-3.5	2.9	1.0	2.0	0	0	49,671	49,671	0	0	443,750	443,750
Spottail shiner	1.0-1.4	1.2	0.8	1.0								
Carp and Minnow Family	1.0-1.4	1.2	0.8	1.0	0	49,556	956,166	1,005,722	7,899	162,284	422,449	592,632
Bluegill		0.38	1.1	1.1								
Pumpkinseed	0.3-1.0	0.7	0.7	0.8								
Black crappie		0.9		1.3								
Largemouth bass	1.4-2.0	1.7	1.5	2.3								
Smallmouth bass	1.8-2.8	2.3	1.8	2.9								
Sunfish Family		1.2	1.3	1.7	0	43,103	345,373	388,476	0	44,205	143,892	188,097
OVERALL ENTRAINMENT REDUCTION (%)					0	92,659	2,511,246	2,603,905	7,899	206,489	2,131,020	2,345,408

Species	2.0 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	2.0 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL	1.5 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	1.5 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL
White sucker			0%	0%			0%	0%			100%	100%			100%	100%
Yellow perch			50%	50%			50%	50%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	0%	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		0%	0%	0%	0%	0%	0%	0%		0%	100%	89%		0%	100%	76%
OVERALL ENTRAINMENT REDUCTION (%)				1%				8%				90%				73%

Species	1.0 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	1.0 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL	0.8 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	0.8 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL
White sucker			100%	100%			100%	100%			100%	100%			100%	100%
Yellow perch			100%	100%			100%	100%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	50%	48%	100%	0%	50%	37%		50%	100%	98%	100%	50%	100%	86%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%
OVERALL ENTRAINMENT REDUCTION (%)				90%				84%				99%				97%

Table B. Percent reductions of selected species at Merrimack Station for a range of exclusionarly mesh widths for entrainment estimates based on the design flow (maximum capacity).

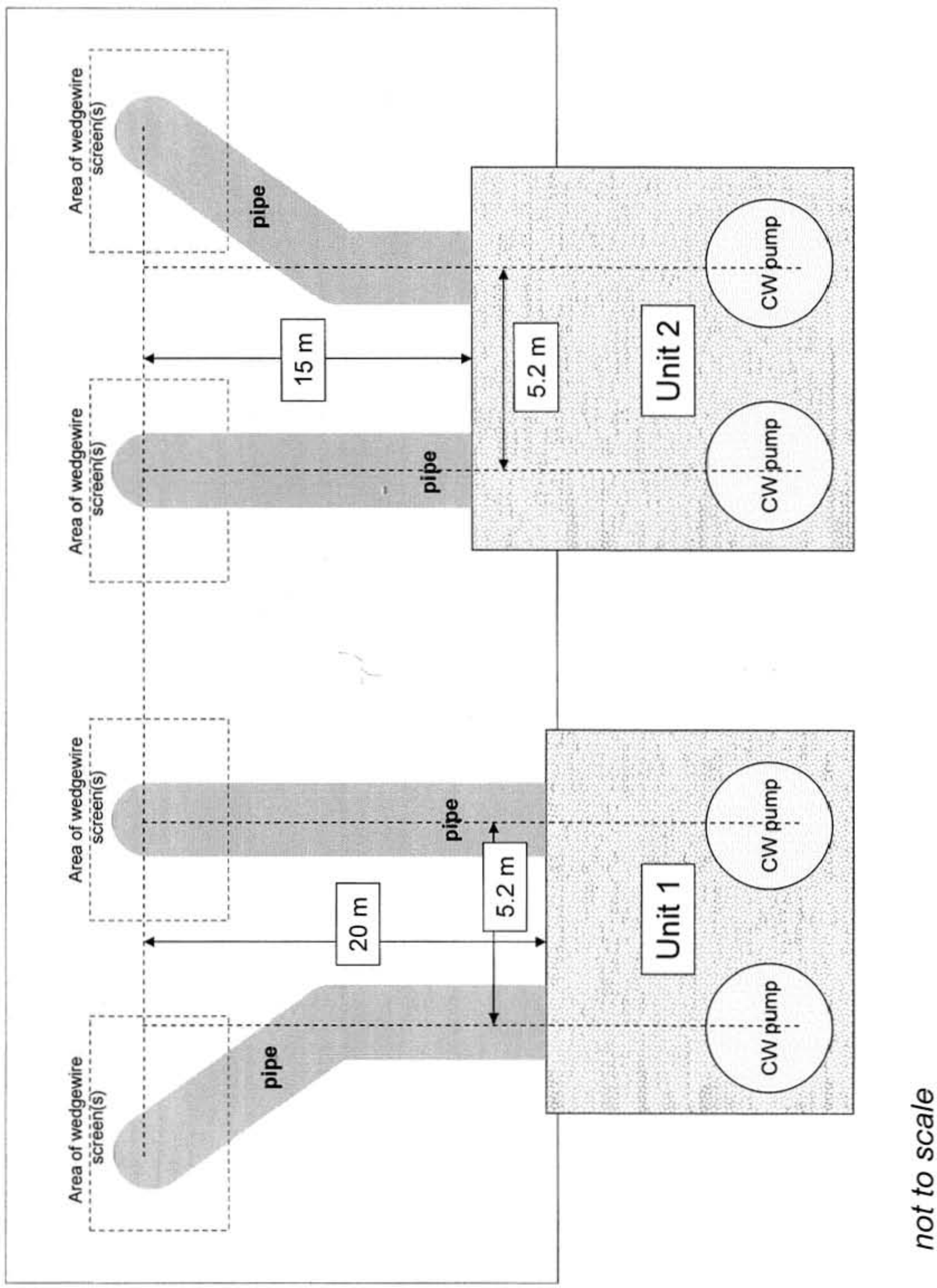
Species	Egg diameter (mm) Range	Egg diameter (mm) Average	YSL Width (mm)	PYSL Width (mm)	2006 Estimated Entrainment Eggs	2006 YSL	2006 PYSL	2006 TOTAL	2007 Estimated Entrainment Eggs	2007 YSL	2007 PYSL	2007 TOTAL
White sucker	2-3.6	2.8	1.5	1.7	0	0	1,320,727	1,320,727	0	0	1,381,150	1,381,150
Yellow perch	2.3-3.5	2.9	1.0	2.0	0	0	53,556	53,556	0	0	541,671	541,671
Spottail shiner	1.0-1.4	1.2	0.8	1.0								
Carp and Minnow Family	1.0-1.4	1.2	0.8	1.0	0	53,438	1,071,716	1,125,154	11,246	196,686	520,325	728,257
Bluegill		0.38	1.1	1.1								
Pumpkinseed	0.3-1.0	0.7	0.7	0.8								
Black crappie		0.9		1.3								
Largemouth bass	1.4-2.0	1.7	1.5	2.3								
Smallmouth bass	1.8-2.8	2.3	1.8	2.9								
Sunfish Family		1.2	1.3	1.7	0	49,267	425,485	474,752	0	105,924	184,208	290,132
OVERALL ENTRAINMENT REDUCTION (%)					0	102,705	2,871,484	2,974,189	11,246	302,610	2,627,354	2,941,210

Species	2.0 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	2.0 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL	1.5 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	1.5 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL
White sucker			0%	0%			0%	0%			100%	100%			100%	100%
Yellow perch			50%	50%			50%	50%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	0%	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		0%	0%	0%	0%	0%	0%	0%		0%	100%	89%		0%	100%	76%
OVERALL ENTRAINMENT REDUCTION (%)				1%				9%				81%				72%

Species	1.0 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	1.0 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL	0.8 mm 2006 % Reduction Eggs	YSL	PYSL	TOTAL	0.8 mm 2007 % Reduction Eggs	YSL	PYSL	TOTAL
White sucker			100%	100%			100%	100%			100%	100%			100%	100%
Yellow perch			100%	100%			100%	100%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	50%	48%	100%	0%	50%	37%		50%	100%	98%	100%	50%	100%	86%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%
OVERALL ENTRAINMENT REDUCTION (%)				80%				84%				99%				97%

ASSUMPTIONS, ETC.

1. Spottail shiner is representative for the carp and minnow family due to its high abundance in Hooksett Pool
2. Took average of 5 common centrarchid species to represent the entrainment catch that was identifed to sunfish family
3. If a mesh size and egg/larvae diameter are the same value, it is assumed that 50% of the entrainment catch will pass through the screen
4. Mesh sizes of 3mm and 2.5 mm offer 0 % reduction in entrainment
5. Table A presents entrainment values based on actual plant flows, Table B presents entrainment values based on the design flow (maximum capacity) of Units 1 & 2 (59,000 gpm and 140,000gpm, respectively) as obtained from the Merrimack Station PIC.


Area of wedgewire screen(s)
pipe
Area of wedgewire screen(s)
pipe
15 m
5.2 m
Unit 2
CW pump
CW pump
Area of wedgewire screen(s)
pipe
Area of wedgewire screen(s)
pipe
20 m
5.2 m
Unit 1
CW pump
CW pump
not to scale

Attachment 2 – Post-Modification Conceptual Drawings

PSNH001-SK-001 – Closed-loop Cooling Conceptual Layout Drawing

PSNH001-SK-002 – Cooling Tower Power & Control Building – Plan View

PSNH001-SK-003 – Cooling Tower Power & Control Building – Section

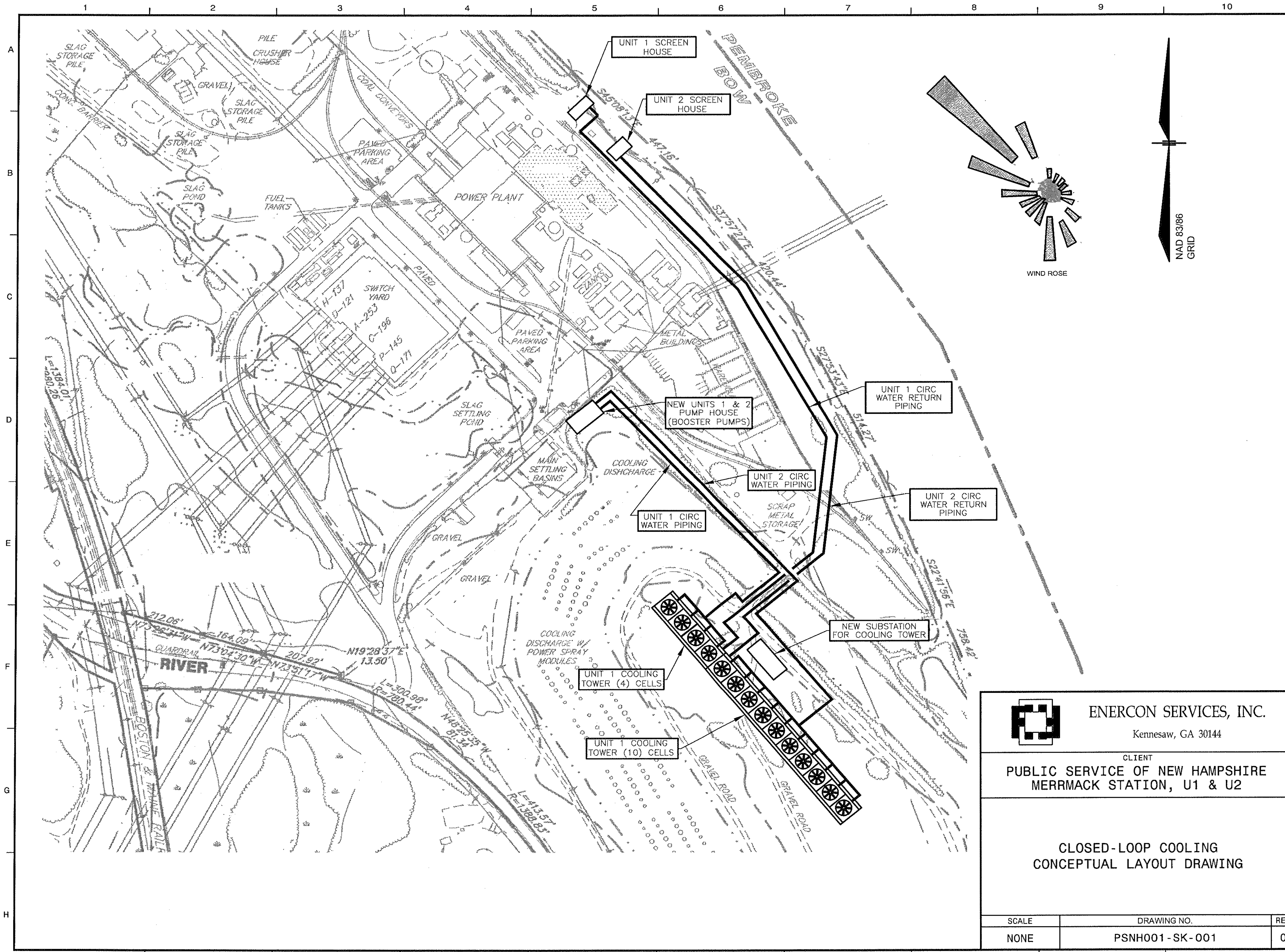
PSNH001-SK-004 – Cooling Tower – Simplified P&ID

PSNH001-SK-005 – Discharge Canal Cooling Tower

PSNH001-SK-006 – Upgraded Fish Return Trough

PSNH001-SK-007 – Wide-slot Wedgewire Screen Layout

PSNH001-SK-008 – Narrow-slot Wedgewire Screen Layout


UNIT 1 SCREEN HOUSE
UNIT 2 SCREEN HOUSE
PEMBROKE BOW
POWER PLANT
SWITCH YARD
SLAG SETTLING POND
MAIN SETTLING BASINS
COOLING DISCHARGE
NEW UNITS 1 & 2 PUMP HOUSE (BOOSTER PUMPS)
UNIT 1 CIRC WATER RETURN PIPING
UNIT 2 CIRC WATER PIPING
UNIT 2 CIRC WATER RETURN PIPING
UNIT 1 CIRC WATER PIPING
SCRAP METAL STORAGE
NEW SUBSTATION FOR COOLING TOWER
COOLING DISCHARGE W/ POWER SPRAY MODULES
UNIT 1 COOLING TOWER (4) CELLS
UNIT 1 COOLING TOWER (10) CELLS
RIVER
WIND ROSE
NAD 83/86 GRID
ENERCON SERVICES, INC.
Kennesaw, GA 30144
CLIENT
PUBLIC SERVICE OF NEW HAMPSHIRE
MERRMACK STATION, U1 & U2
CLOSED-LOOP COOLING
CONCEPTUAL LAYOUT DRAWING
SCALE
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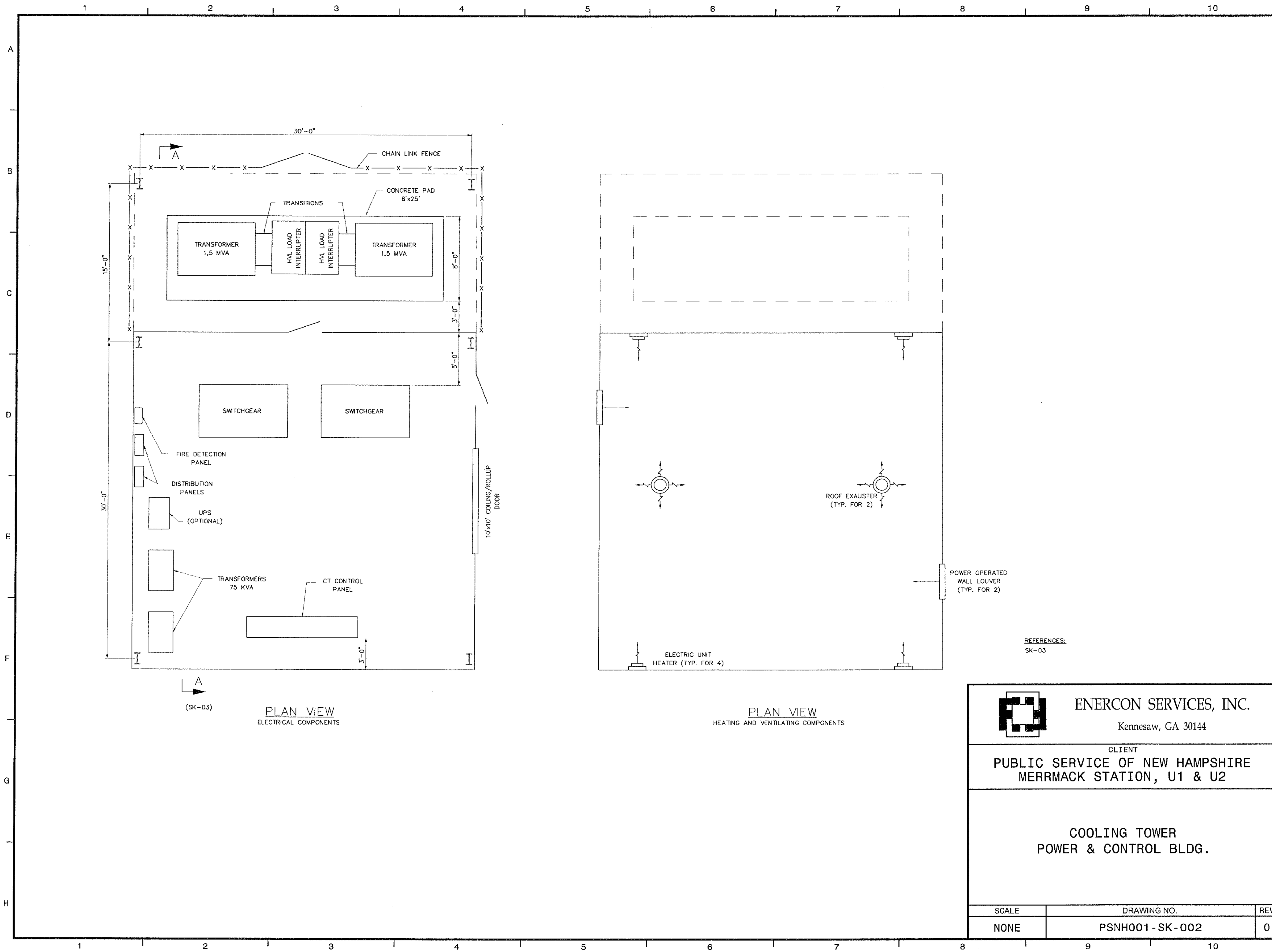
DRAWING NO.
PSNH001-SK-001
REV
0


30'-0"
CHAIN LINK FENCE
CONCRETE PAD 8'x25'
TRANSITIONS
TRANSFORMER 1.5 MVA
HVL LOAD INTERRUPTER
HVL LOAD INTERRUPTER
TRANSFORMER 1.5 MVA
15'-0"
8'-0"
3'-0"
5'-0"
SWITCHGEAR
SWITCHGEAR
FIRE DETECTION PANEL
DISTRIBUTION PANELS
UPS (OPTIONAL)
30'-0"
10'x10' COILING/ROLLUP DOOR
TRANSFORMERS 75 KVA
CT CONTROL PANEL
3'-0"
A
(SK-03)
PLAN VIEW
ELECTRICAL COMPONENTS
ROOF EXAUSTER (TYP. FOR 2)
POWER OPERATED WALL LOUVER (TYP. FOR 2)
ELECTRIC UNIT HEATER (TYP. FOR 4)
PLAN VIEW
HEATING AND VENTILATING COMPONENTS
REFERENCES:
SK-03
ENERCON SERVICES, INC.
Kennesaw, GA 30144
CLIENT
PUBLIC SERVICE OF NEW HAMPSHIRE
MERRMACK STATION, U1 & U2
COOLING TOWER
POWER & CONTROL BLDG.
SCALE
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DRAWING NO.
PSNH001-SK-002
REV
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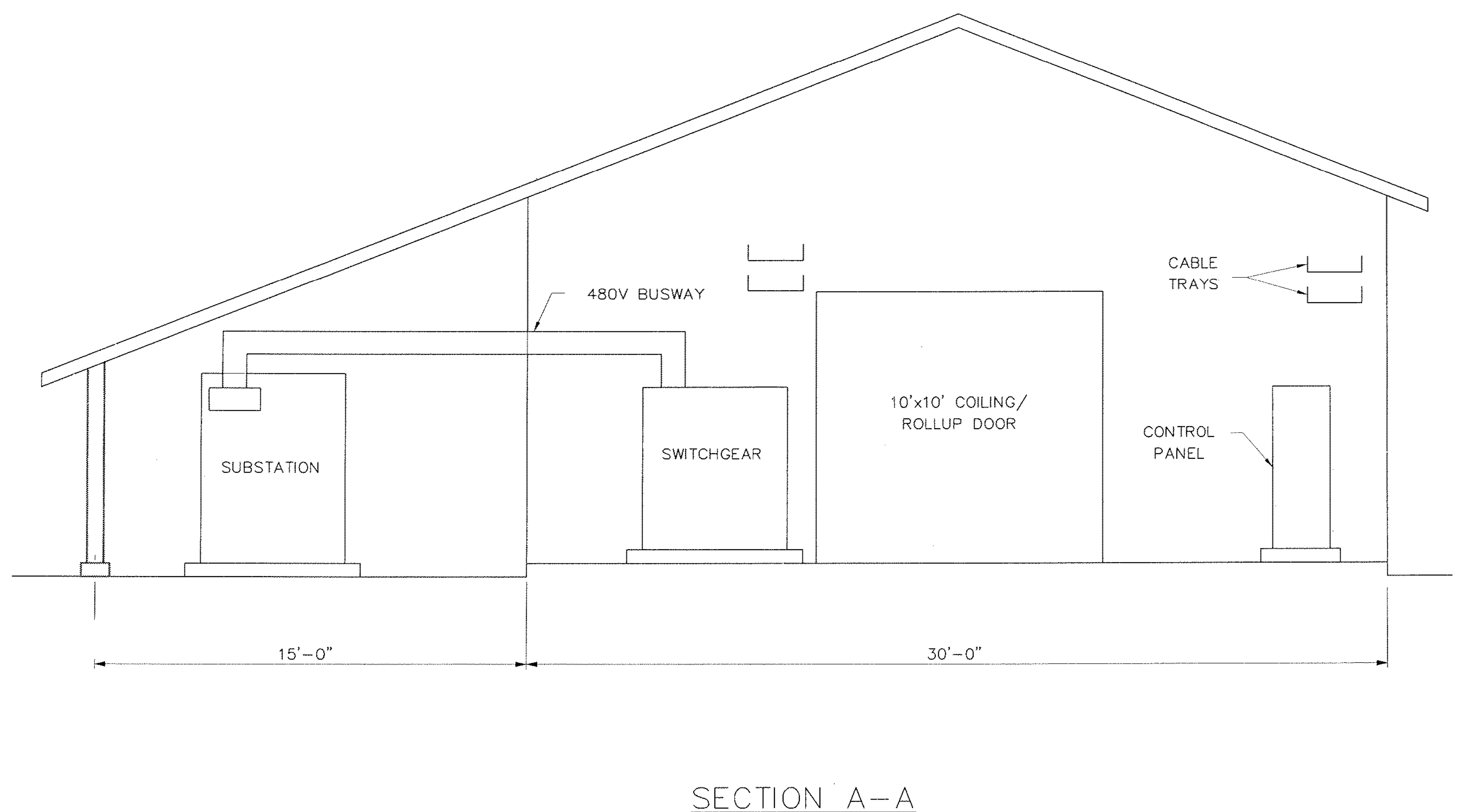
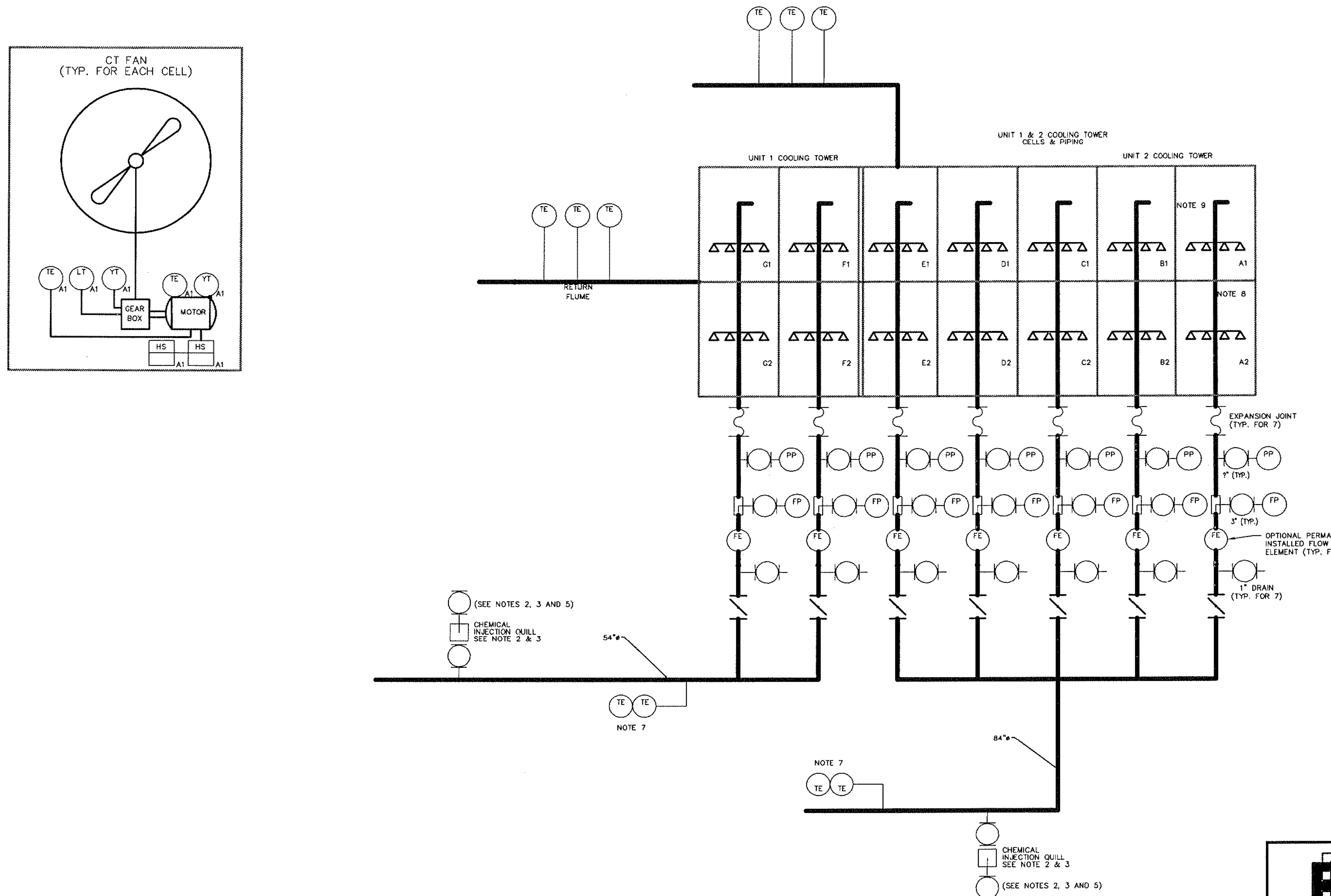


ENERCON SERVICES, INC. Kennesaw, GA 30144	
CLIENT: PUBLIC SERVICE OF NEW HAMPSHIRE MERRMACK STATION, U1 & U2	
COOLING TOWER POWER & CONTROL BLDG.	

SCALE	DRAWING NO.	REV
NONE	PSNH001-SK-003	0



NOTES:

1. ALL 54" AND 84" LINES ARE CARBON STEEL, CEMENT LINED, UNLESS OTHERWISE INDICATED BY PIPE CLASS. THE 36" DIA. RISERS ARE NOT CEMENT LINED.
2. THESE CONNECTIONS ARE PROVIDED TO BE USED BY CHEMISTRY FOR THE FOLLOWING:
   A. INSERTION OF AN INJECTION QUILL FOR THE ADDITION OF WATER TREATMENT CHEMICALS
   B. UTILIZATION OF MONITORING EQUIPMENT
   C. WITHDRAWING A SAMPLE OF CIRCULATING WATER
   D. OTHER USES AS DETERMINED BY PLANT STAFF.
3. COMPONENTS AND VALVES MAY BE PERIODICALLY REMOVED TO FACILITATE USE OF THE CONNECTIONS AS DESCRIBED IN NOTE 2.
4. CLEAN OUT CANNOT BE OPENED WHILE CT IS IN OPERATION.
5. PLANT CONFIGURATION MAY CONFORM TO THE FOLLOWING APPROVED CONFIGURATIONS.
   A. PLUG/CAP/BLIND FLANGE INSTALLED (DO NOT INSTALL IF THERE IS POTENIAL FOR FREEZING)
   B. OPEN END PIPE
   C. CHICAGO TYPE HOSE END
6. ALL 36" DIA. & SMALLER PIPING IS NON-LINED CARBON STEEL.
7. RTD TEMPERATURE ELEMENTS ARE INSTALLED IN SEPARATE THERMO WELLS.
8. A SAMPLE POINT MAY BE INSTALLED FOR MONITORING WATER CHEMISTRY AT THE EXIT OF CT FILL MATERIAL.
9. STANDPIPE AT END OF DISTRIBUTION HEADER PROVIDED FOR OVERPRESSURE PROTECTION (TYPICAL FOR 7). FLOW FROM STANDPIPE INDICATIVE OF > 115% DESIGN FLOW.

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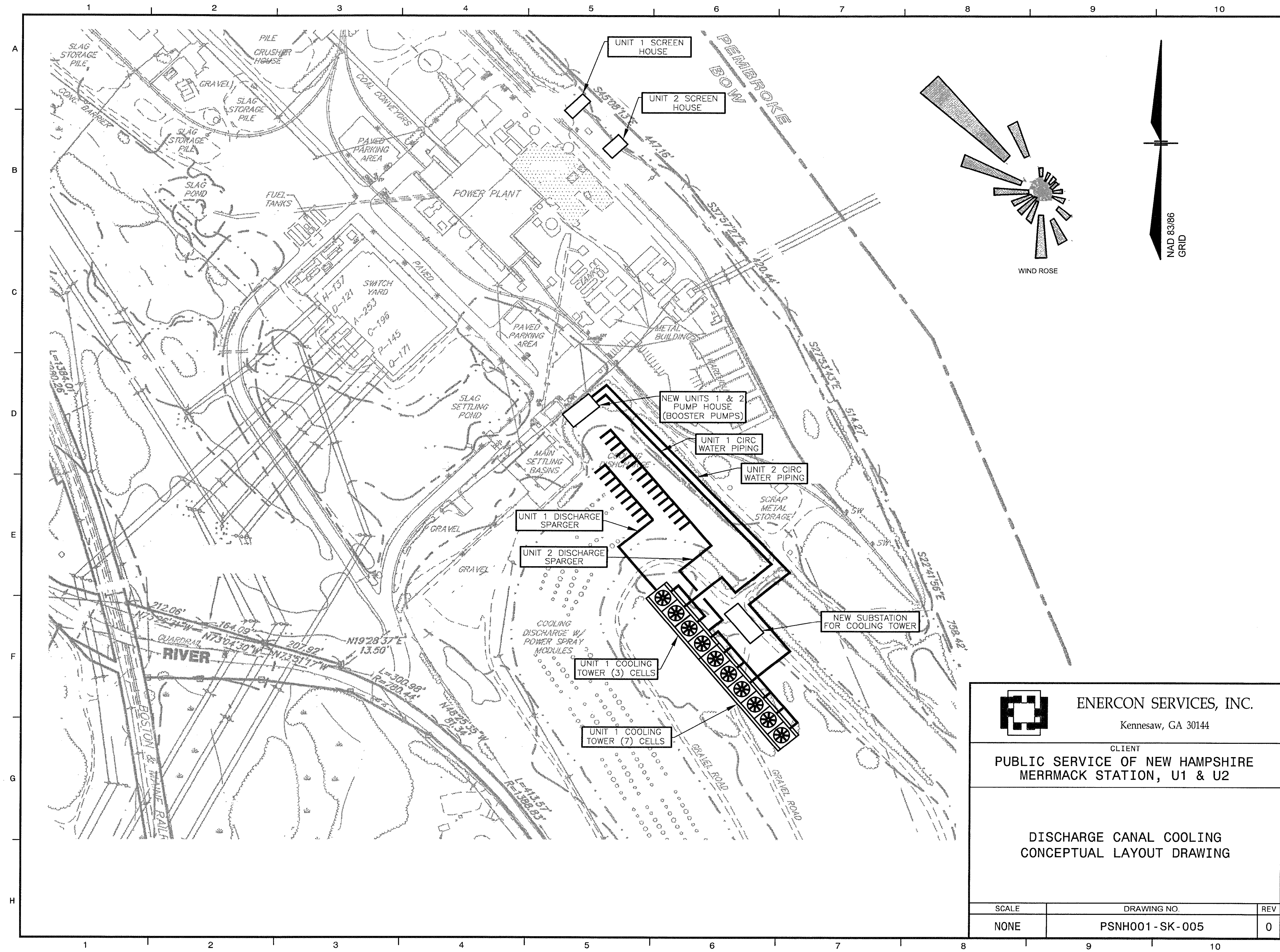
MERRMACK STATION, U1 & U2

COOLING TOWER
SIMPLIFIED P&ID

SCALE	DRAWING NO.	REV
NONE	PSNH001-SK-004	0


UNIT 1 SCREEN HOUSE
UNIT 2 SCREEN HOUSE
PEMBROKE BOW
POWER PLANT
SWITCH YARD
SLAG STORAGE PILE
SLAG POND
FUEL TANKS
PAVED PARKING AREA
COAL CONVEYORS
SLAG SETTLING POND
MAIN SETTLING BASINS
METAL BUILDING
NEW UNITS 1 & 2 PUMP HOUSE (BOOSTER PUMPS)
UNIT 1 CIRC WATER PIPING
UNIT 2 CIRC WATER PIPING
SCRAP METAL STORAGE
UNIT 1 DISCHARGE SPARGER
UNIT 2 DISCHARGE SPARGER
COOLING DISCHARGE W/ POWER SPRAY MODULES
NEW SUBSTATION FOR COOLING TOWER
UNIT 1 COOLING TOWER (3) CELLS
UNIT 1 COOLING TOWER (7) CELLS
GRAVEL
RIVER
GRAVEL ROAD
BOSTON & MAINE RAIL
WIND ROSE
NAD 83/86 GRID
ENERCON SERVICES, INC.
Kennesaw, GA 30144
CLIENT
PUBLIC SERVICE OF NEW HAMPSHIRE
MERRMACK STATION, U1 & U2
DISCHARGE CANAL COOLING
CONCEPTUAL LAYOUT DRAWING
SCALE
NONE
DRAWING NO.
PSNH001-SK-005
REV
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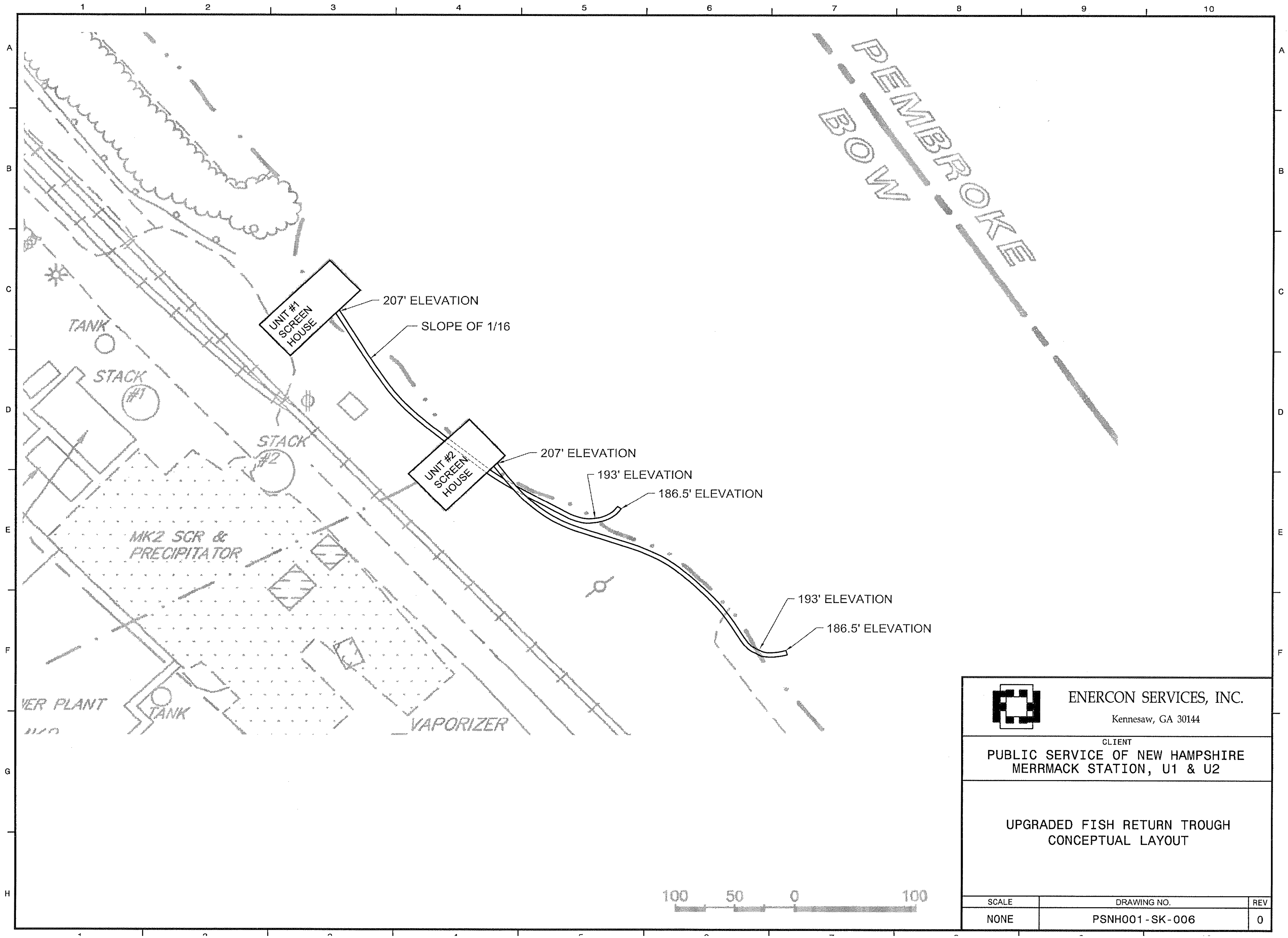
PEMBROKE
BOW
UNIT #1 SCREEN HOUSE
207' ELEVATION
SLOPE OF 1/16
UNIT #2 SCREEN HOUSE
207' ELEVATION
193' ELEVATION
186.5' ELEVATION
193' ELEVATION
186.5' ELEVATION
TANK
STACK #1
STACK #2
MK2 SCR & PRECIPITATOR
TANK
VAPORIZER
100 50 0 100
ENERCON SERVICES, INC.
Kennesaw, GA 30144
CLIENT
PUBLIC SERVICE OF NEW HAMPSHIRE
MERRMACK STATION, U1 & U2
UPGRADED FISH RETURN TROUGH
CONCEPTUAL LAYOUT
SCALE
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DRAWING NO.
PSNH001-SK-006
REV
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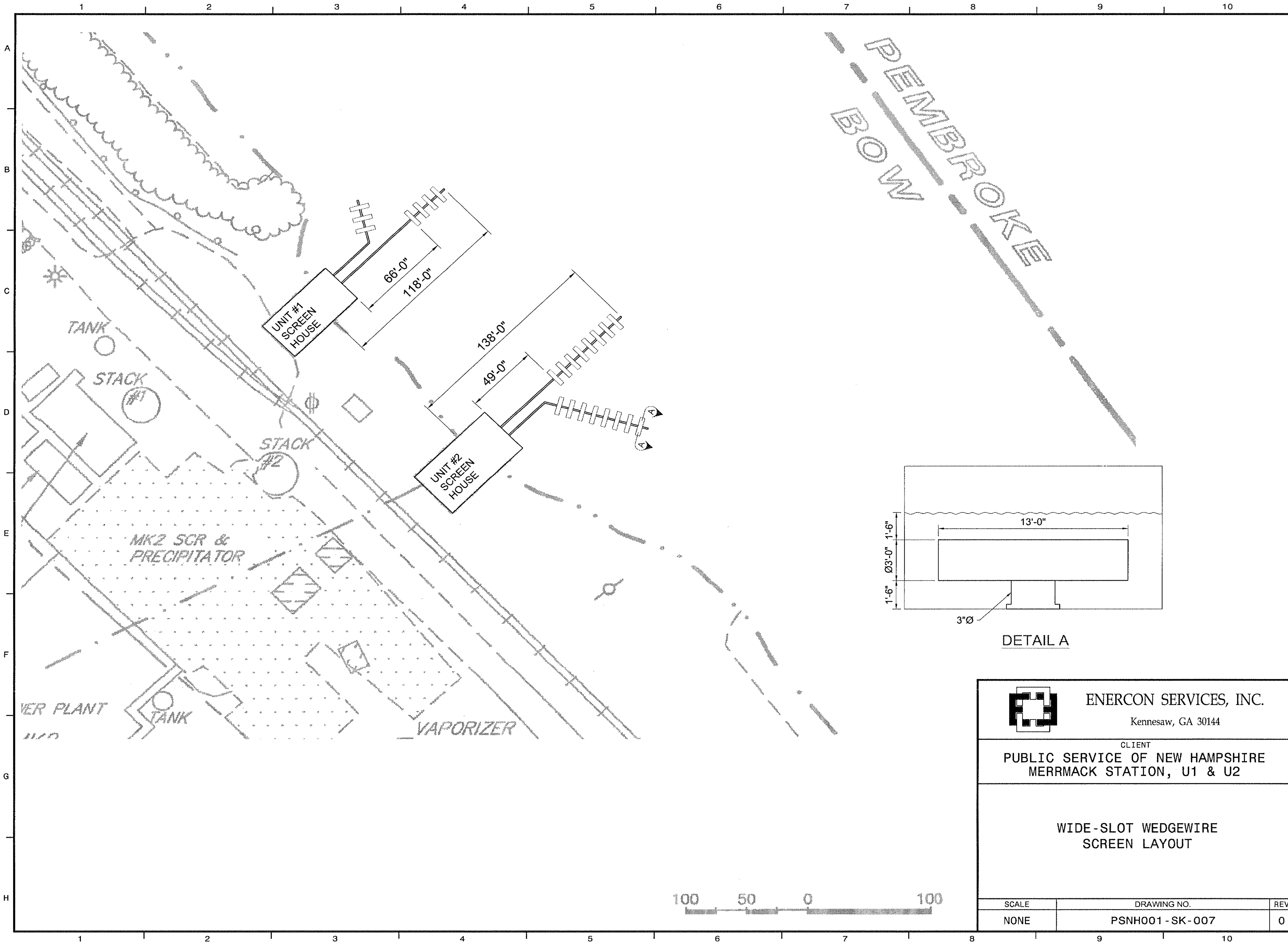
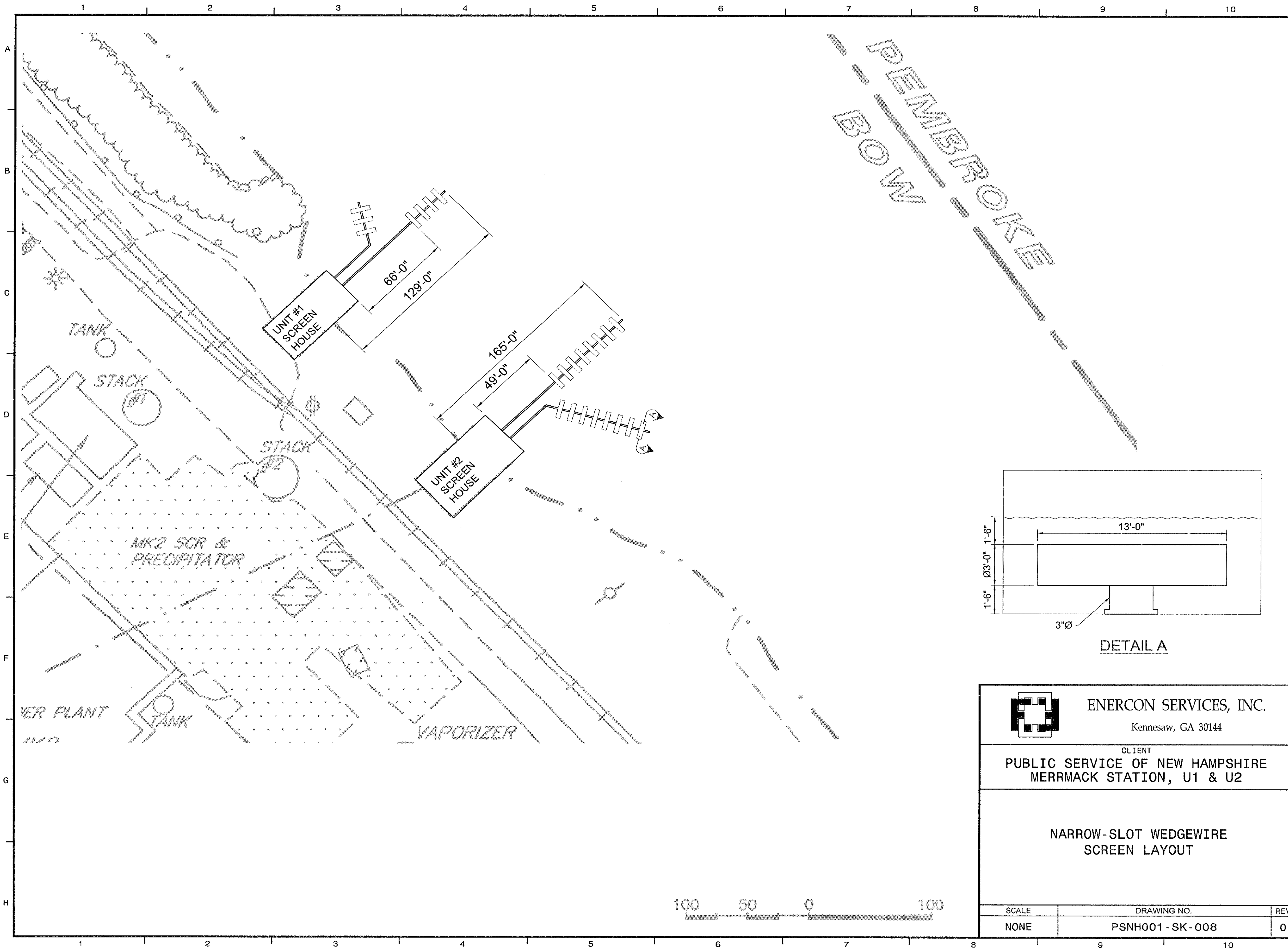

PEMBROKE
BOW
UNIT #1 SCREEN HOUSE
66'-0"
118'-0"
138'-0"
49'-0"
UNIT #2 SCREEN HOUSE
TANK
STACK #1
STACK #2
MK2 SCR & PRECIPITATOR
VAPORIZER
TANK
13'-0"
1'-6"
Ø3'-0"
1'-6"
3"Ø
DETAIL A
100 50 0 100
ENERCON SERVICES, INC.
Kennesaw, GA 30144
CLIENT
PUBLIC SERVICE OF NEW HAMPSHIRE
MERRMACK STATION, U1 & U2
WIDE-SLOT WEDGEWIRE
SCREEN LAYOUT
SCALE NONE
DRAWING NO. PSNH001-SK-007
REV 0


PEMBROKE
BOW
UNIT #1 SCREEN HOUSE
UNIT #2 SCREEN HOUSE
66'-0"
129'-0"
165'-0"
49'-0"
TANK
STACK #1
STACK #2
MK2 SCR & PRECIPITATOR
VAPORIZER
13'-0"
1'-6"
Ø3'-0"
1'-6"
3"Ø
DETAIL A
100 50 0 100
ENERCON SERVICES, INC.
Kennesaw, GA 30144
CLIENT
PUBLIC SERVICE OF NEW HAMPSHIRE
MERRMACK STATION, U1 & U2
NARROW-SLOT WEDGEWIRE
SCREEN LAYOUT
SCALE
NONE
DRAWING NO.
PSNH001-SK-008
REV
0

Attachment 3

Closed-Loop Station Performance and Merrimack River Thermal Analysis

Section 1: Data Recovery Analysis

Section 2: Closed-Loop Condenser Performance

Section 3: PSM Approach to Wet Bulb Assessment

Section 4: PSM Historical Performance

Section 5: PSM Performance at Minimum Flow

Section 6: 10-Cell Thermal Discharge Cooling Tower Historical Performance

Section 7: 10-Cell Thermal Discharge Cooling Tower Performance at Minimum Flow

Attachment 3

Section 1: Data Recovery Analysis

Section 1 tabulates both the monthly number of hours with the necessary coincident environmental conditions and the monthly percentage of time with meteorological data. To define the thermal discharge produced by the Station the wet bulb, dry bulb, and N10 river water temperatures are necessary; however, due to the unavailability of data during Merrimack River freezing conditions, a significant amount of time is unrecorded from December through March. Hourly meteorological data for the Concord Municipal Airport is obtained from the National Climatic Data Center (NCDC), which is subsequently measured by the National Weather Service (NWS), which is quality controlled and publicly available.

Merrimack Station Data Availability Analysis

Month	Hours of Recorded Coincident Data[1]					
	2002	*2003*	*2004*	*2005*	*2006*	Total
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	83	N/A[2]	N/A[2]	N/A[2]	34	117
April	719	327	520	608	720	2894
May	744	662	685	744	739	3574
June	712	716	720	696	720	3564
July	723	742	744	744	742	3695
August	744	743	744	744	741	3716
September	715	720	719	718	720	3592
October	740	732	744	698	744	3658
November	131	439	371	720	720	2381
December	N/A[2]	N/A[2]	N/A[2]	11	350	361
Annual	5311	5081	5247	5683	6230	27552
Freezing	3410	3550	3410	3002	2519	15891

[1] *Analysis limited by coincident wet bulb, dry bulb, and N10 river water temperatures*

[2] *N/A values indicate times when Merrimack River data was not recorded due to freezing conditions*

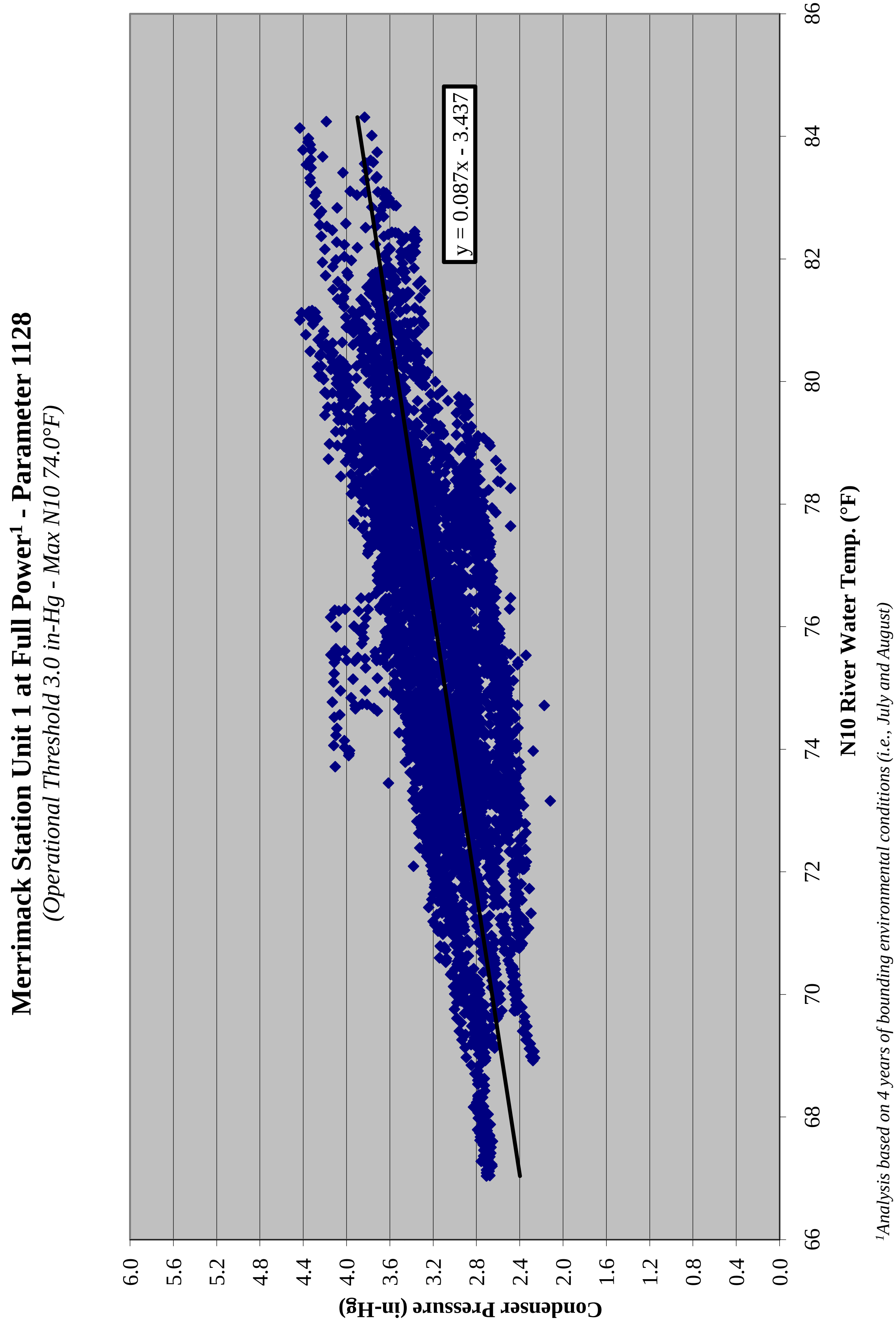
Concord Municipal Airport Meteorological Data Recovery Rate

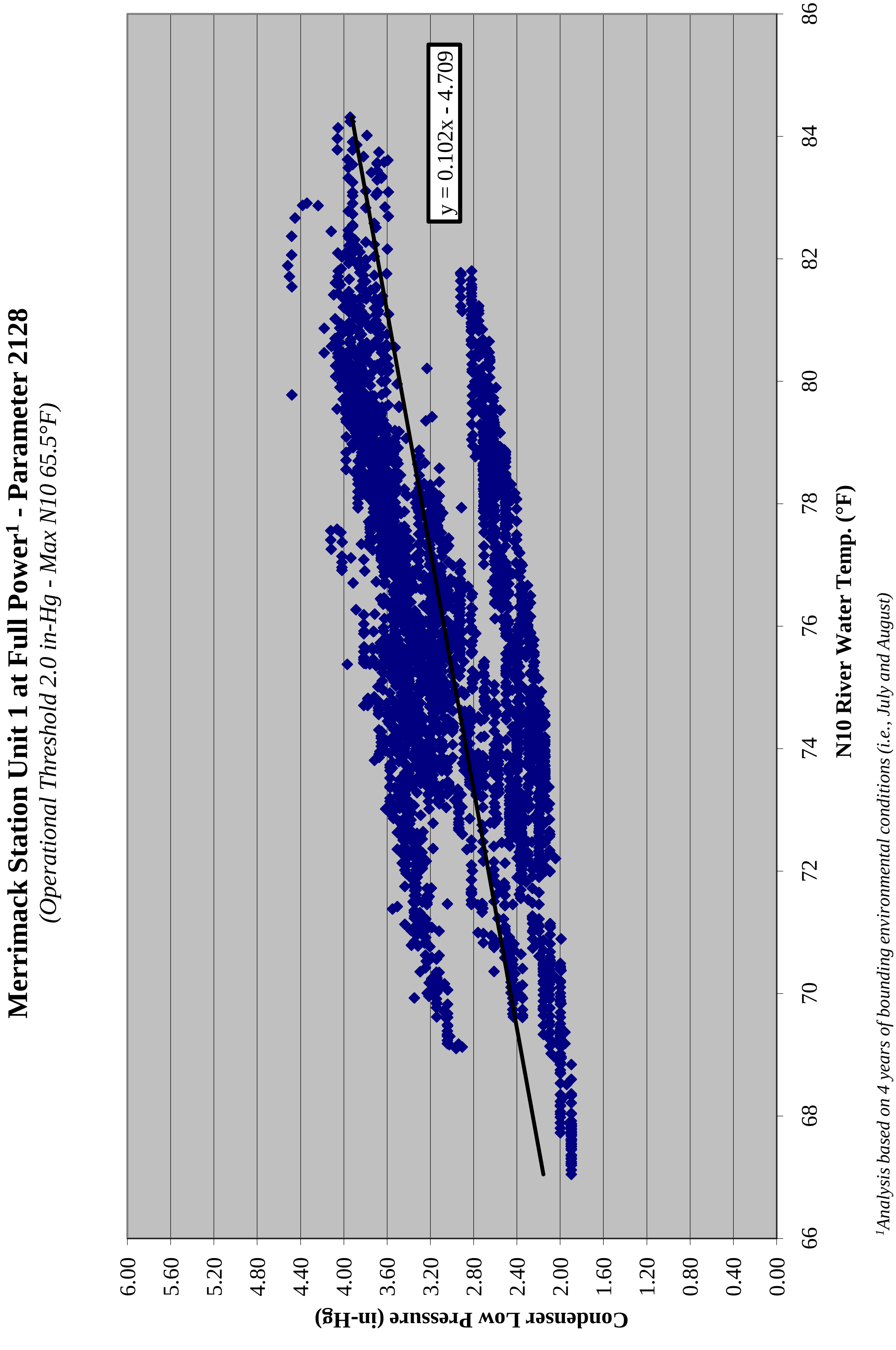
Month	2002	2003	2004	2005	2006	Average
January	100.0%	100.0%	96.4%	100.0%	100.0%	99.3%
February	97.2%	100.0%	100.0%	100.0%	100.0%	99.4%
March	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
April	99.9%	96.7%	98.5%	99.6%	100.0%	98.9%
May	100.0%	98.1%	92.1%	100.0%	99.9%	98.0%
June	99.2%	99.4%	100.0%	97.2%	100.0%	99.2%
July	97.2%	100.0%	100.0%	100.0%	100.0%	99.4%
August	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%
September	100.0%	100.0%	99.9%	99.9%	100.0%	99.9%
October	99.9%	99.3%	100.0%	100.0%	100.0%	99.8%
November	100.0%	97.4%	100.0%	100.0%	100.0%	99.5%
December	100.0%	99.9%	99.9%	100.0%	99.9%	99.9%
Total	99.5%	99.2%	98.9%	99.7%	100.0%	99.5%

Attachment 3

Section 2: Closed-Loop Condenser Performance

Section 2 evaluates the closed-loop performance of the Station utilizing the limiting condenser operational threshold pressures for both units. Since closed-loop operation involves recirculating the cooling water from the cooling towers back through the condensers, closed-loop performance may be modeled using N10 river water temperatures (i.e., the input temperature into the Station via current once through performance). Closed-loop condenser analysis is limited to the operational data for the condensers provided from July to August over four years (2003-2006).


Merrimack Station Unit 1 at Full Power[1] - Parameter 1128
(Operational Threshold 3.0 in-Hg - Max N10 74.0°F)
Condenser Pressure (in-Hg)
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
N10 River Water Temp. (°F)
66
68
70
72
74
76
78
80
82
84
86
y = 0.087x - 3.437
[1]Analysis based on 4 years of bounding environmental conditions (i.e., July and August)

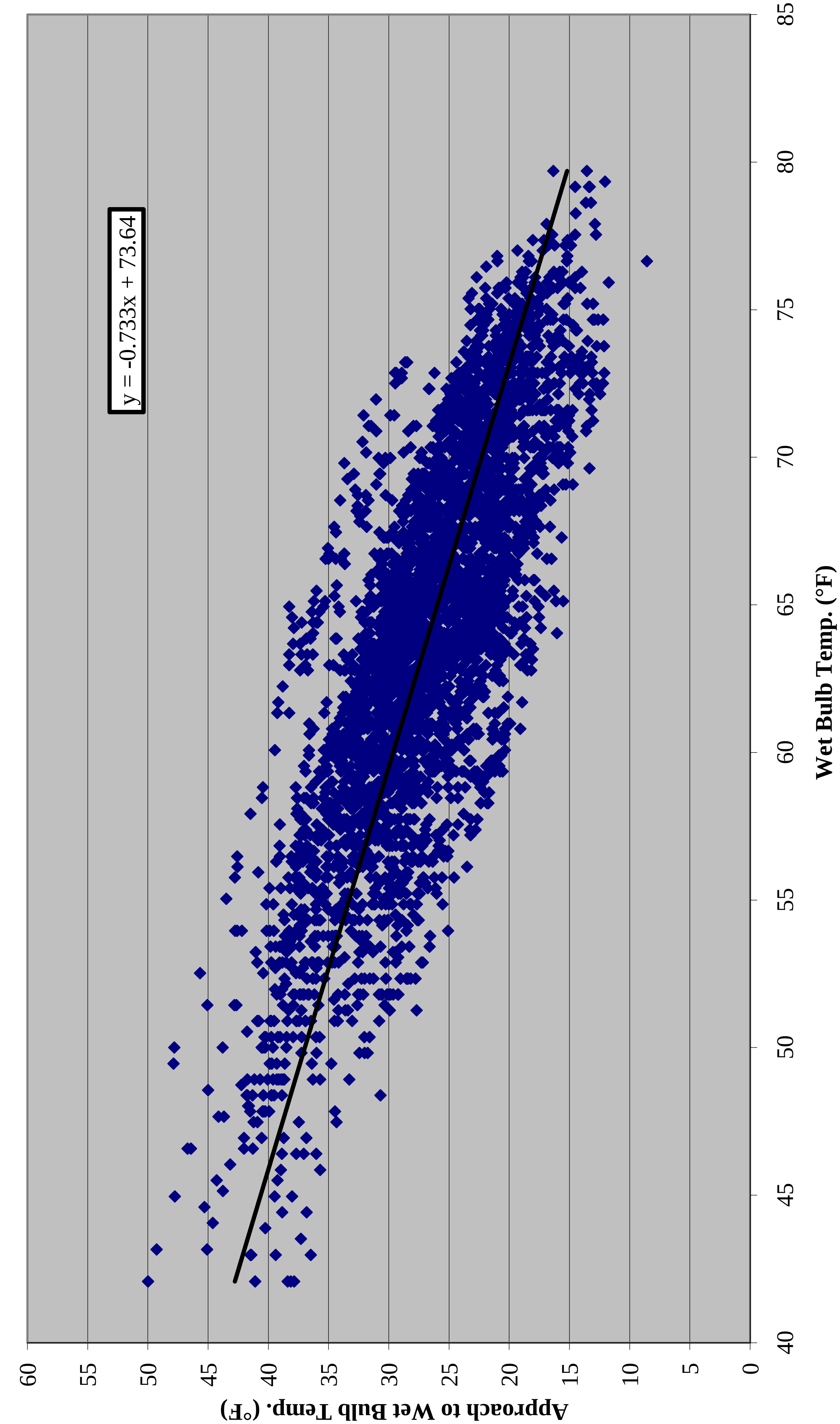

Merrimack Station Unit 1 at Full Power[1] - Parameter 2128
(Operational Threshold 2.0 in-Hg - Max N10 65.5°F)
y = 0.102x - 4.709
Condenser Low Pressure (in-Hg)
6.00
5.60
5.20
4.80
4.40
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
66
68
70
72
74
76
78
80
82
84
86
N10 River Water Temp. (°F)
[1]Analysis based on 4 years of bounding environmental conditions (i.e., July and August)

Attachment 3

Section 3: PSM Approach to Wet Bulb Assessment

Section 3 evaluates the performance of the PSMs by defining their approach to wet bulb across a range of ambient wet bulb temperatures. The analysis is limited to full power Station operation during the months of July and August across five years of measured data (2002-2006). As the months of July and August are the two months with the highest average wet bulb temperatures, this limited assessment is determined to be bounding.

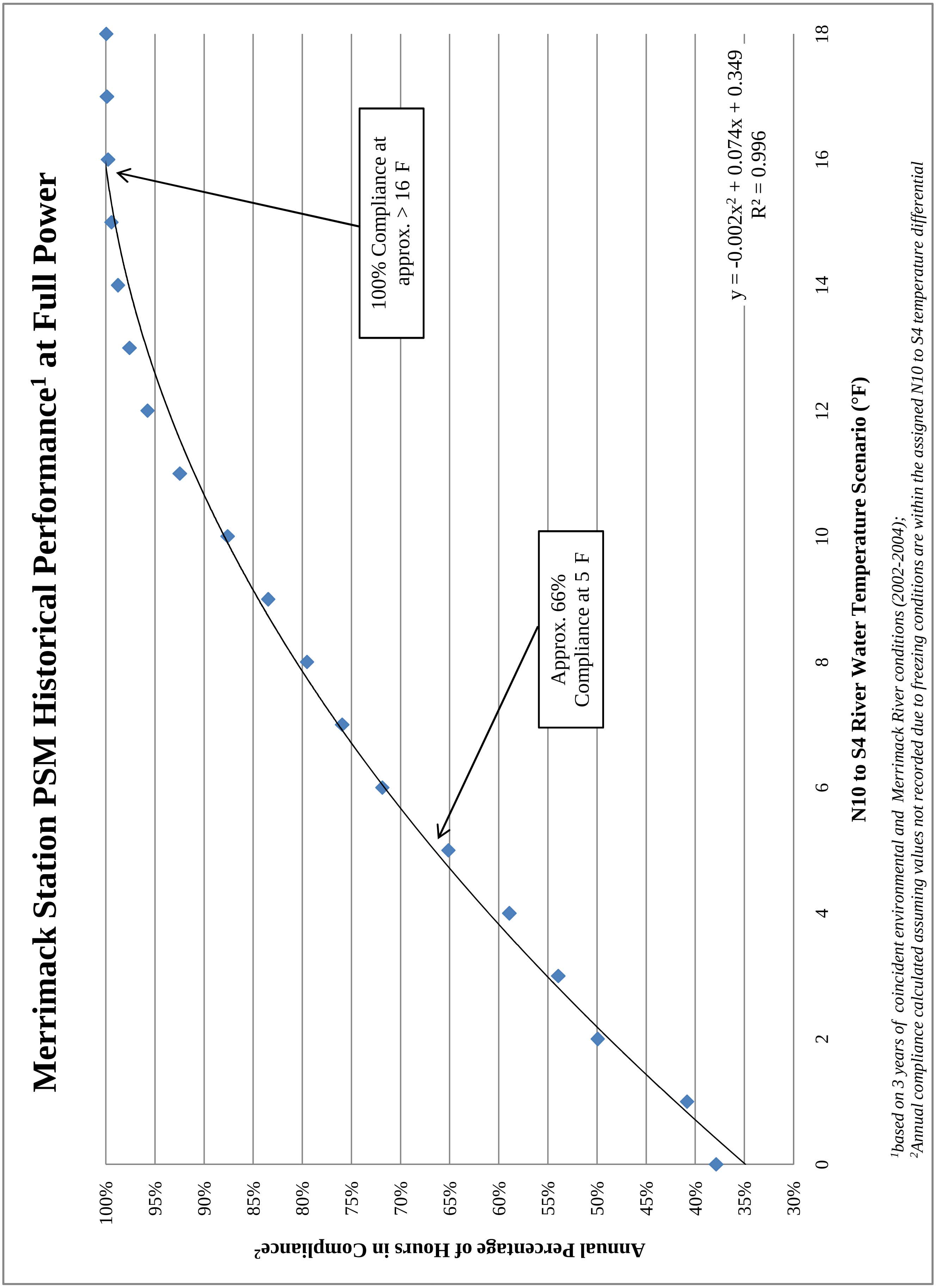
Full Power Merrimack Station PSM Performance
(based on July-August data enveloping 2002-2006)



Attachment 3

Section 4: PSM Historical Performance

Section 4 provides both the graphical representation of the PSM performance at historical conditions and the tabulated monthly values which provide the basis for the graphical representation. Performance of the PSMs under historical conditions is calculated directly from the measured N10 and S4 river water temperatures, and is only altered to conservatively exclude measured 5°F N10-S4 temperature differential attainment hours at conditions where the Station was operated at less than full power. In order to satisfy this restriction the analysis is limited to the years with provided plant electrical output and river water temperatures at N10 and S4 (2002-2004), and is limited primarily by the unavailability of Merrimack River data during freezing conditions on the river. Both the percentage of measured 5°F N10-S4 temperature differential attainment (i.e., the hours in attainment divided by the number of hours with recorded data) and the percentage of annual 5°F N10-S4 temperature differential attainment (i.e., the summation of the hours in attainment and the unrecorded hours due to freezing conditions divided by the total number of hours with recorded data) are provided within the basis tables, however, only the percentage of annual 5°F N10-S4 temperature differential attainment has been charted on the summary figure.


Merrimack Station PSM Historical Performance¹ at Full Power
Annual Percentage of Hours in Compliance²
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
0
2
4
6
8
10
12
14
16
18
N10 to S4 River Water Temperature Scenario (°F)
100% Compliance at approx. > 16 F
Approx. 66% Compliance at 5 F
y = -0.002x² + 0.074x + 0.349
R² = 0.996
¹based on 3 years of coincident environmental and Merrimack River conditions (2002-2004);
²Annual compliance calculated assuming values not recorded due to freezing conditions are within the assigned N10 to S4 temperature differential

Annual Full Power PSM Compliance (2002-2004)		
	§308 0°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	0.3	0.1%
May	49.3	6.6%
June	13.0	1.8%
July	15.3	2.1%
August	0.0	0.0%
September	2.0	0.3%
October	26.7	3.6%
November	0.3	0.1%
December	N/A[1]	N/A[1]
Measured Compliance[2]	107.0	2.0%
Annual Compliance[3]	3230.0	37.9%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 0 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 1°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	5.5	1.0%
May	183.7	24.7%
June	86.3	12.0%
July	25.7	3.4%
August	1.7	0.2%
September	12.0	1.7%
October	33.8	4.5%
November	12.8	3.1%
December	N/A[1]	N/A[1]
Measured Compliance[2]	361.5	6.7%
Annual Compliance[3]	3484.5	40.8%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 1 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
Month	**§308 2°F Temperature Differential Scenario**	
	Average Hours	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	50.8	8.9%
May	652.5	87.7%
June	209.0	29.0%
July	37.7	5.1%
August	32.0	4.3%
September	72.0	10.0%
October	46.8	6.3%
November	35.2	8.4%
December	N/A[1]	N/A[1]
Measured Compliance[2]	1136.0	21.0%
Annual Compliance[3]	4259.0	49.9%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 2 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
Month	**§308 3°F Temperature Differential Scenario**	
	Average Hours	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	96.3	16.8%
May	736.0	98.9%
June	243.8	33.9%
July	64.0	8.6%
August	89.7	12.1%
September	111.7	15.5%
October	89.5	12.0%
November	47.0	11.3%
December	N/A[1]	N/A[1]
Measured Compliance[2]	1478.0	27.3%
Annual Compliance[3]	4601.0	53.9%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 3 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 4°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	153.0	26.7%
May	743.0	99.9%
June	352.7	49.0%
July	105.3	14.2%
August	126.7	17.0%
September	136.7	19.0%
October	172.8	23.2%
November	113.2	27.1%
December	N/A[1]	N/A[1]
Measured Compliance[2]	1903.3	35.2%
Annual Compliance[3]	5026.3	58.9%

[1] *N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within the 4 °F temperature differential scenario*

Annual Full Power PSM Compliance (2002-2004)		
	§308 5°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	267.5	46.6%
May	743.5	99.9%
June	418.3	58.1%
July	163.3	22.0%
August	180.8	24.3%
September	175.0	24.3%
October	253.7	34.1%
November	230.3	55.2%
December	N/A[1]	N/A[1]
Measured Compliance[2]	2432.5	45.0%
Annual Compliance[3]	5555.5	65.1%

[1] *N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within the 5 °F temperature differential scenario*

Annual Full Power PSM Compliance (2002-2004)		
Month	§308 6°F Temperature Differential Scenario	
	Average Hours	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	475.0	82.8%
May	744.0	100.0%
June	456.3	63.4%
July	201.8	27.1%
August	228.5	30.7%
September	224.2	31.1%
October	324.2	43.6%
November	352.5	84.5%
December	N/A[1]	N/A[1]
Measured Compliance[2]	3006.5	55.6%
Annual Compliance[3]	6129.5	71.9%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 6 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
Month	§308 7°F Temperature Differential Scenario	
	Average Hours	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	546.0	95.1%
May	744.0	100.0%
June	486.5	67.6%
July	257.8	34.7%
August	297.8	40.0%
September	267.3	37.1%
October	385.8	51.9%
November	369.5	88.6%
December	N/A[1]	N/A[1]
Measured Compliance[2]	3354.8	62.0%
Annual Compliance[3]	6477.8	75.9%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 7 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 8°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	573.0	99.8%
May	744.0	100.0%
June	520.8	72.3%
July	324.0	43.5%
August	349.5	47.0%
September	317.5	44.1%
October	459.3	61.7%
November	373.5	89.6%
December	N/A[1]	N/A[1]
Measured Compliance[2]	3661.7	67.7%
Annual Compliance[3]	6784.7	79.5%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 8 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 9°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	573.5	99.9%
May	744.0	100.0%
June	583.0	81.0%
July	406.5	54.6%
August	415.2	55.8%
September	368.8	51.2%
October	527.0	70.8%
November	380.0	91.1%
December	N/A[1]	N/A[1]
Measured Compliance[2]	3998.0	73.9%
Annual Compliance[3]	7121.0	83.5%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 9 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 10°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	573.5	99.9%
May	744.0	100.0%
June	631.7	87.7%
July	512.3	68.9%
August	492.8	66.2%
September	436.3	60.6%
October	573.5	77.1%
November	385.5	92.4%
December	N/A[1]	N/A[1]
Measured Compliance[2]	4349.7	80.4%
Annual Compliance[3]	7472.7	87.6%

[1] *N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within the 10 °F temperature differential scenario*

Annual Full Power PSM Compliance (2002-2004)		
	§308 11°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	573.5	99.9%
May	744.0	100.0%
June	678.0	94.2%
July	643.7	86.5%
August	582.3	78.3%
September	511.7	71.1%
October	639.3	85.9%
November	392.0	94.0%
December	N/A[1]	N/A[1]
Measured Compliance[2]	4764.5	88.1%
Annual Compliance[3]	7887.5	92.5%

[1] *N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within the 11 °F temperature differential scenario*

Annual Full Power PSM Compliance (2002-2004)		
	§308 12°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	573.5	99.9%
May	744.0	100.0%
June	708.3	98.4%
July	710.5	95.5%
August	650.7	87.5%
September	574.8	79.8%
October	685.5	92.1%
November	398.0	95.4%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5045.3	93.3%
Annual Compliance[3]	8168.3	95.8%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 12 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 13°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	573.5	99.9%
May	744.0	100.0%
June	717.0	99.6%
July	735.7	98.9%
August	684.0	91.9%
September	629.0	87.4%
October	714.5	96.0%
November	404.0	96.9%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5201.7	96.2%
Annual Compliance[3]	8324.7	97.6%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 13 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 14°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	574.0	100.0%
May	744.0	100.0%
June	719.0	99.9%
July	740.3	99.5%
August	707.3	95.1%
September	672.2	93.4%
October	737.5	99.1%
November	408.5	98.0%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5302.8	98.1%
Annual Compliance[3]	8425.8	98.8%

[1] *N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within the 14 °F temperature differential scenario*

Annual Full Power PSM Compliance (2002-2004)		
	§308 15°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	574.0	100.0%
May	744.0	100.0%
June	720.0	100.0%
July	742.5	99.8%
August	722.0	97.0%
September	700.0	97.2%
October	743.5	99.9%
November	413.0	99.0%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5359.0	99.1%
Annual Compliance[3]	8482.0	99.4%

[1] *N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within the 15 °F temperature differential scenario*

Annual Full Power PSM Compliance (2002-2004)		
	§308 16°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	574.0	100.0%
May	744.0	100.0%
June	720.0	100.0%
July	744.0	100.0%
August	729.7	98.1%
September	715.3	99.4%
October	744.0	100.0%
November	416.5	99.9%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5387.5	99.6%
Annual Compliance[3]	8510.5	99.8%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 16 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 17°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	574.0	100.0%
May	744.0	100.0%
June	720.0	100.0%
July	744.0	100.0%
August	734.5	98.7%
September	719.7	100.0%
October	744.0	100.0%
November	417.0	100.0%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5397.2	99.8%
Annual Compliance[3]	8520.2	99.9%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 17 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 18°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	574.0	100.0%
May	744.0	100.0%
June	720.0	100.0%
July	744.0	100.0%
August	741.0	99.6%
September	720.0	100.0%
October	744.0	100.0%
November	417.0	100.0%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5404.0	99.9%
Annual Compliance[3]	8527.0	100.0%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 18 °F temperature differential scenario

Annual Full Power PSM Compliance (2002-2004)		
	§308 19°F Temperature Differential Scenario	
Month	*Average Hours*	*Percentage*
January	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]
March	N/A[1]	N/A[1]
April	574.0	100.0%
May	744.0	100.0%
June	720.0	100.0%
July	744.0	100.0%
August	744.0	100.0%
September	720.0	100.0%
October	744.0	100.0%
November	417.0	100.0%
December	N/A[1]	N/A[1]
Measured Compliance[2]	5407.0	100.0%
Annual Compliance[3]	8530.0	100.0%

[1] N/A values indicate times when Merrimack River data was not recorded due to freezing conditions (Nov. 18th - Mar. 28th)

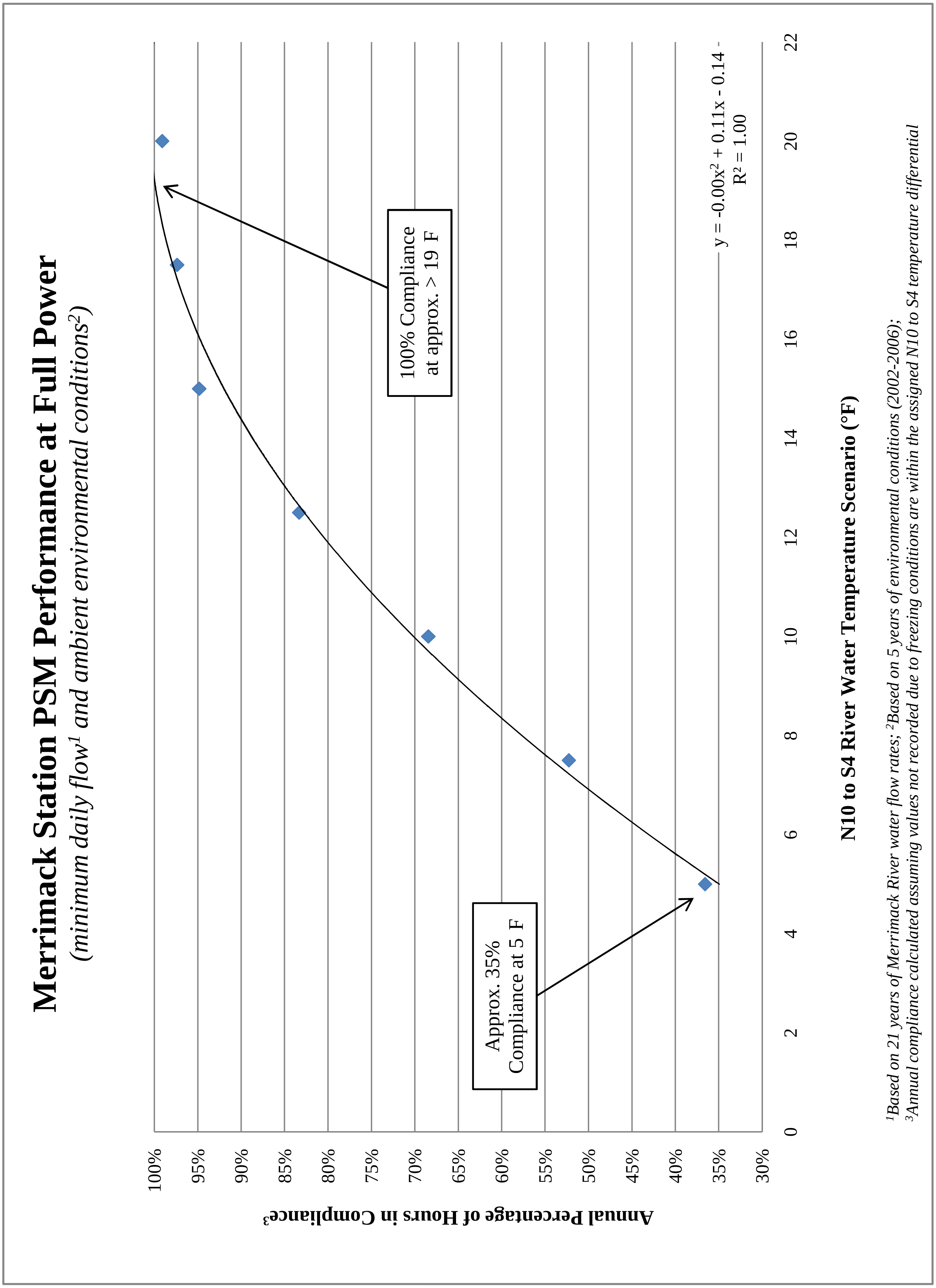
[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within the 19 °F temperature differential scenario

Attachment 3

Section 5: PSM Performance at Minimum Flow

Section 5 provides both the graphical representation of the PSM performance at minimum river flow conditions and the tabulated monthly values which provided the basis for the graphical representation. Performance of the PSMs at minimum river flow rate conditions is calculated via a thermal discharge analysis which defines the S4 river water temperature as a function of the Station electrical output, N10 river water temperature, dry bulb temperature, wet bulb temperature, and river water flow rate. Furthermore, minimum river water flow rate is defined daily as the minimum average daily flow rate occurring over the 21 years of river water flow rates provided (1984-2004). The analysis is restricted by the five years of meteorological data obtained (2002-2006) coincident with the provided N10 river water temperatures, and is limited primarily by the unavailability of Merrimack River data during freezing conditions on the river. Both the percentage of measured 5°F N10-S4 temperature differential attainment (i.e., the hours in attainment divided by the number of hours with recorded data) and the percentage of annual 5°F N10-S4 temperature differential attainment (i.e., the summation of the hours in attainment and the unrecorded hours due to freezing conditions divided by the total number of hours with recorded data) are provided within the basis tables, however, only the percentage of annual 5°F N10-S4 temperature differential attainment has been charted on the summary figure.


Merrimack Station PSM Performance at Full Power
(minimum daily flow1 and ambient environmental conditions2)
Annual Percentage of Hours in Compliance3
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
0
2
4
6
8
10
12
14
16
18
20
22
N10 to S4 River Water Temperature Scenario (°F)
100% Compliance at approx. > 19 F
Approx. 35% Compliance at 5 F
y = -0.00x2 + 0.11x - 0.14
R2 = 1.00
1Based on 21 years of Merrimack River water flow rates; 2Based on 5 years of environmental conditions (2002-2006);
3Annual compliance calculated assuming values not recorded due to freezing conditions are within the assigned N10 to S4 temperature differential

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	0.0%	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%
April	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
May	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
June	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
November	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
December	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%	0.0%
Measured Compliance[3]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Annual Compliance[4]	39.1%	41.1%	39.4%	34.6%	28.8%	36.6%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 5°F temperature differential scenario

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 7.5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	81.6%	81.6%	81.6%	81.9%	79.3%	81.2%
June	6.6%	5.9%	7.2%	8.3%	6.1%	6.8%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	0.3%	0.0%	0.0%	0.0%	0.0%	0.1%
November	18.3%	17.3%	19.1%	14.4%	8.2%	14.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	90.6%	90.9%
Measured Compliance[3]	27.9%	19.4%	22.9%	24.5%	28.3%	24.7%
Annual Compliance[4]	56.1%	52.5%	53.3%	50.6%	48.9%	52.3%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 7.5°F temperature differential scenario

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 10°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	77.5%	77.7%	75.8%	70.7%	70.6%	74.5%
July	7.9%	14.0%	11.7%	5.8%	3.1%	8.5%
August	5.9%	0.4%	4.8%	5.0%	8.1%	4.8%
September	0.8%	0.8%	0.3%	1.4%	1.0%	0.9%
October	39.1%	37.3%	38.0%	40.1%	38.2%	38.5%
November	100.0%	98.6%	100.0%	95.8%	94.9%	96.9%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	49.4%	46.5%	48.2%	51.3%	54.7%	50.2%
Annual Compliance[4]	69.2%	68.5%	68.6%	68.1%	67.7%	68.4%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 10°F temperature differential scenario

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 12.5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	96.6%	96.6%	96.7%	96.6%	96.3%	96.5%
July	65.4%	69.8%	64.4%	67.9%	59.6%	65.4%
August	50.9%	42.5%	43.8%	50.5%	47.0%	47.0%
September	25.5%	22.5%	20.7%	24.1%	25.1%	23.6%
October	69.2%	64.6%	71.5%	68.6%	72.8%	69.4%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	73.6%	70.6%	71.6%	75.5%	76.5%	73.7%
Annual Compliance[4]	83.9%	82.7%	82.8%	83.9%	83.3%	83.3%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 12.5°F temperature differential scenario

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition [1])

Month	Percentage of Hours in Compliance with 15°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A	N/A	N/A	N/A	N/A	N/A
February	N/A	N/A	N/A	N/A	N/A	N/A
March	100.0%	N/A	N/A	N/A	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	96.6%	96.6%	96.7%	96.6%	96.7%	96.6%
July	92.8%	98.0%	94.9%	100.0%	95.7%	96.3%
August	75.3%	75.4%	76.5%	79.3%	78.5%	77.0%
September	74.4%	75.4%	76.9%	72.7%	76.7%	75.2%
October	92.7%	93.7%	93.8%	94.1%	91.9%	93.2%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A	N/A	N/A	100.0%	100.0%	100.0%
Measured Compliance[3]	90.6%	91.2%	91.4%	92.7%	92.9%	91.8%
Annual Compliance[4]	94.3%	94.8%	94.8%	95.2%	94.9%	94.8%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 15 °F temperature differential scenario

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition [1])

Month	Percentage of Hours in Compliance with 17.5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	96.6%	96.6%	97.2%	96.6%	96.7%	96.7%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	81.6%	80.3%	82.5%	83.2%	83.4%	82.2%
September	89.7%	91.7%	89.8%	88.0%	90.8%	90.0%
October	99.1%	100.0%	100.0%	100.0%	100.0%	99.8%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	95.4%	95.5%	95.7%	95.9%	96.6%	95.9%
Annual Compliance[4]	97.2%	97.3%	97.4%	97.3%	97.6%	97.4%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 17.5 °F temperature differential scenario

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 20°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	97.5%	98.7%	98.6%	98.4%	96.9%	98.0%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	95.2%	94.3%	95.4%	95.6%	96.9%	95.5%
September	93.7%	96.8%	97.5%	96.5%	94.4%	95.8%
October	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	98.1%	98.5%	98.8%	98.8%	98.6%	98.6%
Annual Compliance[4]	98.9%	99.1%	99.3%	99.2%	99.0%	99.1%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)
[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions
[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data
[4] Annual compliance calculated assuming all N/A values are within 20°F temperature differential scenario

Merrimack Station Current PSM and Discharge Canal Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

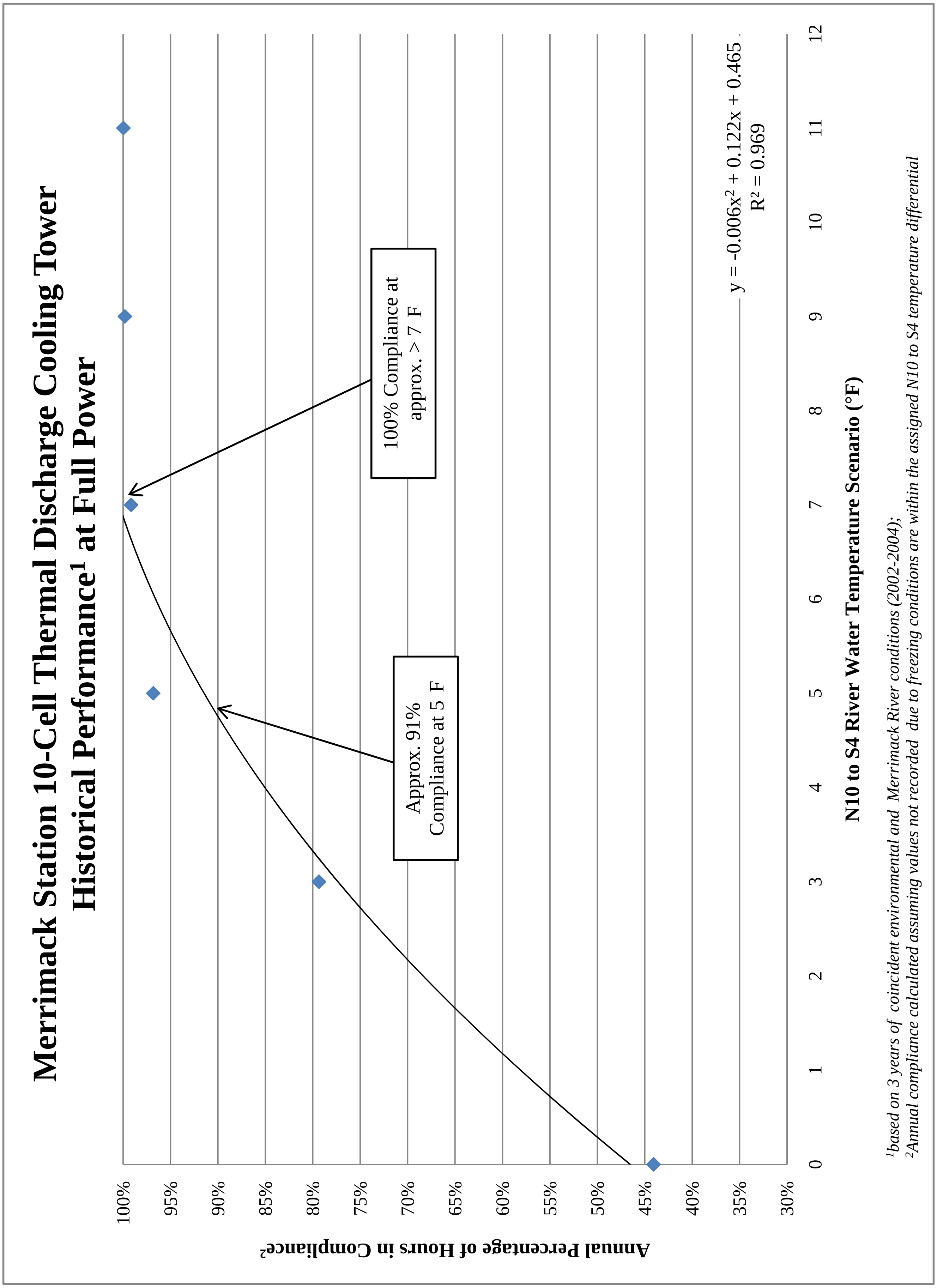
Month	Percentage of Hours in Compliance with 22.5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
September	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
October	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Annual Compliance[4]	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)
[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions
[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data
[4] Annual compliance calculated assuming all N/A values are within 22.5°F temperature differential scenario

Attachment 3

Section 6: 10-Cell Thermal Discharge Cooling Tower Historical Performance

Section 6 provides both the graphical representation of the 10-cell thermal discharge cooling tower performance at historical conditions and the tabulated monthly values which provide the basis for the graphical representation. Performance of the 10-cell thermal discharge cooling tower over historical conditions is calculated via a thermal discharge analysis which defines the S4 river water temperature as a function of the Station electrical output, N10 river water temperature, dry bulb temperature, wet bulb temperature, and river water flow rate. Furthermore, historical river water flow rates are defined daily as recorded average daily flow rate occurring coincidently with the provided environmental temperatures. As such, the analysis is restricted by the three years of coincident river flow rates, river water temperatures, and meteorological data (2002-2004), and is limited primarily by the unavailability of Merrimack River data during freezing conditions on the river. Both the percentage of measured 5°F N10-S4 temperature differential attainment (i.e., the hours in attainment divided by the number of hours with recorded data) and the percentage of annual 5°F N10-S4 temperature differential attainment (i.e., the summation of the hours in attainment and the unrecorded hours due to freezing conditions divided by the total number of hours with recorded data) are provided within the basis tables, however, only the percentage of annual 5°F N10-S4 temperature differential attainment has been charted on the summary figure.


Merrimack Station 10-Cell Thermal Discharge Cooling Tower Historical Performance[1] at Full Power
Annual Percentage of Hours in Compliance[2]
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
0
1
2
3
4
5
6
7
8
9
10
11
12
N10 to S4 River Water Temperature Scenario (°F)
100% Compliance at approx. > 7 F
Approx. 91% Compliance at 5 F
y = -0.006x² + 0.122x + 0.465
R² = 0.969
[1]based on 3 years of coincident environmental and Merrimack River conditions (2002-2004);
[2]Annual compliance calculated assuming values not recorded due to freezing conditions are within the assigned N10 to S4 temperature differential

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	Percentage of Hours in Compliance with 0°F Temp. Differential Scenario			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	0.0%	N/A	N/A	0.0%
April	0.0%	0.0%	0.0%	0.0%
May	0.0%	0.0%	0.0%	0.0%
June	0.0%	10.8%	14.9%	8.6%
July	25.3%	28.2%	17.5%	23.6%
August	0.9%	26.5%	15.7%	14.4%
September	0.7%	7.8%	0.4%	3.0%
October	0.0%	0.0%	0.0%	0.0%
November	0.0%	0.0%	0.0%	0.0%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Comliance[3]	3.7%	10.6%	6.8%	7.0%
Annual Compliance[4]	41.3%	47.4%	43.5%	44.1%

[1] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within 0 °F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	Percentage of Hours in Compliance with 3°F Temp. Differential Scenario			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	0.0%	N/A[1]	N/A[1]	0.0%
April	15.2%	22.9%	46.7%	27.3%
May	50.0%	66.9%	94.7%	70.0%
June	94.9%	97.6%	98.9%	97.2%
July	64.2%	91.6%	100.0%	85.5%
August	30.0%	96.6%	96.8%	74.5%
September	4.6%	83.5%	94.4%	61.0%
October	33.4%	35.9%	73.7%	47.7%
November	46.6%	33.0%	43.7%	39.1%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Comliance[3]	41.1%	71.3%	84.9%	65.6%
Annual Compliance[4]	64.2%	83.1%	90.9%	79.3%

[1] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within 3 °F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	Percentage of Hours in Compliance with 5°F Temp. Differential Scenario			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	100.0%	N/A[1]	N/A[1]	100.0%
April	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%
July	98.1%	100.0%	100.0%	99.4%
August	90.7%	100.0%	99.7%	96.8%
September	41.0%	100.0%	100.0%	80.4%
October	61.8%	100.0%	100.0%	87.2%
November	72.5%	100.0%	100.0%	96.2%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Comliance[3]	84.5%	100.0%	100.0%	94.7%
Annual Compliance[4]	90.6%	100.0%	100.0%	96.8%

[1] *N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within 5 °F temperature differential scenario*

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	Percentage of Hours in Compliance with 7°F Temp. Differential Scenario			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	100.0%	N/A[1]	N/A[1]	100.0%
April	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%
September	86.6%	100.0%	100.0%	95.5%
October	83.2%	100.0%	100.0%	94.4%
November	100.0%	100.0%	100.0%	100.0%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Comliance[3]	95.9%	100.0%	100.0%	98.6%
Annual Compliance[4]	97.5%	100.0%	100.0%	99.2%

[1] *N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within 7 °F temperature differential scenario*

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	Percentage of Hours in Compliance with 9°F Temp. Differential Scenario			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	100.0%	N/A[1]	N/A[1]	100.0%
April	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%
September	95.5%	100.0%	100.0%	98.5%
October	97.6%	100.0%	100.0%	99.2%
November	100.0%	100.0%	100.0%	100.0%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Comliance[3]	99.1%	100.0%	100.0%	99.7%
Annual Compliance[4]	99.4%	100.0%	100.0%	99.8%

[1] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within 9 °F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	Percentage of Hours in Compliance with 11°F Temp. Differential Scenario			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	100.0%	N/A[1]	N/A[1]	100.0%
April	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%
September	100.0%	100.0%	100.0%	100.0%
October	98.6%	100.0%	100.0%	99.5%
November	100.0%	100.0%	100.0%	100.0%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Comliance[3]	99.8%	100.0%	100.0%	99.9%
Annual Compliance[4]	99.9%	100.0%	100.0%	100.0%

[1] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[2] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[3] Annual compliance calculated assuming all N/A values are within 11 °F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power
(Coincident Daily Measured River Flow Rate Condition)

Month	Percentage of Hours in Compliance with 13°F Temp. Differential Scenario			
	2002	*2003*	*2004*	*Average*
January	N/A[1]	N/A[1]	N/A[1]	N/A[1]
February	N/A[1]	N/A[1]	N/A[1]	N/A[1]
March	100.0%	N/A[1]	N/A[1]	100.0%
April	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%
September	100.0%	100.0%	100.0%	100.0%
October	100.0%	100.0%	100.0%	100.0%
November	100.0%	100.0%	100.0%	100.0%
December	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Measured Comliance[3]	100.0%	100.0%	100.0%	100.0%
Annual Compliance[4]	100.0%	100.0%	100.0%	100.0%

[1] *N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

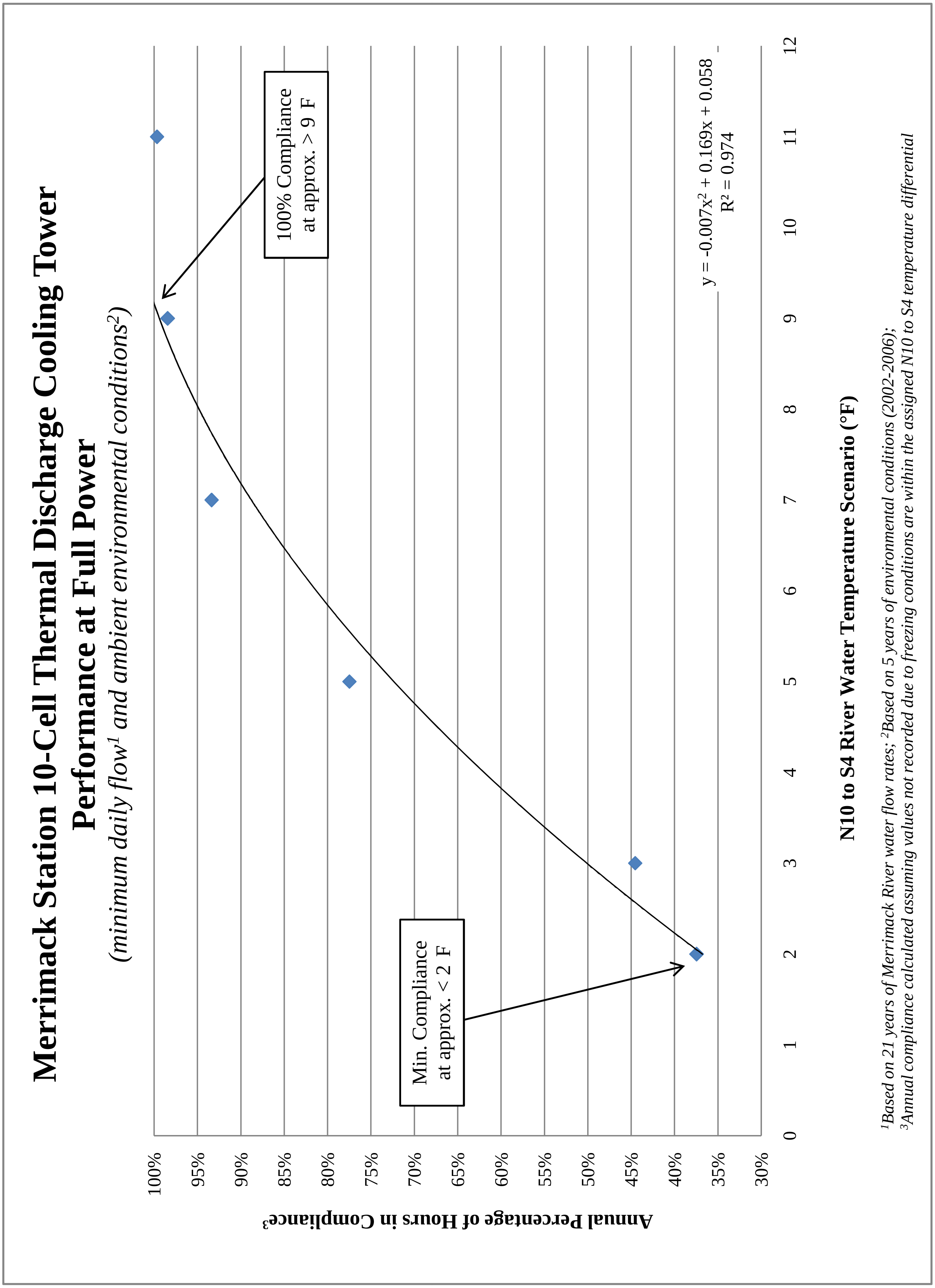
[2] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[3] *Annual compliance calculated assuming all N/A values are within 13 °F temperature differential scenario*

Attachment 3

Section 7: 10-Cell Thermal Discharge Cooling Tower Performance at Minimum Flow

Section 7 provides both the graphical representation of the 10-cell thermal discharge cooling tower performance at minimum river flow conditions and the tabulated monthly values which provide the basis for the graphical representation. Performance of the 10-cell thermal discharge cooling tower at minimum river flow rate conditions is calculated via a thermal discharge analysis which defines the S4 river water temperature as a function of the Station electrical output, N10 river water temperature, dry bulb temperature, wet bulb temperature, and river water flow rate. Furthermore, minimum river water flow rate is defined daily as the minimum average daily flow rate occurring over the 21 years of river water flow rates provided (1984-2004). The analysis is restricted by the five years of meteorological data obtained (2002-2006) coincident with the provided N10 river water temperatures, and is limited primarily by the unavailability of Merrimack River data during freezing conditions on the river. Both the percentage of measured 5°F N10-S4 temperature differential attainment (i.e., the hours in attainment divided by the number of hours with recorded data) and the percentage of annual 5°F N10-S4 temperature differential attainment (i.e., the summation of the hours in attainment and the unrecorded hours due to freezing conditions divided by the total number of hours with recorded data) are provided within the basis tables, however, only the percentage of annual 5°F N10-S4 temperature differential attainment has been charted on the summary figure.


Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance at Full Power
(minimum daily flow[1] and ambient environmental conditions[2])
100% Compliance at approx. > 9 F
Min. Compliance at approx. < 2 F
y = -0.007x² + 0.169x + 0.058
R² = 0.974
Annual Percentage of Hours in Compliance[3]
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
0
1
2
3
4
5
6
7
8
9
10
11
12
N10 to S4 River Water Temperature Scenario (°F)
[1]Based on 21 years of Merrimack River water flow rates; [2]Based on 5 years of environmental conditions (2002-2006);
[3]Annual compliance calculated assuming values not recorded due to freezing conditions are within the assigned N10 to S4 temperature differential

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 1°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	0.0%	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%
April	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
May	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
June	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
November	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
December	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%	0.0%
Measured Compliance[3]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Annual Compliance[4]	39.1%	41.1%	39.4%	34.6%	28.8%	36.6%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 1°F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 2°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	0.0%	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%
April	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
May	0.0%	0.0%	2.2%	0.0%	0.0%	0.4%
June	0.6%	2.7%	11.3%	0.1%	0.1%	3.0%
July	2.6%	7.5%	0.0%	2.7%	2.2%	3.0%
August	5.2%	1.5%	2.4%	6.2%	5.0%	4.1%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
November	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
December	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%	0.0%
Measured Compliance[3]	1.2%	1.7%	2.2%	1.2%	0.9%	1.4%
Annual Compliance[4]	39.8%	42.1%	40.7%	35.3%	29.4%	37.5%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 2°F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 3°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	0.0%	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%
April	0.7%	0.0%	4.8%	6.1%	15.7%	6.2%
May	12.5%	19.8%	50.8%	14.8%	21.0%	23.4%
June	26.5%	44.6%	54.7%	34.2%	30.8%	38.2%
July	14.7%	33.2%	6.6%	10.1%	5.7%	14.0%
August	18.1%	7.1%	7.3%	23.5%	15.2%	14.3%
September	0.8%	1.3%	1.1%	0.4%	1.1%	0.9%
October	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
November	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
December	N/A[2]	N/A[2]	N/A[2]	0.0%	0.0%	0.0%
Measured Compliance[3]	10.1%	14.9%	16.7%	11.2%	10.5%	12.6%
Annual Compliance[4]	45.2%	49.9%	49.5%	41.9%	36.3%	44.5%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 3°F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 5°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	80.9%	91.5%	95.8%	79.5%	75.8%	84.7%
July	57.8%	87.5%	61.6%	70.6%	46.0%	64.7%
August	65.5%	35.1%	43.8%	61.3%	52.8%	51.7%
September	22.7%	20.3%	22.5%	27.2%	26.8%	23.9%
October	34.3%	23.9%	31.6%	35.5%	32.4%	31.5%
November	55.7%	62.0%	77.1%	60.4%	61.3%	63.3%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	93.1%	93.4%
Measured Compliance[3]	66.2%	61.9%	64.1%	66.4%	63.8%	64.5%
Annual Compliance[4]	79.4%	77.6%	78.2%	78.0%	74.2%	77.5%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 5°F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 7°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	96.1%	98.0%	98.5%	96.6%	95.7%	97.0%
July	89.9%	100.0%	94.8%	98.9%	95.6%	95.9%
August	91.5%	75.6%	89.1%	92.6%	91.1%	88.0%
September	67.1%	57.5%	67.9%	70.5%	66.9%	66.0%
October	70.3%	70.9%	80.9%	71.5%	80.0%	74.8%
November	100.0%	98.9%	100.0%	99.6%	97.6%	99.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	88.3%	85.8%	90.4%	91.2%	91.4%	89.6%
Annual Compliance[4]	92.9%	91.7%	94.2%	94.2%	93.9%	93.4%

[1] *River flow rate conditions based on 21 years of recorded daily averages (1984-2004)*

[2] *N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

[3] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[4] *Annual compliance calculated assuming all N/A values are within 7°F temperature differential scenario*

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 9°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	96.6%	99.0%	100.0%	98.0%	96.7%	98.1%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	98.5%	86.3%	97.4%	99.3%	97.4%	95.8%
September	89.1%	89.6%	94.3%	93.9%	87.1%	90.8%
October	96.5%	96.0%	99.6%	96.4%	95.0%	96.7%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	97.4%	95.8%	98.8%	98.5%	97.2%	97.5%
Annual Compliance[4]	98.4%	97.5%	99.3%	99.0%	98.0%	98.4%

[1] *River flow rate conditions based on 21 years of recorded daily averages (1984-2004)*

[2] *N/A values indicates times when Merrimack River data was not recorded due to freezing conditions*

[3] *Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data*

[4] *Annual compliance calculated assuming all N/A values are within 9°F temperature differential scenario*

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 11°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	97.9%	99.9%	100.0%	99.3%	97.8%	99.0%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	100.0%	96.4%	100.0%	100.0%	99.9%	99.2%
September	95.5%	98.5%	98.7%	99.3%	99.3%	98.3%
October	98.6%	100.0%	100.0%	100.0%	99.9%	99.7%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	98.9%	99.2%	99.8%	99.8%	99.6%	99.5%
Annual Compliance[4]	99.3%	99.5%	99.9%	99.9%	99.7%	99.7%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 11°F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 13°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
September	99.7%	100.0%	100.0%	100.0%	100.0%	99.9%
October	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Annual Compliance[4]	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 13°F temperature differential scenario

Merrimack Station 10-Cell Thermal Discharge Cooling Tower Performance
Units 1 & 2 - Full Power

(Historical Daily Minimum Measured River Flow Rate Condition[1])

Month	Percentage of Hours in Compliance with 15°F Temp. Differential Scenario					
	2002	*2003*	*2004*	*2005*	*2006*	*Average*
January	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
February	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
March	100.0%	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%
April	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
June	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
September	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
October	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
November	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
December	N/A[2]	N/A[2]	N/A[2]	100.0%	100.0%	100.0%
Measured Compliance[3]	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Annual Compliance[4]	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[1] River flow rate conditions based on 21 years of recorded daily averages (1984-2004)

[2] N/A values indicates times when Merrimack River data was not recorded due to freezing conditions

[3] Measured compliance calculated by dividing the average hours within compliance by the number of hours with recorded data

[4] Annual compliance calculated assuming all N/A values are within 15 °F temperature differential scenario

Attachment 4

Capital Costs Assessments

Section 1: Conversion to Closed Loop Cooling (Both Units)

Section 2: Conversion to Closed Loop Cooling (Unit 1 Only)

Section 3: Conversion to Closed Loop Cooling (Unit 2 Only)

Section 4: Cooling Towers to Reduce Discharge Temperatures

Section 5: Coarse Mesh Screening Technologies and Fish Return

Section 6: Fish Return System Stand-alone

Section 7: Variable Speed Pumps

Section 8: Acoustic Fish Deterrence System

Cost Multipliers

Each cost estimate in this table will have two cost multipliers:

- Recommended Minimum Contingency (25%)
- Corporate Overheads and Work In Progress Cost (AFUDC) (12%)

The current stage of development of the various conceptual designs provides a sound basis for estimating the associated overall design, procurement, and construction costs. Estimated design costs were scaled based on actual design costs taken from previous, similar applications, procurement costs were based on vendor budgetary estimates whenever available, and construction costs were derived utilizing established construction cost estimating tools. However, none of this captures the full scope of work, as would be possible if the final detailed design were completed, all associated bill of materials developed, and vendor quotes obtained for all materials. For this reason, a Recommended Minimum Contingency of 25% was added to all cost estimates.

Additionally, PSNH routinely applies a cost multiplier of 12% to all major capital projects; this multiplier captures both corporate overhead and the cost of carrying the associated funding, i.e., a Corporate Overheads and Work In Progress Cost.

The following summarizes the construction cost estimate in 2007 dollars for conversion of both units to closed loop cooling.

Work Scope	Estimated Cost
Design Engineering	$1,300,000
Mobilization/Setup	$156,700
General Site Modifications Clearing and Grubbing Storm Drainage Other Site Preparation	$237,000
Construction to be Performed While Units Online	
Cooling Tower Install Concrete Basin Delivery & Erection by SPX Automated Control System w/ RTD Array	 $2,171,600 $16,332,500 $75,000 $25,000
New Cooling Water Discharge and Supply Piping	$5,749,100
Electrical Substation for Cooling Tower / Pump House & Feeds to Each Electrical On-Tower	 $1,092,700 $1,043,300
Intake Pumping Station Modifications	$972,600
Booster Pumping Station Pump House Pumps Chemical Injection Station	$4,183,800
Admin, Support Craft and Misc.	$6,172,600
Construction to be Performed While Units Offline	
Booster Pumping Station Valves and Tie-ins	$295,100
Intake Pumping Station Modifications Unit 1 Tie-in to Screenwell Unit 2 Tie-in to Screenwell	$648,400
Electrical Tie-ins at Switchyard	$188,700
Condenser Tube Cleaning System Unit 1 Unit 2	 $300,000 $400,000
Testing and Commissioning	$132,200
Admin, Support Craft, and Misc	$404,500
Units Back Online	
Demobilization	$163,900
Total Preliminary Construction Estimate	$42,044,700
Payment and Performance Bond	$252,300
Recommended Minimum Contingency (25%)	$10,574,300
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$6,344,600
Recommended Engineering and Construction Budget	**$59,215,900**

The following summarizes the construction cost estimate in 2007 dollars for conversion to closed loop cooling for Unit 1 only. Estimate is based on a % of two-unit conversion cost for each item, with the associated multiplier noted in parenthesis (0.xx).

Work Scope	Estimated Cost
Design Engineering (0.40)	$520,000
Mobilization/Setup (0.35)	$54,800
General Site Modifications (0.35) Clearing and Grubbing Storm Drainage Other Site Preparation	$83,000
Construction to be Performed While Units Online	
Cooling Tower (0.35)	
Install Concrete Basin	$760,000
Delivery & Erection by SPX	$5,716,400
Automated Control System	$50,000
w/ RTD Array	$15,000
New Cooling Water Discharge and Supply Piping (0.40)	$2,229,600
Electrical (0.35)	
Substation for Cooling Tower / Pump House & Feeds to Each	$382,400
Electrical On-Tower	$365,200
Intake Pumping Station Modifications (0.50)	$486,300
Booster Pumping Station (0.40) Pump House Pumps Chemical Injection Station	$1,673,500
Admin, Support Craft and Misc. (0.40)	$2,469,000
Construction to be Performed While Units Offline	
Booster Pumping Station (0.40) Valves and Tie-ins	$118,000
Intake Pumping Station Modifications (0.45) Unit 1 Tie-in to Screenwell	$291,800
Electrical Tie-ins at Switchyard (0.65)	$122,700
Condenser Tube Cleaning System Unit 1	$300,000
Testing and Commissioning (0.45)	$59,500
Admin, Support Craft, and Misc (0.40)	$161,800
Units Back Online	
Demobilization (0.35)	$57,400
Total Preliminary Construction Estimate	$15,916,400
Payment and Performance Bond	$95,500
Recommended Minimum Contingency (25%)	$4,003,000
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$2,401,800
Recommended Engineering and Construction Budget	**$22,416,700**

The following summarizes the construction cost estimate in 2007 dollars for conversion to closed loop cooling for Unit 2 only. Estimate is based on a % of two-unit conversion cost for each item, with the associated multiplier noted in parenthesis (0.xx).

Work Scope	**Estimated Cost**
Design Engineering (0.60)	$780,000
Mobilization/Setup (0.75)	$117,500
General Site Modifications (0.75) Clearing and Grubbing Storm Drainage Other Site Preparation	$177,800
Construction to be Performed While Units Online	
Cooling Tower (0.75)	
Install Concrete Basin	$1,628,700
Delivery & Erection by SPX	$12,249,400
Automated Control System	$70,000
w/ RTD Array	$20,000
New Cooling Water Discharge and Supply Piping (0.75)	$4,024,400
Electrical (0.75)	
Substation for Cooling Tower / Pump House & Feeds to Each	$819,500
Electrical On-Tower	$782,500
Intake Pumping Station Modifications (0.60)	$583,600
Booster Pumping Station (0.70) Pump House Pumps Chemical Injection Station	$2,928,700
Admin, Support Craft and Misc. (0.75)	$4,320,800
Construction to be Performed While Units Offline	
Booster Pumping Station (0.70) Valves and Tie-ins	$206,600
Intake Pumping Station Modifications (0.60) Unit 2 Tie-in to Screenwell	$389,000
Electrical Tie-ins at Switchyard (0.65)	$122,700
Condenser Tube Cleaning System Unit 2	$400,000
Testing and Commissioning (0.75)	$99,200
Admin, Support Craft, and Misc (0.75)	$303,400
Units Back Online	
Demobilization (0.75)	$122,900
Total Preliminary Construction Estimate	$30,146,700
Payment and Performance Bond	$180,900
Recommended Minimum Contingency (25%)	$7,581,900
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$4,549,100
Recommended Engineering and Construction Budget	**$42,458,600**

The following summarizes the construction cost estimate in 2007 dollars for the construction of cooling towers for the purpose of reducing discharge temperatures (no return to CWIS).

Work Scope	**Estimated Cost**
Design Engineering	$390,000
Mobilization/Setup	$58,800
General Site Modifications Clearing and Grubbing Storm Drainage Other Site Preparation	$88,900
Construction to be Performed While Units Online	
Cooling Tower	
Install Concrete Basin	$1,628,700
Delivery & Erection by SPX	$11,700,000
Automated Control System	$70,000
w/ RTD Array	$20,000
New Cooling Water Discharge and Supply Piping	$1,437,300
Electrical (0.75)	
Substation for Cooling Tower / Pump House & Feeds to Each	$819,500
Electrical On-Tower	$782,500
Booster Pumping Station Pump House Pumps Chemical Injection Station	$2,928,700
Admin, Support Craft and Misc.	$2,160,400
Construction to be Performed While Units Offline	
Booster Pumping Station Valves and Tie-ins	$206,600
Electrical Tie-ins at Switchyard	$122,700
Testing and Commissioning	$74,400
Admin, Support Craft, and Misc	$151,700
Units Back Online	
Demobilization	$61,500
Total Preliminary Construction Estimate	$22,701,700
Payment and Performance Bond	$136,200
Recommended Minimum Contingency (25%)	$5,709,500
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$3,425,700
Recommended Engineering and Construction Budget	**$31,973,100**

The following summarizes the construction cost estimate in 2007 dollars for the replacement of existing traveling screens with coarse mesh Ristroph thru-flow traveling screens with fish return.

Coarse Mesh Ristroph Thru-Flow Traveling Screens	Estimated Cost
Demolition and Disposal of Existing Screens (Both Units)	$24,000
Demolition and Disposal of Existing Trash Sluice	$15,000
Traveling Screens	
Unit 1	$326,000
Unit 2	$381,000
Installation (assuming no structural modifications required)	$30,000
Fish Return (design and construction)	$170,000
Field Service Testing and Commissioning,	$28,000
Recommended Minimum Contingency (25%)	$239,800
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$143,900
Recommended Engineering and Construction Budget	**$1,342,700**

The following summarizes the construction cost estimate in 2007 dollars for the replacement of existing traveling screens with coarse mesh MultiDisc® type screens with fish return.

Coarse Mesh MultiDisc® Type Screens	Estimated Cost
Demolition and Disposal of Existing Screens (Both Units)	$24,000
Demolition and Disposal of Existing Trash Sluice	$15,000
Traveling Screens	
Unit 1	$568,000
Unit 2	$677,000
Freight	$110,000
Installation (assuming no structural modifications required)	$30,000
Fish Return (design and construction)	$170,000
Field Service Testing and Commissioning,	$28,000
Recommended Minimum Contingency (25%)	$405,500
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$243,300
Recommended Engineering and Construction Budget	**$2,270,800**

The following summarizes the construction cost estimate in 2007 dollars for the replacement of existing traveling screens with coarse mesh "WIP" type screens with fish return.

Coarse Mesh "WIP" Type Screens	**Estimated Cost**
Demolition and Disposal of Existing Screens (Both Units)	$24,000
Demolition and Disposal of Existing Trash Sluice	$15,000
Traveling Screens	
Unit 1 Screens	$488,200
Unit 1 Fish Pumps	$67,000
Unit 2 Screens	$532,000
Unit 2 Fish Pumps	$121,000
Installation (assuming no structural modifications required)	$30,000
Fish Return (design and construction)	$170,000
Field Service Testing and Commissioning,	$28,000
Recommended Minimum Contingency (25%)	$368,800
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$221,300
Recommended Engineering and Construction Budget	**$2,065,300**

The following summarizes the construction cost estimate in 2007 dollars for the replacement of existing traveling screens with coarse mesh Ristroph type dual-flow traveling screens.

Coarse Mesh Ristroph Dual-Flow Traveling Screens	**Estimated Cost**
Dismantling of Existing Screens (Both Units)	$24,000
Demolition and Disposal of Existing Trash Sluice	$15,000
Traveling Screens	
Unit 1	$721,000
Unit 2	$821,000
Freight	$30,000
Installation (major modifications to existing CWISs or new CWISs constructed)	See discussion below
Fish Return (design and construction)	$170,000
Testing and Commissioning	$28,000
Recommended Minimum Contingency (25%)	N/A; see discussion below
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	N/A; see discussion below
Recommended Engineering and Construction Budget	

The existing penetrations in the CWIS deck for the traveling screens are not of adequate size to accommodate dual-flow traveling screens. Dual-flow traveling screens are physically larger than the existing units because of the screen configuration. New CWISs or extensive modifications to the existing CWISs would have to be designed for dual-flow traveling screens to be implemented. This cost is estimated to be many times the cost of the traveling screens themselves and therefore this technology is deemed unfeasible for the Merrimack application.

The following summarizes the construction cost estimate in 2007 dollars for the design and construction of a fish return system without other major additions or modifications.

Fish Return System Standalone	**Estimated Cost**
Demolition and Disposal of Existing Trash Sluice	$15,000
Fish Return Sluices (estimated at 500 feet for $340 per foot)	$170,000
Integrate into existing traveling screens for both units (low pressure spray and other changes and enhancements that will reduce fish mortality)	$40,000
Recommended Minimum Contingency (25%)	$56,300
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$33,800
Recommended Engineering and Construction Budget	**$315,100**

The following summarizes the construction cost estimate in 2007 dollars for the replacement of existing circulating water pump motors and installation of variable frequency drives.

New Circulating Water Pump Motors and VFDs	**Estimated Cost**
Existing Motors Removal	$19,000
Mechanical and Electrical Modifications to Support VFDs	$50,000
Variable Frequency Drives	
Unit 1	$49,900
Unit 2	$110,600
Pump Motors	
Unit 1	$267,800
Unit 2	$390,700
Freight	$30,000
Installation	$25,000
Testing and Commissioning	$15,000
Recommended Minimum Contingency (25%)	$239,500
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$143,700
Recommended Engineering and Construction Budget	**$1,341,300**

The following summarizes the construction cost estimate in 2007 dollars for the replacement of existing circulating water pump motors with two-speed motors.

New 2-Speed Circulating Water Pump Motors	**Estimated Cost**
Existing Motors Removal	$19,000
Pump Motors (70% premium over variable speed motors)	
Unit 1	$382,600
Unit 2	$558,200
Freight	$30,000
Installation	$25,000
Testing and Commissioning	$15,000
Recommended Minimum Contingency (25%)	$257,500
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$154,500
Recommended Engineering and Construction Budget	**$1,441,800**

The following summarizes the construction cost estimate in 2007 dollars for installation of an acoustic fish deterrence system.

Acoustic Fish Deterrence System	**Estimated Cost**
Equipment Cost	$800,000
Installation	$150,000
Recommended Minimum Contingency (25%)	$237,500
Corporate Overheads and Work In Progress Cost (AFUDC) (12%)	$142,500
Recommended Engineering and Construction Budget	**$1,330,000**

Attachment 5

Figures

Figure A - Hooksett Pool Topographic

Figure B – Unit 1 Cooling Water Intake Structure

Figure C – Unit 2 Cooling Water Intake Structure

Figure D – Cooling Water Process Flow Diagram

Figure E – Discharge Canal Drawing MK2-S-1023.2

Figure F – Scrubber Drawings M-GA-001 Sheets 1 & 2

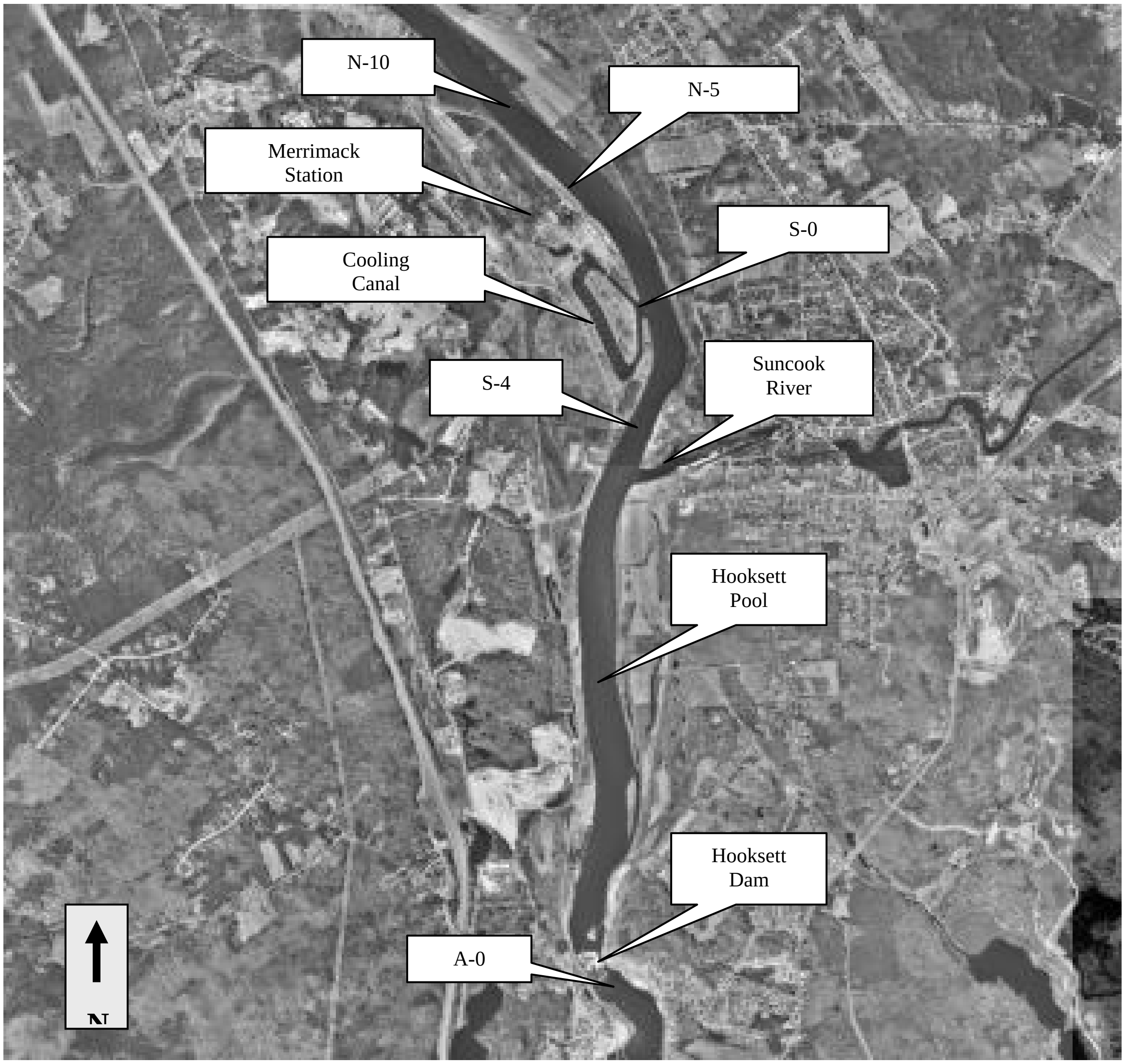
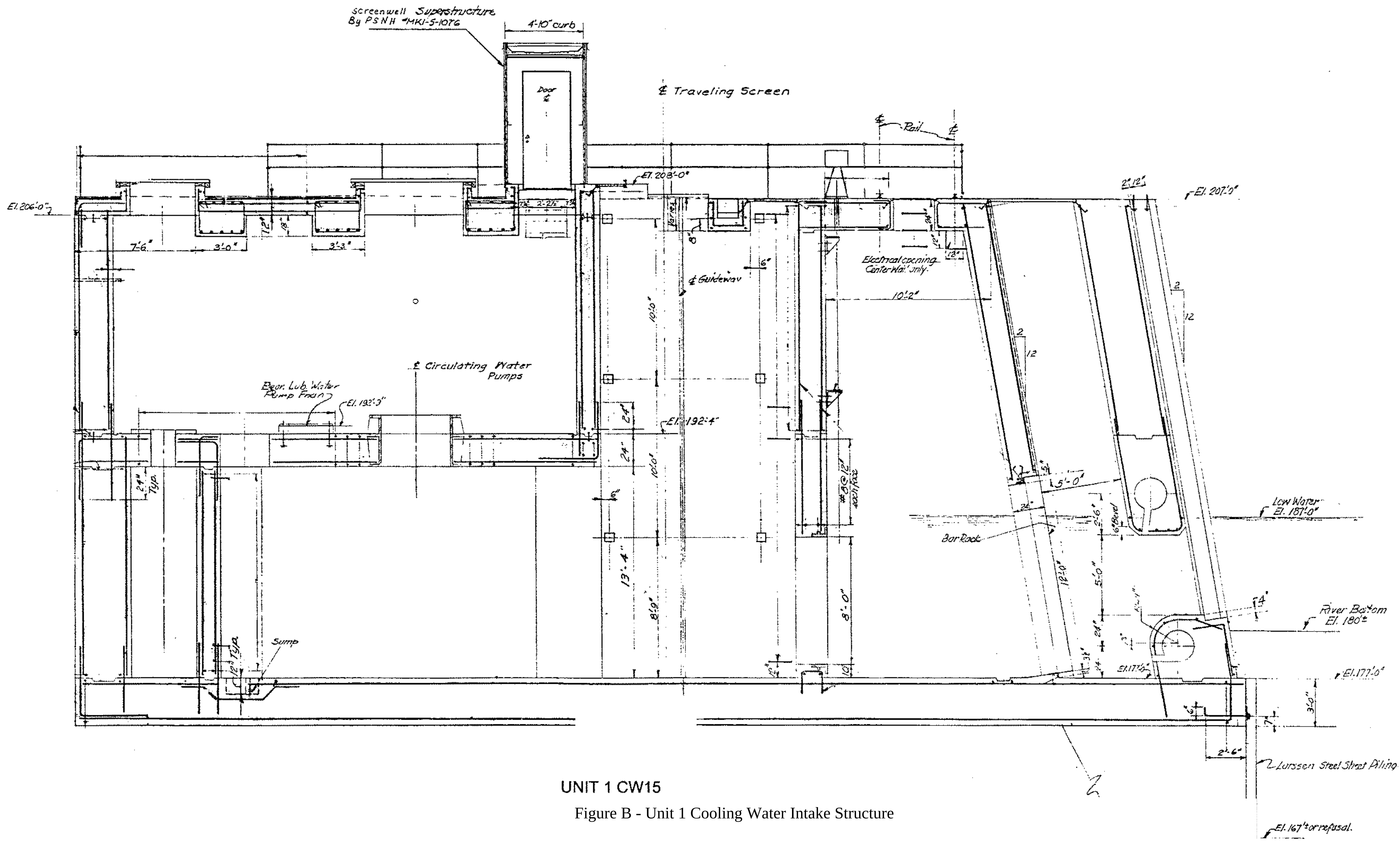


Figure A. Merrimack River Temperature Monitoring Station Locations in the Vicinity of Merrimack Station in Bow, New Hampshire [2].



UNIT 1 CW15

Figure B - Unit 1 Cooling Water Intake Structure

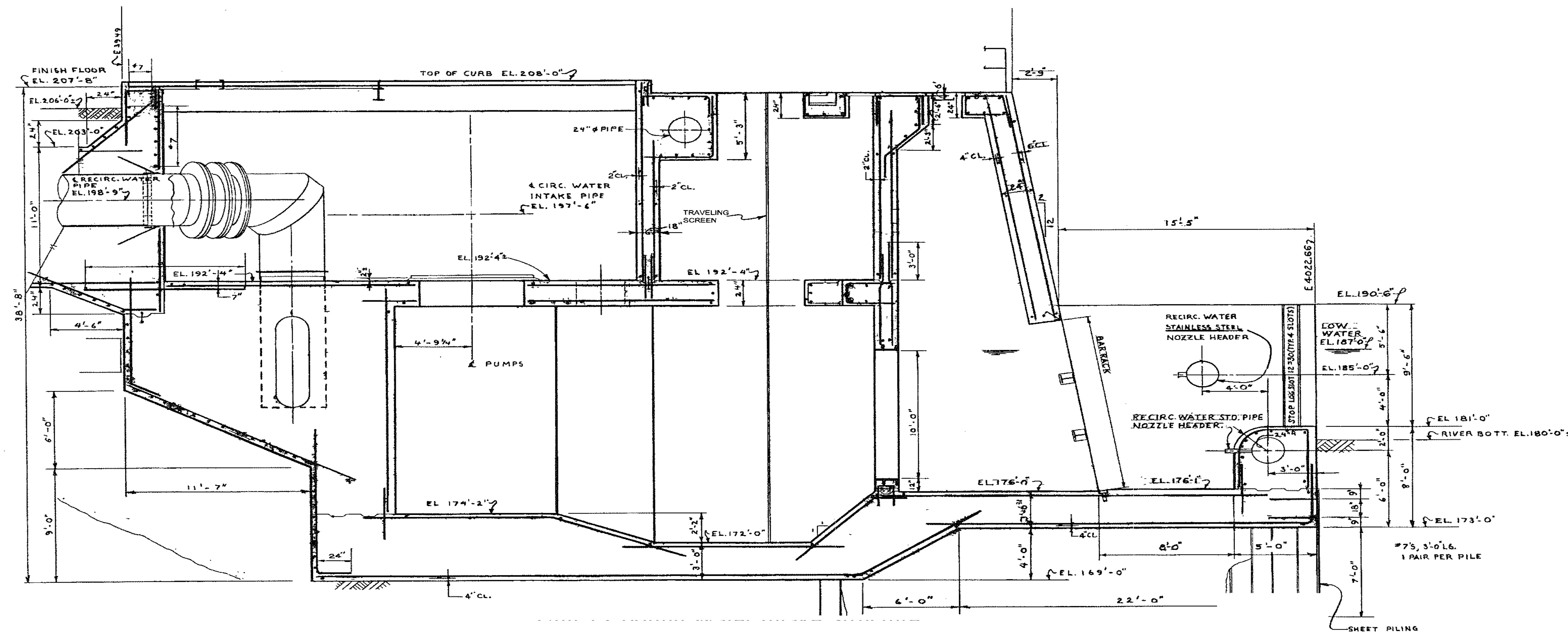


Figure C – Unit 2 Cooling Water Intake Structure

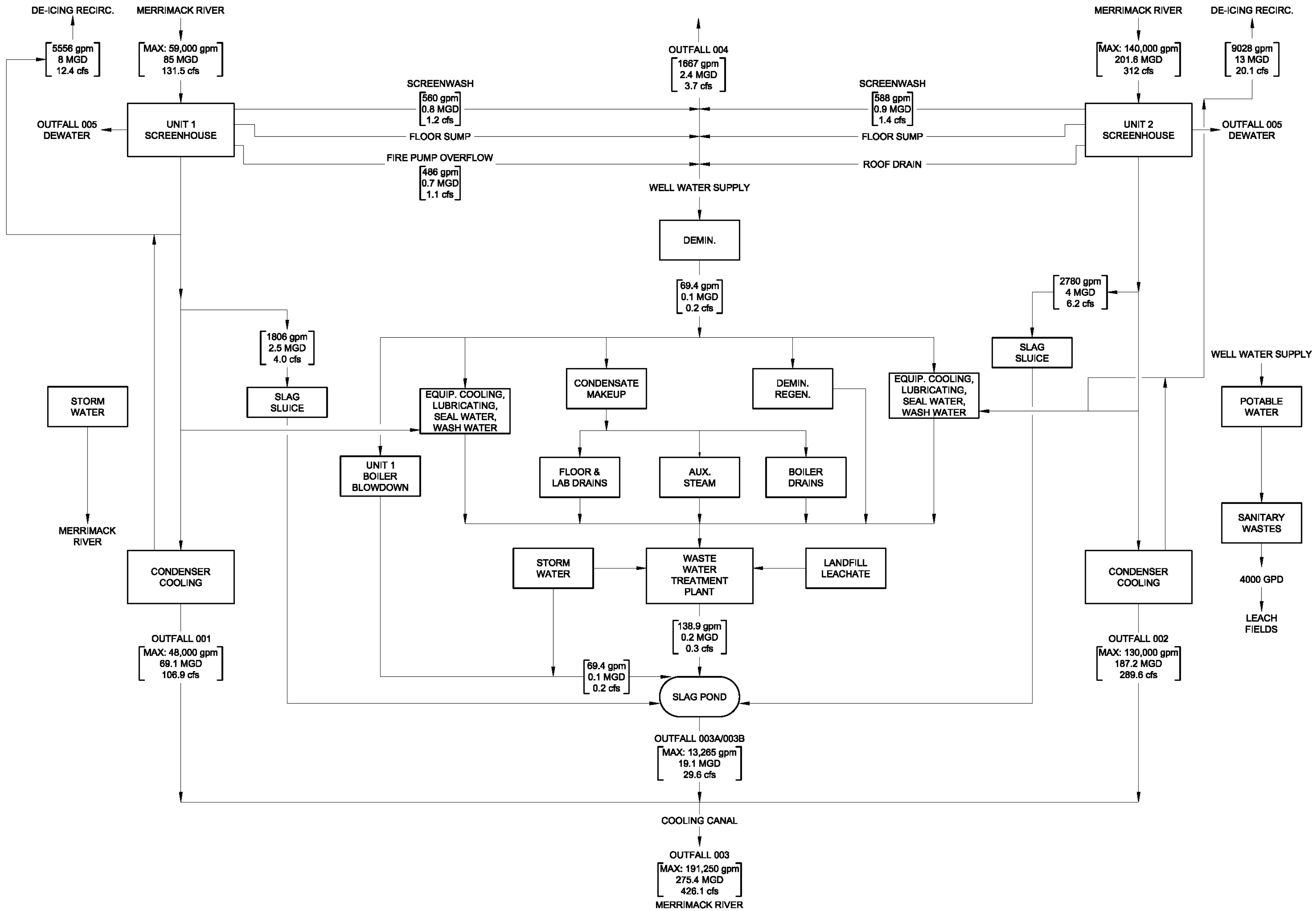
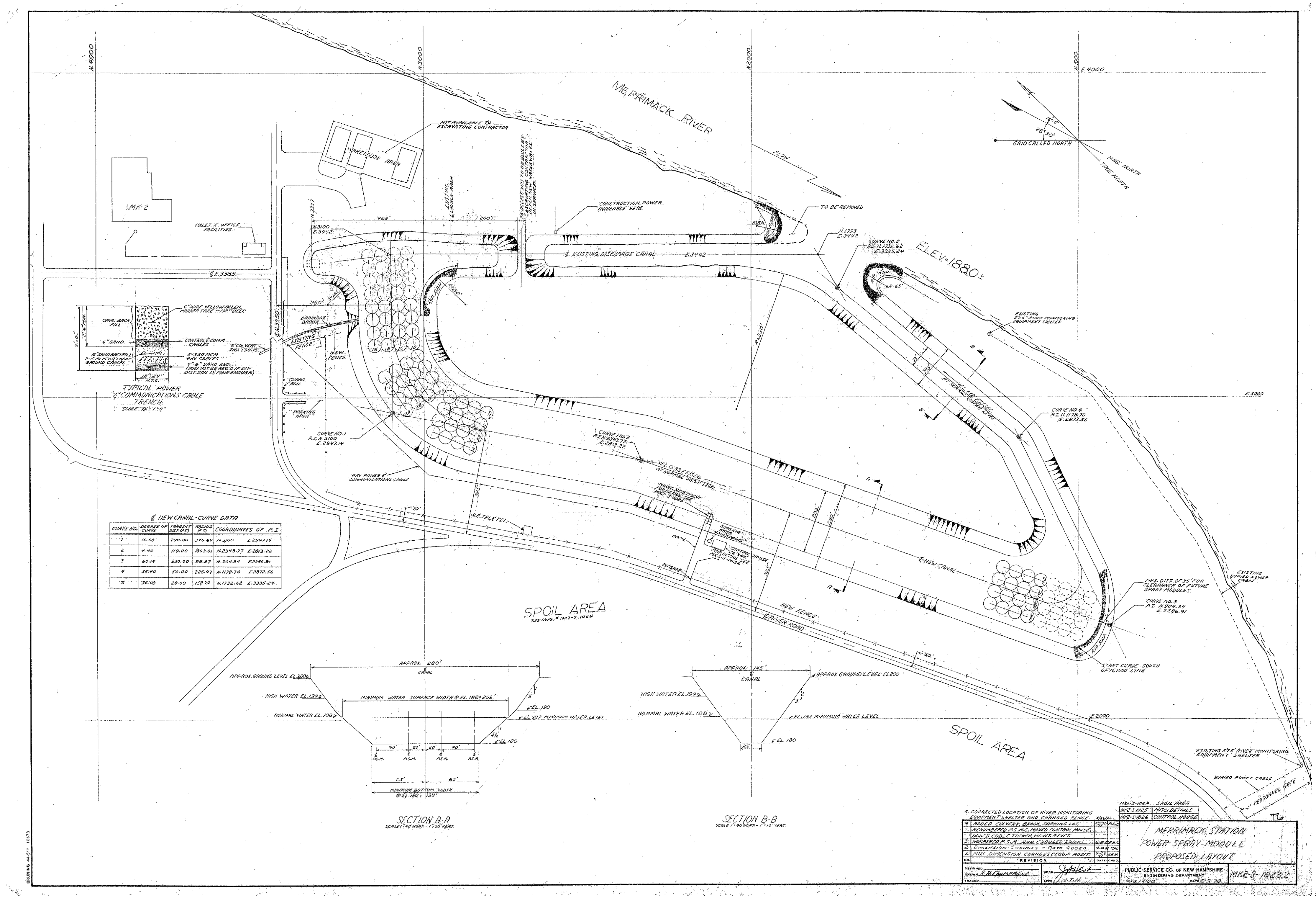


FIGURE D - COOLING WATER PROCESS FLOW DIAGRAM

Figure E - Discharge Canal Drawing MK2-S-1023.2



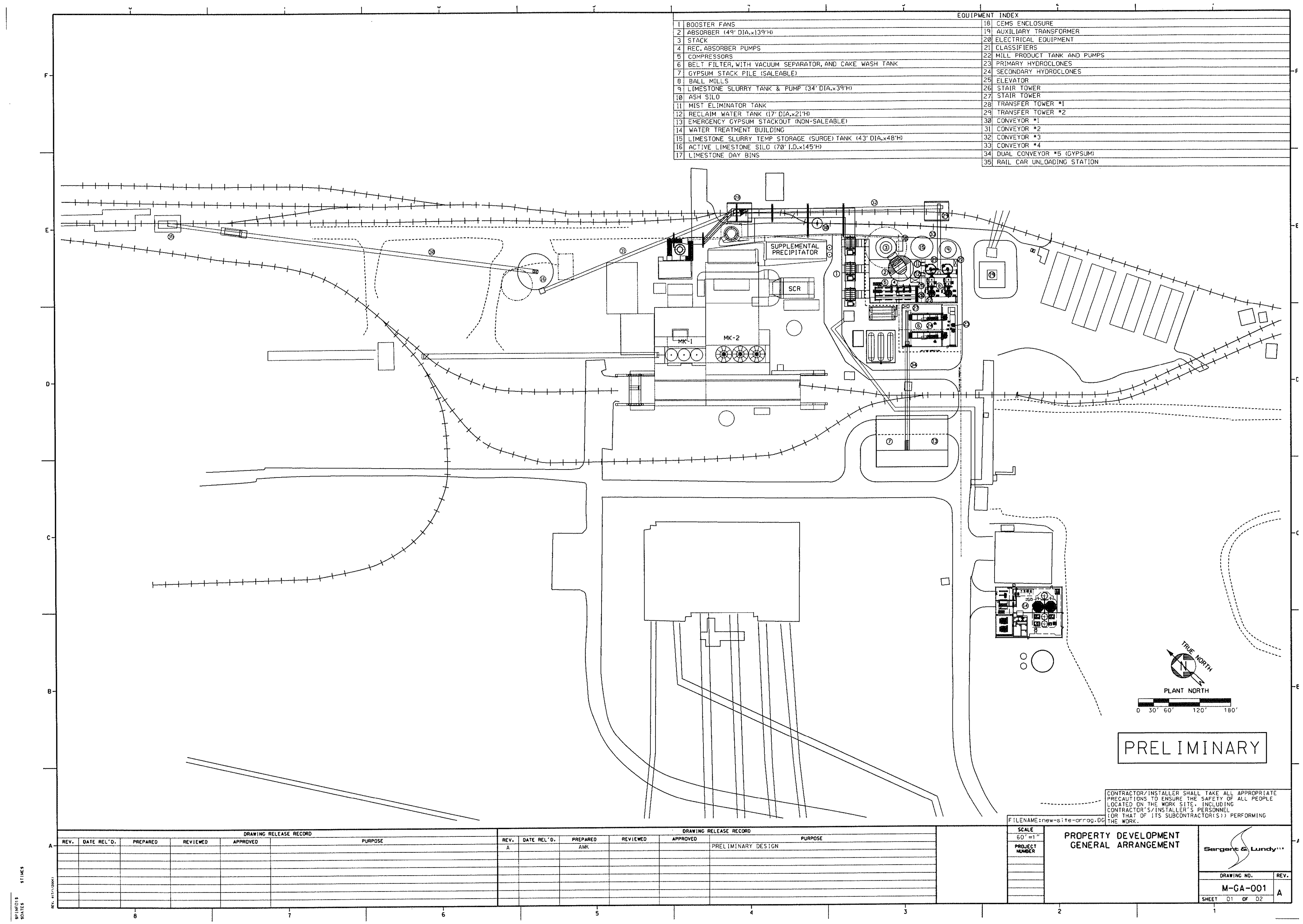


Figure F - Scrubber Drawings M-GA-001 Sheet 1

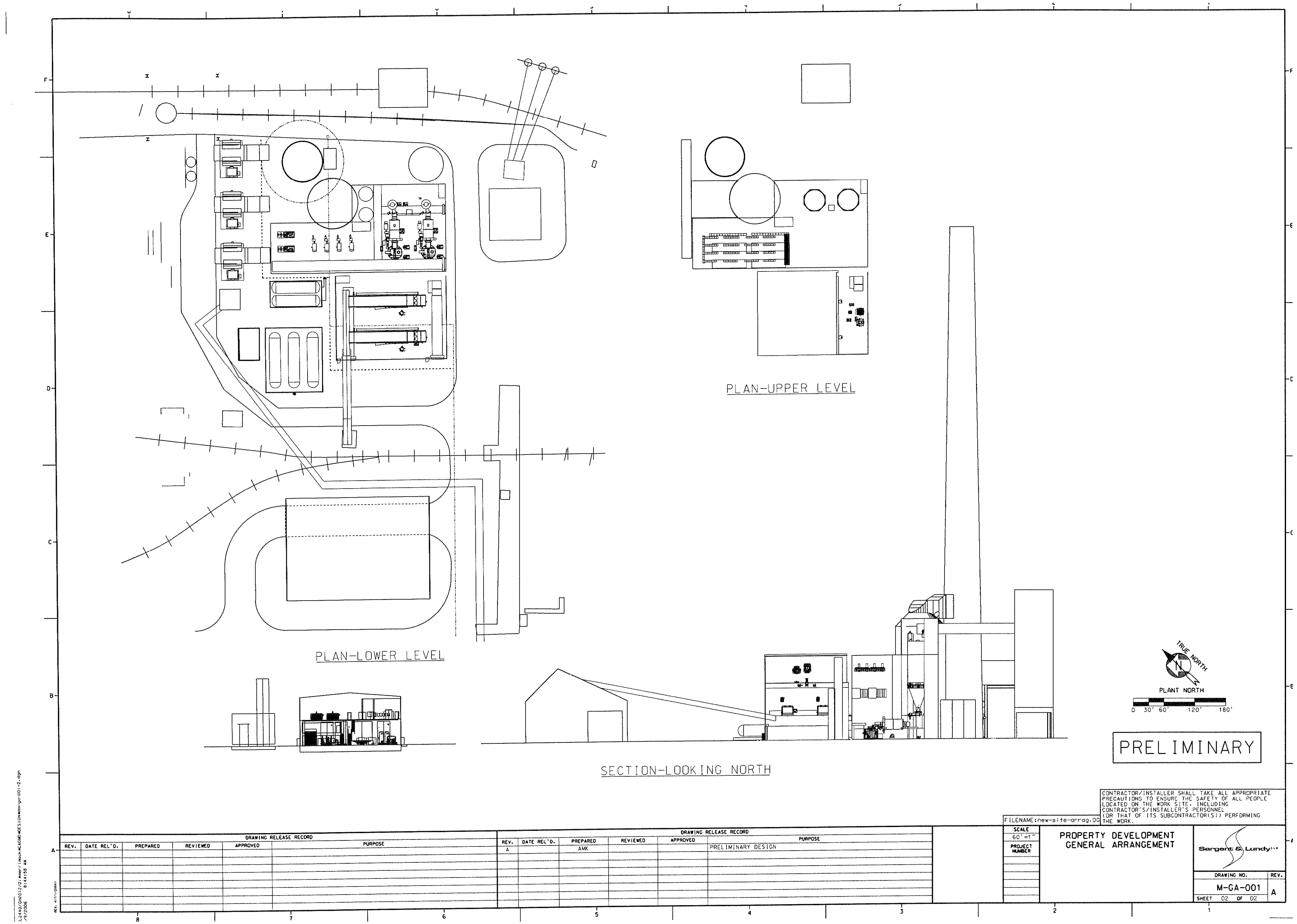


Figure F - Scrubber Drawings M-GA-001 Sheet 2

Attachment 6

Normandeau Biological Assessment Tables

Table 2-1. Merrimack Station Fish Entrainment Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Design Intake Flows[3] by Month, Unit and Year (May 2006 through June 2007).

	Unit 1						Monthly %		Unit 2								Both Units Combined						Monthly %	
	May - Sep 2006		Apr - Jun 2007		Average Year				May - Sep 2006		Apr - Jun 2007		Average Year		Monthly %		May - Sep 2006		Apr - Jun 2007		Average Year			
Month	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Apr	NS[4]	NS	0	0	0	0	0.0%	0.0%	NS	NS	132,851	666	132,851	666	7.4%	6.7%	NS	NS	132,851	666	132,851	666	3.8%	3.9%
May	0	0	683,907	1,289	341,954	645	20.4%	9.2%	800,515	4,847	132,019	724	466,267	2,786	26.1%	28.2%	800,515	4,847	815,926	2,013	808,221	3,430	23.3%	20.3%
Jun	519,081	2,536	1,331,392	7,521	925,237	5,029	55.1%	71.9%	1,281,629	6,200	827,604	6,106	1,054,617	6,153	59.0%	62.2%	1,800,710	8,736	2,158,996	13,627	1,979,853	11,182	57.1%	66.2%
Jul	377,049	1,225	NS	NS	377,049	1,225	22.5%	17.5%	133,273	283	NS	NS	133,273	283	7.5%	2.9%	510,322	1,508	NS	NS	510,322	1,508	14.7%	8.9%
Aug	33,563	94	NS	NS	33,563	94	2.0%	1.3%	0	0	NS	NS	0	0	0.0%	0.0%	33,563	94	NS	NS	33,563	94	1.0%	0.6%
Sep	NS0[5]	NS0	NS0	NS0	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%
Oct	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Nov	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Dec	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Jan	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Feb	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Mar	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Annual	929,693	3,855	2,015,299	8,810	1,677,802	6,992	100.0%	100.0%	2,215,417	11,330	1,092,474	7,496	1,787,008	9,888	100.0%	100.0%	3,145,110	15,185	3,107,773	16,306	3,464,810	16,880	100.0%	100.0%

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated in entrainment samples from Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual entrainment density at Unit 1 and Unit 2 combined.
[3]Design intake pump flows used to extrapolate actual entrainment per unit volume for all life stages of fish sampled up to maximum flows were 131.45 cfs for Unit 1 and 311.92 cfs for Unit 2.
[4]NS = no sampling
[5]NS0 = not sampled and assumed zero abundance

Table 2-1a. Merrimack Station Fish Entrainment Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Actual Intake Flows[3] by Month, Unit and Year (May 2006 through June 2007).

	Unit 1								Unit 2								Both Units Combined							
	May - Sep 2006		Apr - Jun 2007		Average Year		Monthly %		May - Sep 2006		Apr - Jun 2007		Average Year		Monthly %		May - Sep 2006		Apr - Jun 2007		Average Year		Monthly %	
Month	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Apr	NS[4]	NS	0	0	0	0	0.0%	0.0%	NS	NS	59,724	285	59,724	285	3.8%	3.3%	NS	NS	59,724	285	59,724	285	2.1%	2.0%
May	0	0	556,360	1,049	278,180	525	21.6%	9.7%	742,481	4,495	65,726	372	404,104	2,434	25.5%	28.0%	742,481	4,495	622,086	1,421	682,284	2,958	23.7%	21.0%
Jun	351,603	1,717	1,002,996	5,852	677,300	3,785	52.5%	70.3%	1,234,410	5,748	764,462	5,645	999,436	5,697	63.0%	65.6%	1,586,013	7,465	1,767,458	11,497	1,676,736	9,481	58.3%	67.4%
Jul	306,731	997	NS	NS	306,731	997	23.8%	18.5%	123,754	263	NS	NS	123,754	263	7.8%	3.0%	430,485	1,260	NS	NS	430,485	1,260	15.0%	9.0%
Aug	27,304	77	NS	NS	27,304	77	2.1%	1.4%	0	0	NS	NS	0	0	0.0%	0.0%	27,304	77	NS	NS	27,304	77	0.9%	0.5%
Sep	NS0[5]	NS0	NS0	NS0	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%	0	0	NS	NS	0	0	0.0%	0.0%
Oct	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Nov	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Dec	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Jan	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Feb	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Mar	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%	NS0	NS0	NS0	NS0	0	0	0.0%	0.0%
Annual	685,638	2,791	1,559,356	6,901	1,289,515	5,383	100.0%	100.0%	2,100,645	10,506	889,912	6,302	1,587,018	8,678	100.0%	100.0%	2,786,283	13,297	2,449,268	13,203	2,876,532	14,061	100.0%	100.0%

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated at Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual entrainment density at Unit 1 and Unit 2 combined.
[3]Actual monthly intake pump flows used to extrapolate actual entrainment per unit volume for all life stages of fish sampled up to monthly abundance or adult equivalents for Unit 1 and Unit 2 (May 2006 through June 2007).
[4]NS = no sampling
[5]NS0 = not sampled and assumed zero abundance

Table 2-2. Merrimack Station Fish Impingement Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Design Flows[3] by Month, Unit and Year (June 2005 through June 2007)[4].

	Unit 1								Unit 2								Both Units Combined							
	Year 1		Year 2		Average Year		Monthly %		Year 1		Year 2		Average Year		Monthly %		Year 1		Year 2		Average Year		Monthly %	
Month	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Jul	53	5	44	0	49	3	3.7%	0.7%	119	10	192	3	156	6	4.4%	2.2%	171	15	236	3	204	9	4.2%	1.4%
Aug	0	0	11	11	5	5	0.4%	1.4%	31	20	9	0	20	10	0.6%	3.6%	31	20	20	11	26	15	0.5%	2.4%
Sep	30	0	0	0	15	0	1.1%	0.0%	68	15	16	0	42	8	1.2%	2.7%	98	15	16	0	57	8	1.2%	1.2%
Oct	145	67	22	5	83	36	6.3%	9.7%	390	26	128	25	259	25	7.2%	9.0%	535	93	150	30	343	61	7.0%	9.4%
Nov	146	88	40	13	93	51	7.0%	13.7%	158	6	142	54	150	30	4.2%	10.8%	304	94	182	68	243	81	5.0%	12.4%
Dec	498	359	46	28	272	193	20.5%	52.2%	225	99	84	17	155	58	4.3%	20.6%	723	458	130	45	427	252	8.7%	38.5%
Jan	146	32	42	8	94	20	7.1%	5.4%	109	23	42	18	76	20	2.1%	7.2%	255	55	84	26	170	40	3.5%	6.2%
Feb	28	6	20	2	24	4	1.8%	1.1%	171	85	35	1	103	43	2.9%	15.2%	199	92	55	3	127	47	2.6%	7.2%
Mar	245	39	42	19	144	29	10.8%	7.8%	59	13	41	0	50	6	1.4%	2.3%	304	52	83	19	194	35	3.9%	5.4%
Apr	39	0	50	1	45	0	3.3%	0.1%	191	1	59	4	125	2	3.5%	0.8%	230	1	109	4	170	3	3.5%	0.4%
May	333	47	110	4	222	25	16.7%	6.8%	259	2	225	17	242	10	6.8%	3.4%	591	49	335	21	463	35	9.4%	5.4%
Jun	477	5	91	3	284	4	21.4%	1.0%	4236	66	159	59	2198	62	61.5%	22.2%	4713	71	251	62	2482	66	50.6%	10.1%
Annual	**2139**	**648**	**519**	**93**	**1329**	**371**	**100.0%**	**100.0%**	**6016**	**366**	**1133**	**197**	**3574**	**282**	**100.0%**	**100.0%**	**8155**	**1015**	**1651**	**291**	**4903**	**653**	**100.0%**	**100.0%**

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated in impingement samples at Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual impingement counts at Unit 1 and Unit 2 combined.
[3]Design intake pump flows used to extrapolate actual impingement rates for all life stages of fish sampled up to maximum flows were 131.45 cfs for Unit 1 and 311.92 cfs for Unit 2.
[4]Year 1 = 29 June 2005 through 30 June 2006; Year 2 = 1 July 2006 through 30 June 2007.

Table 2-2a. Merrimack Station Fish Impingement Annual Total Abundance (Abund)[1] and Estimated Adult Equivalents (Ad Eq)[2] Based on Actual Intake Flows[3] by Month, Unit and Year (June 2005 through June 2007)[4].

	Unit 1								Unit 2								Both Units Combined							
	Year 1		Year 2		Average Year		Monthly %		Year 1		Year 2		Average Year		Monthly %		Year 1		Year 2		Average Year		Monthly %	
Month	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq	Abund	Ad Eq
Jul	43	4	36	0	40	2	3.9%	0.8%	111	9	179	2	145	6	4.8%	2.4%	154	13	215	3	185	8	4.6%	1.5%
Aug	0	0	9	9	4	4	0.4%	1.6%	29	19	9	0	19	9	0.6%	3.8%	29	19	17	9	23	14	0.6%	2.6%
Sep	25	0	0	0	13	0	1.2%	0.0%	63	14	11	0	37	7	1.2%	2.9%	88	14	11	0	50	7	1.2%	1.4%
Oct	110	51	15	4	62	27	6.2%	10.0%	176	15	119	23	148	19	4.9%	7.8%	286	66	134	27	210	46	5.2%	9.0%
Nov	97	57	29	10	63	34	6.3%	12.4%	147	6	132	51	140	28	4.7%	11.6%	244	63	161	61	203	62	5.1%	12.0%
Dec	371	268	33	19	202	143	20.1%	52.4%	209	92	68	14	139	53	4.6%	21.7%	581	360	102	33	342	196	8.5%	37.9%
Jan	112	25	35	7	74	16	7.3%	5.8%	102	22	32	15	67	18	2.2%	7.5%	214	46	67	22	141	34	3.5%	6.6%
Feb	23	5	16	2	20	3	2.0%	1.2%	141	70	32	1	87	36	2.9%	14.5%	163	75	48	2	106	39	2.6%	7.5%
Mar	200	32	28	12	114	22	11.4%	8.1%	55	12	37	0	46	6	1.5%	2.5%	256	44	66	12	161	28	4.0%	5.4%
Apr	31	0	41	1	36	0	3.6%	0.1%	84	0	16	0	50	0	1.7%	0.1%	115	0	57	1	86	1	2.1%	0.1%
May	231	33	90	3	161	18	16.0%	6.6%	76	1	85	6	81	3	2.7%	1.3%	307	34	174	9	241	21	6.0%	4.1%
Jun	359	4	74	2	217	3	21.6%	1.1%	3941	61	146	55	2044	58	68.1%	23.7%	4300	65	220	57	2260	61	56.4%	11.8%
Annual	**1603**	**478**	**405**	**69**	**1004**	**273**	**100.0%**	**100.0%**	**5133**	**321**	**866**	**167**	**3001**	**244**	**100.0%**	**100.0%**	**6736**	**799**	**1271**	**236**	**4005**	**517**	**100.0%**	**100.0%**

[1]Fish abundance is shown for combined suite of all species and lifestages enumerated in impingement samples at Unit 1 and Unit 2.
[2]Adult equivalents shown for the combined suite of fish species representing 90% of the actual impingement counts at Unit 1 and Unit 2 combined.
[3]Actual monthly intake pump flows used to extrapolate actual fish impingement rates up to monthly abundance or adult equivalents for Unit 1 and Unit 2.
[4]Year 1 = 29 June 2005 through 30 June 2006; Year 2 = 1 July 2006 through 30 June 2007.

Table 8-1. Estimated mortality reduction associated with a change from the existing fish return sluice for Units 1 and 2 of Merrimack Station to an upgraded return sluice, for impingement at maximum flow with the existing intake screens.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]
UNIT 1						
Total number of fish impinged[a]	1,775	648	365	93	2,141	742
Existing screen survival (#)[b]	1,080	372	226	56	1,306	428
Existing screen survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Existing screens + upgraded sluice survival (#)[c]	821	305	161	34	982	338
Upgraded sluice survival (%)	*76.0*	*81.9*	*71.3*	*60.3*	*75.2*	*79.1*
Sluice mortality reduction (%)[f]	**46.3**	**47.0**	**44.0**	**35.9**	**45.9**	**45.6**
UNIT 2						
Total number of fish impinged[a]	5,460	367	941	197	6,400	564
Existing screen survival (#)[b]	3,521	289	703	145	4,225	434
Existing screen survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Existing screens + upgraded sluice survival (#)[c]	2,893	169	574	114	3,467	282
Upgraded sluice survival (%)	*82.2*	*58.3*	*81.5*	*78.4*	*82.1*	*65.0*
Sluice mortality reduction (%)[f]	**53.0**	**46.0**	**61.0**	**57.6**	**54.2**	**50.0**

[a] Numbers impinged estimated from 24-hour sample collections (June 2005 to June 2007, adjusted for collection efficiency; Normandeau 2007) and based on maximum Merrimack Station intake flow.

[b] Based on average seasonal latent 24-hour screen survival tests using golden shiner (Normandeau 2007).

[c] Based on from return sluice testing at Indian Point (Con Edison 1992), using golden shiner survival for spottail shiner and white perch survival for bluegill, black crappie, pumpkinseed, largemouth bass, and yellow perch.

[d] Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)

[e] Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)

[f] Potential percent reduction in mortality rate for screens and sluice combined after replacing the existing Merrimack Station fish return sluice with an upgraded fish return sluice, based Merrimack Station impingement rates for June 2005 to June 2007.

ASSUMPTIONS
An upgraded fish sluice will be installed for use with the existing intake screens.
All fish that were impinged at Merrimack Station between June 2005 and June 2007 were alive when impinged.
All fish flushed into the current Merrimack Station fish return system do not survive due to location of end of sluice pipe.
An upgraded return sluice will only be operable in the ice-free months of April-December.
Upgraded fish return sluice survival will be comparable to survival rates of white perch and golden shiner tested at Indian Point. Survival rates used in this comparison are the mean corrected survival values of multiple tests.
Average conditions during testing of white perch were a pipe length of 225', discharge depth of 55' and system flow of 1990 gpm. Average conditions during testing of golden shiner were a pipe length of 225', discharge depth of 55' and system flow of 2100 gpm.

Con Edison (Consolidated Edison Company of New York, Inc.). 1992. Indian Point Units 2 and 3 Ristroph Screen Return System Prototype Evaluation and Siting Study. November 1992.

Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

Table 8-2. Mortality reduction associated with a change from existing intake screens at Units 1 and 2 of Merrimack Station to Ristroph screens for impingement at maximum flow, with and without adjustment for upgraded return sluice survival.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]
UNIT 1						
Total number of fish impinged [a]	1,775	648	365	93	2,141	742
Existing survival (#) [b]	1,080	372	226	56	1,306	428
Existing survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Ristroph survival (#) [c]	1,185	482	238	62	1,422	544
Ristroph survival (%)	*66.7*	*74.4*	*65.1*	*66.8*	*66.4*	*73.4*
Ristroph + upgraded sluice survival (#)[f]	914	409	163	36	1,077	445
Ristroph + upgraded sluice survival (%)	*51.5*	*63.1*	*44.5*	*38.4*	*50.3*	*60.0*
Screen mortality reduction (%) [g]	**15.0**	**39.8**	**8.7**	**18.2**	**13.9**	**37.2**
Screen + sluice mortality reduction (%)[h,i]	**51.5**	**63.1**	**44.5**	**38.4**	**50.3**	**60.0**
UNIT 2						
Total number of fish impinged[a]	5,460	367	941	197	6,400	564
Existing survival (#)[b]	3,521	289	703	145	4,225	434
Existing survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Ristroph survival (#)[c]	3,510	292	618	134	4,128	426
Ristroph survival (%)	*64.3*	*79.6*	*65.7*	*67.9*	*64.5*	*75.5*
Ristroph + upgraded sluice survival (#)[f]	2,882	169	514	110	3,397	279
Ristroph + upgraded sluice survival (%)	*52.8*	*46.2*	*54.7*	*55.6*	*53.1*	*49.5*
Screen mortality reduction (%)[g]	**-0.6**	**3.0**	**-35.9**	**-20.7**	**-4.4**	**-6.6**
Screen + sluice mortality reduction (%)[h,i]	**52.8**	**46.2**	**54.7**	**55.6**	**53.1**	**49.5**

[a] Numbers impinged estimated from 24-hour sample collections (June 2005 to June 2007, adjusted for collection efficiency; Normandeau 2007) and based on maximum Merrimack Station intake flow.
[b] Based on average seasonal latent 24-hour screen survival tests using golden shiner (Normandeau 2007).
[c] Based on Ristroph screen survival test at Indian Point. Latent 96-hour data available for the period from Jan. to Apr. 1985 for 10 species (Con Edison 1985).
[d] Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)
[e] Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)
[f] Return sluice counts adjusted for survival based on results of Indian Point sluice survival test (see sluice survival table).
[g] Percent reduction in mortality rate between existing Merrimack Station screens and theoretical application of Ristroph screens based on observed Merrimack impingement rates during June 2005 to June 2007.
[h] Percent mortality reduction between existing Merrimack Station screens and fish return sluice and theoretical application of Ristroph screens and upgraded fish return sluice based on Merrimack Station impingement rates in June 2005 to June 2007.
[i] Assumes an existing sluice survival rate of zero.

ASSUMPTIONS
Assumes that all fish that were impinged at Merrimack Station between June 05 and June 07 were alive when impinged.
Existing estimates assume that golden shiner survival rates are representative of all species.
Ristroph estimates are based on survival rates of like species tested at Indian Point (white perch, pumpkinseed, spottail shiner).
Assumes an existing return sluice survival of zero.

Con Edison (Consolidated Edison Company of New York, Inc.). 1985. Biological Evaluation of a Ristroph Screen at Indian Point Unit 2. June 1985.
Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

Table 8-3. Mortality reduction associated with a change from existing intake screens at Units 1 and 2 of Merrimack Station to Geiger multi-disc screens for impingement at maximum flow, with and without adjustment for upgraded return sluice survival.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]
UNIT 1						
Total number of fish impinged [a]	1,775	648	365	93	2,141	742
Existing survival (#) [b]	1,080	372	226	56	1,306	428
Existing survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Geiger multi-disc survival (#) [c]	1,651	559	347	88	1,998	647
Geiger multi-disc survival (%)	*93.0*	*86.3*	*95.1*	*94.0*	*93.4*	*87.3*
Geiger + upgraded sluice survival (#) [f]	1,231	447	245	53	1,475	500
Geiger + upgraded sluice survival (%)	*69.3*	*68.9*	*67.0*	*56.5*	*68.9*	*67.4*
Screen mortality reduction (%) [g]	**82.1**	**67.8**	**87.1**	**85.3**	**82.9**	**69.9**
Screen + sluice mortality reduction (%) [h,i]	**69.3**	**68.9**	**67.0**	**56.5**	**68.9**	**67.4**
UNIT 2						
Total number of fish impinged [a]	5,460	367	941	197	6,400	564
Existing survival (#) [b]	3,521	289	703	145	4,225	434
Existing survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Geiger multi-disc survival (#) [c]	5,256	305	891	182	6,148	488
Geiger multi-disc survival (%)	*96.3*	*83.3*	*94.8*	*92.5*	*96.1*	*86.5*
Geiger + upgraded sluice survival (#) [f]	4,374	194	730	144	5,104	338
Geiger + upgraded sluice survival (%)	*80.1*	*52.9*	*77.6*	*73.1*	*79.7*	*60.0*
Screen mortality reduction (%) [g]	**89.5**	**20.7**	**79.3**	**71.7**	**88.4**	**41.3**
Screen + sluice mortality reduction (%) [h,i]	**80.1**	**52.9**	**77.6**	**73.1**	**79.7**	**60.0**

[a]Numbers impinged estimated from 24-hour sample collections (June 2005-June 2007, adjusted for collection efficiency; Normandeau 2007) and based on maximum Merrimack Station intake flow.
[b]Based on average seasonal latent 24-hour screen survival tests using golden shiner (Normandeau 2007).
[c]Based on Geiger multi-disc screen 48-hr latent survival test at Potomac River Generating Station (EPRI 2007). Survival rates available for bluegill, pumpkinseed, yellow perch, largemouth bass, and spottail shiner (black crappie estimated from bluegill).
[d]Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)
[e]Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)
[f]Return sluice counts adjusted for survival based on results of Indian Point sluice survival test (See sluice survival table).
[g]Percent reduction in mortality rates between existing Merrimack Station screens and theoretical application of Geiger multi-disc screens based on observed Merrimack impingement rates for June 2005 to June 2007.
[h]Percent reduction in mortality rates between existing Merrimack Station screens and fish return sluice and theoretical application of Geiger screens and upgraded fish return sluice, based on Merrimack Station impingement rates in June 2005 to June 2007.
[i]Assumes an existing sluice survival rate of zero.

ASSUMPTIONS
Assumes that all fish that were impinged at Merrimack Station between June 05 and June 07 were alive when impinged.
Existing estimates assume that golden shiner survival rates are representative of all species.
Assumes an existing return sluice survival of zero.

EPRI (Electric Power Research Institute). 2007. Latent impingement mortality assessment of the Geiger MultiDisc screening system at the Potomac River Generating Station.
Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

Table 8-4. Mortality reduction associated with a change from existing intake screens at Units 1 and 2 of Merrimack Station to Beaudrey WIP screens and FPS system for impingement at maximum flow, with and without adjustment for upgraded return sluice survival.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]
UNIT 1						
Total number of fish impinged [a]	1,775	648	365	93	2,141	742
Existing survival (#) [b]	1,080	372	226	56	1,306	428
Existing survival (%)	*60.8*	*57.5*	*61.8*	*59.4*	*61.0*	*57.7*
Beaudrey WIP survival (#) [c]	1,580	577	325	83	1,905	660
Beaudrey WIP survival (%)	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*
Beaudrey WIP + upgraded sluice survival (#) [f]	1,191	472	227	49	1,418	521
Beaudrey WIP + upgraded sluice survival (%)	*67.1*	*72.8*	*62.1*	*52.6*	*66.2*	*70.2*
Screen mortality reduction (%) [g]	**71.9**	**74.1**	**71.2**	**72.9**	**71.8**	**74.0**
Screen + sluice mortality reduction (%) [h,i]	**67.1**	**72.8**	**62.1**	**52.6**	**66.2**	**70.2**
UNIT 2						
Total number of fish impinged [a]	5,460	367	941	197	6,400	564
Existing survival (#) [b]	3,521	289	703	145	4,225	434
Existing survival (%)	*64.5*	*78.9*	*74.8*	*73.4*	*66.0*	*77.0*
Beaudrey WIP survival (#) [c]	4,859	326	837	176	5,696	502
Beaudrey WIP survival (%)	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*	*89.0*
Beaudrey WIP + upgraded sluice survival (#) [f]	4,024	199	689	141	4,714	340
Beaudrey WIP + upgraded sluice survival (%)	*73.7*	*54.3*	*73.3*	*71.4*	*73.7*	*60.3*
Screen mortality reduction (%) [g]	**69.0**	**47.8**	**56.4**	**58.7**	**67.6**	**52.2**
Screen + sluice mortality reduction (%) [h,i]	**73.7**	**54.3**	**73.3**	**71.4**	**73.7**	**60.3**

[a] Numbers impinged estimated from 24-hour sample collections (June 2005-June 2007, adjusted for collection efficiency; Normandeau 2007) and based on maximum Merrimack Station intake flow.
[b] Based on average seasonal latent 24-hour screen survival tests using golden shiner (Normandeau 2007).
[c] Based on Beaudrey FPS system survival testing at Le Blayais Nuclear Power Station in France.
[d] Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)
[e] Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)
[f] Return sluice counts adjusted for survival based on results of Indian Point sluice survival test (See sluice survival table).
[g] Percent reduction in mortality rates between existing Merrimack Station screens and theoretical application of Beaudrey WIP screens, based on Merrimack impingement rates for June 2005 to June 2007.
[h] Percent reduction in mortality rates between existing Merrimack Station screens and fish return sluice and theoretical application of Beaudrey WIP screens and upgraded fish return sluice, based on Merrimack Station impingement rates for June 2005 to June 2007.
[i] Assumes an existing sluice survival rate of zero.

ASSUMPTIONS
Assumes that all fish that were impinged at Merrimack Station between June 2005 and June 2007 were alive when impinged.
Existing estimates assume that golden shiner survival rates are representative of all species.
Beaudrey WIP estimates assume that survival rates are similar for fish impinged at Le Blayais and Merrimack stations.
Assumes an existing return sluice survival of zero.

Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

Attach. 6, Table 6-1. Monthly and annual impingement estimates for Unit 1 at maximum capacity flows (100%) and for each 5% flow reduction.

	Jun05	Jul05	Aug05	Sep05	Oct05	Nov05	Dec05	Jan06	Feb06	Mar06	Apr06	May06	Jun06	Year 1
100% [a]	0	23	0	15	145	129	463	83	18	150	1	322	427	1,775
95%	0	22	0	14	138	122	440	79	17	142	1	306	405	1,687
90%	0	21	0	13	131	116	417	75	17	135	1	289	384	1,598
85%	0	19	0	13	123	109	393	71	16	127	1	273	363	1,509
80%	0	18	0	12	116	103	370	67	15	120	1	257	341	1,420
75%	0	17	0	11	109	96	347	62	14	112	1	241	320	1,331
70%	0	16	0	10	102	90	324	58	13	105	1	225	299	1,243
65%	0	15	0	10	94	84	301	54	12	97	1	209	277	1,154
60%	0	14	0	9	87	77	278	50	11	90	1	193	256	1,065
55%	0	13	0	8	80	71	255	46	10	82	1	177	235	976
50%	0	11	0	7	73	64	231	42	9	75	1	161	213	888
45%	0	10	0	7	65	58	208	37	8	67	1	145	192	799
40%	0	9	0	6	58	51	185	33	7	60	1	129	171	710
35%	0	8	0	5	51	45	162	29	6	52	1	113	149	621
30%	0	7	0	4	44	39	139	25	6	45	0	96	128	533
25%	0	6	0	4	36	32	116	21	5	37	0	80	107	444
20%	0	5	0	3	29	26	93	17	4	30	0	64	85	355
15%	0	3	0	2	22	19	69	12	3	22	0	48	64	266
10%	0	2	0	1	15	13	46	8	2	15	0	32	43	178
5%	0	1	0	1	7	6	23	4	1	7	0	16	21	89
	Jul06	**Aug06**	**Sep06**	**Oct06**	**Nov06**	**Dec06**	**Jan07**	**Feb07**	**Mar07**	**Apr07**	**May07**	**Jun07**	**Year 2**	**Total**
100% [a]	28	11	0	22	40	45	23	20	22	7	73	74	365	2,141
95%	27	10	0	21	38	43	22	19	21	6	69	70	347	2,034
90%	25	10	0	20	36	41	21	18	20	6	66	66	329	1,926
85%	24	9	0	18	34	39	20	17	19	6	62	63	310	1,819
80%	22	9	0	17	32	36	19	16	18	5	59	59	292	1,712
75%	21	8	0	16	30	34	18	15	17	5	55	55	274	1,605
70%	20	7	0	15	28	32	16	14	16	5	51	52	256	1,498
65%	18	7	0	14	26	30	15	13	15	4	48	48	237	1,391
60%	17	6	0	13	24	27	14	12	13	4	44	44	219	1,284
55%	15	6	0	12	22	25	13	11	12	4	40	41	201	1,177
50%	14	5	0	11	20	23	12	10	11	3	37	37	183	1,070
45%	13	5	0	10	18	20	11	9	10	3	33	33	164	963
40%	11	4	0	9	16	18	9	8	9	3	29	30	146	856
35%	10	4	0	8	14	16	8	7	8	2	26	26	128	749
30%	8	3	0	7	12	14	7	6	7	2	22	22	110	642
25%	7	3	0	5	10	11	6	5	6	2	18	18	91	535
20%	6	2	0	4	8	9	5	4	4	1	15	15	73	428
15%	4	2	0	3	6	7	4	3	3	1	11	11	55	321
10%	3	1	0	2	4	5	2	2	2	1	7	7	37	214
5%	1	1	0	1	2	2	1	1	1	0	4	4	18	107

[a] 100% represents estimated impingement totals for 90% of species impinged (black crappie, bluegill, largemouth bass, pumpkinseed, spottail shiner, yellow perch) as estimated on a monthly and annual basis from 24-hour samples, adjusted for collection efficiency, and maximum capacity flows at Unit 1.

Assumptions:
Unit 1 maximum capacity flow of 0.32 MCM/day.

Attach. 6, Table 6-2. Monthly and annual impingement estimates for Unit 2 at maximum capacity flows (100%) and for each 5% flow reduction.

	Jun05	Jul05	Aug05	Sep05	Oct05	Nov05	Dec05	Jan06	Feb06	Mar06	Apr06	May06	Jun06	Year 1
100% [a]	3	64	21	53	359	144	145	23	86	30	114	231	4,189	5,460
95%	3	61	20	50	341	136	137	22	81	28	108	219	3,980	5,187
90%	3	58	19	48	323	129	130	21	77	27	102	208	3,770	4,914
85%	2	55	18	45	305	122	123	20	73	25	97	196	3,561	4,641
80%	2	52	17	42	287	115	116	19	68	24	91	184	3,352	4,368
75%	2	48	16	40	269	108	108	17	64	22	85	173	3,142	4,095
70%	2	45	15	37	251	101	101	16	60	21	80	161	2,933	3,822
65%	2	42	14	34	233	93	94	15	56	19	74	150	2,723	3,549
60%	2	39	12	32	215	86	87	14	51	18	68	138	2,514	3,276
55%	2	35	11	29	197	79	80	13	47	16	63	127	2,304	3,003
50%	1	32	10	26	179	72	72	12	43	15	57	115	2,095	2,730
45%	1	29	9	24	161	65	65	10	38	13	51	104	1,885	2,457
40%	1	26	8	21	143	57	58	9	34	12	45	92	1,676	2,184
35%	1	23	7	18	126	50	51	8	30	10	40	81	1,466	1,911
30%	1	19	6	16	108	43	43	7	26	9	34	69	1,257	1,638
25%	1	16	5	13	90	36	36	6	21	7	28	58	1,047	1,365
20%	1	13	4	11	72	29	29	5	17	6	23	46	838	1,092
15%	0	10	3	8	54	22	22	3	13	4	17	35	628	819
10%	0	6	2	5	36	14	14	2	9	3	11	23	419	546
5%	0	3	1	3	18	7	7	1	4	1	6	12	209	273

	Jul06	Aug06	Sep06	Oct06	Nov06	Dec06	Jan07	Feb07	Mar07	Apr07	May07	Jun07	Year 2	Total
100% [a]	162	0	16	128	142	84	25	17	2	47	209	108	941	6,400
95%	154	0	15	122	135	80	24	16	2	45	198	103	894	6,080
90%	146	0	14	115	128	76	23	15	2	42	188	97	847	5,760
85%	138	0	14	109	121	72	21	14	2	40	178	92	800	5,440
80%	130	0	13	102	114	67	20	13	2	38	167	86	752	5,120
75%	122	0	12	96	107	63	19	13	2	35	157	81	705	4,800
70%	114	0	11	90	99	59	18	12	1	33	146	76	658	4,480
65%	105	0	10	83	92	55	16	11	1	31	136	70	611	4,160
60%	97	0	10	77	85	51	15	10	1	28	125	65	564	3,840
55%	89	0	9	70	78	46	14	9	1	26	115	59	517	3,520
50%	81	0	8	64	71	42	13	8	1	23	104	54	470	3,200
45%	73	0	7	58	64	38	11	8	1	21	94	49	423	2,880
40%	65	0	6	51	57	34	10	7	1	19	84	43	376	2,560
35%	57	0	6	45	50	29	9	6	1	16	73	38	329	2,240
30%	49	0	5	38	43	25	8	5	1	14	63	32	282	1,920
25%	41	0	4	32	36	21	6	4	1	12	52	27	235	1,600
20%	32	0	3	26	28	17	5	3	0	9	42	22	188	1,280
15%	24	0	2	19	21	13	4	3	0	7	31	16	141	960
10%	16	0	2	13	14	8	3	2	0	5	21	11	94	640
5%	8	0	1	6	7	4	1	1	0	2	10	5	47	320

[a] 100% represents estimated impingement totals for 90% of species impinged (black crappie, bluegill, largemouth bass, pumpkinseed, spottail shiner, yellow perch) as estimated on a monthly and annual basis from 24-hour samples, adjusted for collection efficiency, and maximum capacity flows at Unit 2.

Assumptions:
Unit 2 maximum capacity flow of 0.76 MCM/day.

Attach. 6, Table 6-3. Monthly and annual adult equivalent losses due to impingement at Unit 1 at maximum capacity flows (100%) and for each 5% flow reduction.

	Jun05	Jul05	Aug05	Sep05	Oct05	Nov05	Dec05	Jan06	Feb06	Mar06	Apr06	May06	Jun06	Year 1
100% [a]	0	5	0	0	67	88	359	32	6	39	0	47	5	648
95%	0	5	0	0	64	84	341	30	6	37	0	44	5	616
90%	0	5	0	0	61	80	323	29	5	35	0	42	4	583
85%	0	4	0	0	57	75	305	27	5	33	0	40	4	551
80%	0	4	0	0	54	71	287	26	5	31	0	37	4	518
75%	0	4	0	0	50	66	269	24	5	29	0	35	4	486
70%	0	4	0	0	47	62	251	22	4	27	0	33	3	454
65%	0	3	0	0	44	57	233	21	4	25	0	30	3	421
60%	0	3	0	0	40	53	215	19	4	23	0	28	3	389
55%	0	3	0	0	37	49	197	18	3	21	0	26	3	356
50%	0	3	0	0	34	44	180	16	3	19	0	23	2	324
45%	0	2	0	0	30	40	162	14	3	17	0	21	2	292
40%	0	2	0	0	27	35	144	13	2	16	0	19	2	259
35%	0	2	0	0	24	31	126	11	2	14	0	16	2	227
30%	0	2	0	0	20	27	108	10	2	12	0	14	1	194
25%	0	1	0	0	17	22	90	8	2	10	0	12	1	162
20%	0	1	0	0	13	18	72	6	1	8	0	9	1	130
15%	0	1	0	0	10	13	54	5	1	6	0	7	1	97
10%	0	1	0	0	7	9	36	3	1	4	0	5	0	65
5%	0	0	0	0	3	4	18	2	0	2	0	2	0	32
	Jul06	**Aug06**	**Sep06**	**Oct06**	**Nov06**	**Dec06**	**Jan07**	**Feb07**	**Mar07**	**Apr07**	**May07**	**Jun07**	**Year 2**	**Total**
100% [a]	0	11	0	5	13	28	8	2	19	1	4	3	93	742
95%	0	10	0	5	13	27	8	2	18	1	4	3	89	704
90%	0	10	0	4	12	25	7	2	17	1	4	2	84	667
85%	0	9	0	4	11	24	7	2	16	1	4	2	79	630
80%	0	9	0	4	11	22	7	1	15	1	3	2	75	593
75%	0	8	0	4	10	21	6	1	14	1	3	2	70	556
70%	0	7	0	3	9	20	6	1	13	0	3	2	65	519
65%	0	7	0	3	9	18	5	1	12	0	3	2	61	482
60%	0	6	0	3	8	17	5	1	11	0	2	2	56	445
55%	0	6	0	3	7	15	5	1	10	0	2	1	51	408
50%	0	5	0	2	7	14	4	1	9	0	2	1	47	371
45%	0	5	0	2	6	13	4	1	8	0	2	1	42	334
40%	0	4	0	2	5	11	3	1	8	0	2	1	37	297
35%	0	4	0	2	5	10	3	1	7	0	1	1	33	260
30%	0	3	0	1	4	8	2	1	6	0	1	1	28	222
25%	0	3	0	1	3	7	2	0	5	0	1	1	23	185
20%	0	2	0	1	3	6	2	0	4	0	1	1	19	148
15%	0	2	0	1	2	4	1	0	3	0	1	0	14	111
10%	0	1	0	0	1	3	1	0	2	0	0	0	9	74
5%	0	1	0	0	1	1	0	0	1	0	0	0	5	37

[a] 100% represents adult equivalent losses for 90% of species impinged (black crappie, bluegill, largemouth bass, pumpkinseed, spottail shiner, yellow perch) as estimated on a monthly and annual basis from 24-hour samples, adjusted for collection efficiency, and maximum capacity flows at Unit 1.

Assumptions:
Unit 1 maximum capacity flow of 0.32 MCM/day.

Attach. 6, Table 6-4. Monthly and annual adult equivalent losses due to impingement at Unit 2 at maximum capacity flows (100%) and for each 5% flow reduction.

	Jun05	Jul05	Aug05	Sep05	Oct05	Nov05	Dec05	Jan06	Feb06	Mar06	Apr06	May06	Jun06	Year 1
100% [a]	0	10	20	15	26	6	99	23	86	13	1	2	66	367
95%	0	9	19	14	25	6	94	22	81	12	1	2	62	348
90%	0	9	18	14	23	6	89	21	77	12	1	2	59	330
85%	0	8	17	13	22	5	84	20	73	11	1	2	56	312
80%	0	8	16	12	21	5	79	19	68	10	1	2	53	293
75%	0	7	15	11	19	5	74	17	64	10	1	2	49	275
70%	0	7	14	11	18	4	69	16	60	9	1	2	46	257
65%	0	6	13	10	17	4	64	15	56	8	1	2	43	238
60%	0	6	12	9	16	4	59	14	51	8	1	1	39	220
55%	0	5	11	8	14	3	54	13	47	7	1	1	36	202
50%	0	5	10	8	13	3	49	12	43	6	0	1	33	183
45%	0	4	9	7	12	3	44	10	38	6	0	1	30	165
40%	0	4	8	6	10	2	40	9	34	5	0	1	26	147
35%	0	3	7	5	9	2	35	8	30	5	0	1	23	128
30%	0	3	6	5	8	2	30	7	26	4	0	1	20	110
25%	0	2	5	4	6	2	25	6	21	3	0	1	16	92
20%	0	2	4	3	5	1	20	5	17	3	0	0	13	73
15%	0	1	3	2	4	1	15	3	13	2	0	0	10	55
10%	0	1	2	2	3	1	10	2	9	1	0	0	7	37
5%	0	0	1	1	1	0	5	1	4	1	0	0	3	18
	Jul06	**Aug06**	**Sep06**	**Oct06**	**Nov06**	**Dec06**	**Jan07**	**Feb07**	**Mar07**	**Apr07**	**May07**	**Jun07**	**Year 2**	**Total**
100% [a]	3	0	0	25	54	17	18	1	0	4	17	59	197	564
95%	2	0	0	24	52	16	17	1	0	4	16	56	187	536
90%	2	0	0	22	49	16	16	1	0	3	15	53	178	507
85%	2	0	0	21	46	15	15	1	0	3	14	50	168	479
80%	2	0	0	20	44	14	14	1	0	3	13	47	158	451
75%	2	0	0	19	41	13	13	1	0	3	13	44	148	423
70%	2	0	0	17	38	12	12	1	0	3	12	41	138	395
65%	2	0	0	16	35	11	11	1	0	2	11	38	128	367
60%	2	0	0	15	33	10	11	0	0	2	10	35	118	338
55%	1	0	0	14	30	9	10	0	0	2	9	33	109	310
50%	1	0	0	12	27	9	9	0	0	2	8	30	99	282
45%	1	0	0	11	25	8	8	0	0	2	8	27	89	254
40%	1	0	0	10	22	7	7	0	0	2	7	24	79	226
35%	1	0	0	9	19	6	6	0	0	1	6	21	69	197
30%	1	0	0	7	16	5	5	0	0	1	5	18	59	169
25%	1	0	0	6	14	4	4	0	0	1	4	15	49	141
20%	1	0	0	5	11	3	4	0	0	1	3	12	39	113
15%	0	0	0	4	8	3	3	0	0	1	3	9	30	85
10%	0	0	0	2	5	2	2	0	0	0	2	6	20	56
5%	0	0	0	1	3	1	1	0	0	0	1	3	10	28

[a]100% represents adult equivalent losses for 90% of species impinged (black crappie, bluegill, largemouth bass, pumpkinseed, spottail shiner, yellow perch) as estimated on a monthly and annual basis from 24-hour samples, adjusted for collection efficiency, and maximum capacity flows at Unit 2.

Assumptions:
Unit 2 maximum capacity flow of 0.76 MCM/day.

Attach. 6, Table 6-5. Monthly and seasonal entrainment estimates for Unit 1 at maximum capacity flows (100%) and for each 5% flow reduction.

	Monthly and Seasonal Entrainment Reductions									
	May06	**Jun06**	**Jul06**	**Aug06**	**Year 1**	**Apr07**	**May07**	**Jun07**	**Year 2**	**Total**
100% [a]	0	474,030	292,620	22,326	788,976	0	672,617	1,267,714	1,940,331	2,729,307
95%	0	450,329	277,989	21,210	749,527	0	638,986	1,204,328	1,843,314	2,592,842
90%	0	426,627	263,358	20,093	710,078	0	605,355	1,140,943	1,746,298	2,456,376
85%	0	402,926	248,727	18,977	670,630	0	571,724	1,077,557	1,649,281	2,319,911
80%	0	379,224	234,096	17,861	631,181	0	538,094	1,014,171	1,552,265	2,183,446
75%	0	355,523	219,465	16,745	591,732	0	504,463	950,786	1,455,248	2,046,980
70%	0	331,821	204,834	15,628	552,283	0	470,832	887,400	1,358,232	1,910,515
65%	0	308,120	190,203	14,512	512,834	0	437,201	824,014	1,261,215	1,774,050
60%	0	284,418	175,572	13,396	473,386	0	403,570	760,628	1,164,199	1,637,584
55%	0	260,717	160,941	12,279	433,937	0	369,939	697,243	1,067,182	1,501,119
50%	0	237,015	146,310	11,163	394,488	0	336,309	633,857	970,166	1,364,654
45%	0	213,314	131,679	10,047	355,039	0	302,678	570,471	873,149	1,228,188
40%	0	189,612	117,048	8,930	315,590	0	269,047	507,086	776,132	1,091,723
35%	0	165,911	102,417	7,814	276,142	0	235,416	443,700	679,116	955,257
30%	0	142,209	87,786	6,698	236,693	0	201,785	380,314	582,099	818,792
25%	0	118,508	73,155	5,582	197,244	0	168,154	316,929	485,083	682,327
20%	0	94,806	58,524	4,465	157,795	0	134,523	253,543	388,066	545,861
15%	0	71,105	43,893	3,349	118,346	0	100,893	190,157	291,050	409,396
10%	0	47,403	29,262	2,233	78,898	0	67,262	126,771	194,033	272,931
5%	0	23,702	14,631	1,116	39,449	0	33,631	63,386	97,017	136,465

[a] 100% represents estimated entrainment for 90% of species entrained (white sucker, yellow perch, family Cyprinidae, family Centrarchidae) as estimated on a monthly and seasonal basis for maximum capacity flows at Unit 1.

Assumptions:
Unit 1 maximum capacity flow of 0.32 MCM/day.

Attach. 6, Table 6-6. Monthly and seasonal entrainment estimates for Unit 2 at maximum capacity flows (100%) and for each 5% flow reduction.

	Monthly and Seasonal Entrainment Reductions										
	May06	**Jun06**	**Jul06**	**Aug06**	**Sep06**	**Year 1**	**Apr07**	**May07**	**Jun07**	**Year 2**	**Total**
100% [a]	800,515	1,331,392	53,307	0	0	2,185,214	132,851	132,019	773,944	1,038,814	3,224,028
95%	760,489	1,264,822	50,642	0	0	2,075,953	126,208	125,418	735,247	986,873	3,062,827
90%	720,464	1,198,253	47,976	0	0	1,966,693	119,566	118,817	696,550	934,933	2,901,625
85%	680,438	1,131,683	45,311	0	0	1,857,432	112,923	112,216	657,852	882,992	2,740,424
80%	640,412	1,065,114	42,646	0	0	1,748,171	106,281	105,615	619,155	831,051	2,579,222
75%	600,386	998,544	39,980	0	0	1,638,911	99,638	99,014	580,458	779,111	2,418,021
70%	560,361	931,974	37,315	0	0	1,529,650	92,996	92,413	541,761	727,170	2,256,820
65%	520,335	865,405	34,650	0	0	1,420,389	86,353	85,812	503,064	675,229	2,095,618
60%	480,309	798,835	31,984	0	0	1,311,128	79,711	79,211	464,366	623,288	1,934,417
55%	440,283	732,266	29,319	0	0	1,201,868	73,068	72,610	425,669	571,348	1,773,215
50%	400,258	665,696	26,654	0	0	1,092,607	66,426	66,010	386,972	519,407	1,612,014
45%	360,232	599,126	23,988	0	0	983,346	59,783	59,409	348,275	467,466	1,450,813
40%	320,206	532,557	21,323	0	0	874,086	53,140	52,808	309,578	415,526	1,289,611
35%	280,180	465,987	18,657	0	0	764,825	46,498	46,207	270,880	363,585	1,128,410
30%	240,155	399,418	15,992	0	0	655,564	39,855	39,606	232,183	311,644	967,208
25%	200,129	332,848	13,327	0	0	546,304	33,213	33,005	193,486	259,704	806,007
20%	160,103	266,278	10,661	0	0	437,043	26,570	26,404	154,789	207,763	644,806
15%	120,077	199,709	7,996	0	0	327,782	19,928	19,803	116,092	155,822	483,604
10%	80,052	133,139	5,331	0	0	218,521	13,285	13,202	77,394	103,881	322,403
5%	40,026	66,570	2,665	0	0	109,261	6,643	6,601	38,697	51,941	161,201

[a] 100% represents estimated entrainment for 90% of species entrained (white sucker, yellow perch, family Cyprinidae, family Centrarchidae) as estimated on a monthly and seasonal basis for maximum capacity flows at Unit 2.

Assumptions:
Unit 2 maximum capacity flow of 0.76 MCM/day.

Attach. 6, Table 6-7. Monthly and seasonal adult equivalent losses due to entrainment for Unit 1 at maximum capacity flows (100%) and for each sequential 5% flow reduction.

	Monthly and Seasonal Reductions in Adult Equivalent Losses due to Entrainment									
	May06	**Jun06**	**Jul06**	**Aug06**	**Year 1**	**Apr07**	**May07**	**Jun07**	**Year 2**	**Total**
100% [a]	0	2,536	1,225	94	3,855	0	1,289	7,521	8,810	12,665
95%	0	2,409	1,164	89	3,662	0	1,225	7,145	8,370	12,032
90%	0	2,282	1,103	85	3,470	0	1,160	6,769	7,929	11,399
85%	0	2,156	1,041	80	3,277	0	1,096	6,393	7,489	10,765
80%	0	2,029	980	75	3,084	0	1,031	6,017	7,048	10,132
75%	0	1,902	919	71	2,891	0	967	5,641	6,608	9,499
70%	0	1,775	858	66	2,699	0	902	5,265	6,167	8,866
65%	0	1,648	796	61	2,506	0	838	4,889	5,727	8,232
60%	0	1,522	735	56	2,313	0	773	4,513	5,286	7,599
55%	0	1,395	674	52	2,120	0	709	4,137	4,846	6,966
50%	0	1,268	613	47	1,928	0	645	3,761	4,405	6,333
45%	0	1,141	551	42	1,735	0	580	3,384	3,965	5,699
40%	0	1,014	490	38	1,542	0	516	3,008	3,524	5,066
35%	0	888	429	33	1,349	0	451	2,632	3,084	4,433
30%	0	761	368	28	1,157	0	387	2,256	2,643	3,800
25%	0	634	306	24	964	0	322	1,880	2,203	3,166
20%	0	507	245	19	771	0	258	1,504	1,762	2,533
15%	0	380	184	14	578	0	193	1,128	1,322	1,900
10%	0	254	123	9	386	0	129	752	881	1,267
5%	0	127	61	5	193	0	64	376	441	633

[a] 100% represents adult equivalent losses for 90% of species entrained (white sucker, yellow perch, family Cyprinidae, family Centrarchidae) as estimated on a monthly and seasonal basis for maximum capacity flows at Unit 1.

Assumptions:
Unit 1 maximum capacity flow of 0.32 MCM/day.

Attach. 6, Table 6-8. Monthly and seasonal adult equivalent losses due to entrainment for Unit 2 at maximum capacity flows (100%) and for each sequential 5% flow reduction.

	Monthly and Seasonal Reductions in Adult Equivalent Losses due to Entrainment									
	May06	**Jun06**	**Jul06**	**Aug06**	**Sep06**	**Year 1**	**Apr07**	**May07**	**Jun07**	**Year 2**	**Total**
100% [a]	4,847	6,200	283	0	0	11,330	666	724	6,105	7,495	18,825
95%	4,605	5,890	269	0	0	10,764	633	688	5,800	7,120	17,884
90%	4,362	5,580	255	0	0	10,197	599	652	5,495	6,746	16,943
85%	4,120	5,270	241	0	0	9,631	566	615	5,189	6,371	16,001
80%	3,878	4,960	226	0	0	9,064	533	579	4,884	5,996	15,060
75%	3,635	4,650	212	0	0	8,498	500	543	4,579	5,621	14,119
70%	3,393	4,340	198	0	0	7,931	466	507	4,274	5,247	13,178
65%	3,151	4,030	184	0	0	7,365	433	471	3,968	4,872	12,236
60%	2,908	3,720	170	0	0	6,798	400	434	3,663	4,497	11,295
55%	2,666	3,410	156	0	0	6,232	366	398	3,358	4,122	10,354
50%	2,424	3,100	142	0	0	5,665	333	362	3,053	3,748	9,413
45%	2,181	2,790	127	0	0	5,099	300	326	2,747	3,373	8,471
40%	1,939	2,480	113	0	0	4,532	266	290	2,442	2,998	7,530
35%	1,696	2,170	99	0	0	3,966	233	253	2,137	2,623	6,589
30%	1,454	1,860	85	0	0	3,399	200	217	1,832	2,249	5,648
25%	1,212	1,550	71	0	0	2,833	167	181	1,526	1,874	4,706
20%	969	1,240	57	0	0	2,266	133	145	1,221	1,499	3,765
15%	727	930	42	0	0	1,700	100	109	916	1,124	2,824
10%	485	620	28	0	0	1,133	67	72	611	750	1,883
5%	242	310	14	0	0	567	33	36	305	375	941

[a] 100% represents adult equivalent losses for 90% of species entrained (white sucker, yellow perch, family Cyprinidae, family Centrarchidae) as estimated on a monthly and seasonal basis for maximum capacity flows at Unit 2.

Assumptions:
Unit 2 maximum capacity flow of 0.76 MCM/day.

Attach. 6, Table 6-9. Summary of potential reductions in impingement mortality and entrainment at Merrimack Station with closed-loop cooling at Unit 1 and operational measures to reduce cooling water flow in combination with an upgraded fish return system at Unit 2, expressed as adult equivalents per year (assuming spring outages for Unit 2 and fall outages for Unit 1):

Unit	Type of impact	Maximum flow with existing sluice	Maximum flow with upgraded sluice	Reduced flow with upgraded sluice	Percent reduction due to reduced flow alone	Total percent reduction
Unit 1	Impingement mortality	371	202	22	89.3	94.2
	Entrainment	7,167	7,167	437	93.9	93.9
	Total	**7,537**	**7,368**	**459**	**93.8**	**93.9**
Unit 2	Impingement mortality	282	141	79	44.1	72.1
	Entrainment	10,027	10,027	4,958	50.5	50.5
	Total	**10,308**	**10,167**	**5,037**	**50.5**	**51.1**
Both units combined	Impingement mortality	653	342	100	70.7	84.6
	Entrainment	17,193	17,193	5,396	68.6	68.6
	Total	**17,846**	**17,536**	**5,496**	**68.7**	**69.2**

Attach. 6, Table 6-10. Summary of potential reductions in impingement mortality and entrainment at Merrimack Station with closed-loop cooling at Unit 2 and operational measures to reduce cooling water flow in combination with an upgraded fish return system at Unit 1, expressed as adult equivalents per year (assuming spring outages for Unit 1 and fall outages for Unit 2):

Unit	Type of impact	Maximum flow with existing sluice	Maximum flow with upgraded sluice	Reduced flow with upgraded sluice	Percent reduction due to reduced flow alone	Total percent reduction
Unit 1	Impingement mortality	371	202	152	24.4	58.9
	Entrainment	7,167	7,167	4,604	35.8	35.8
	Total	**7,537**	**7,368**	**4,756**	**35.5**	**36.9**
Unit 2	Impingement mortality	282	141	12	91.7	95.9
	Entrainment	10,027	10,027	453	95.5	95.5
	Total	**10,308**	**10,167**	**465**	**95.4**	**95.5**
Both units combined	Impingement mortality	653	342	164	52.1	74.9
	Entrainment	17,193	17,193	5,057	70.6	70.6
	Total	**17,846**	**17,536**	**5,221**	**70.2**	**70.7**

Attach. 6, Table 6-11. Summary of potential reductions in impingement mortality and entrainment at Merrimack Station with closed-loop cooling at Unit 1 and Unit 2, expressed as adult equivalents per year (assuming spring outages for Unit 2 and fall outages for Unit 1):

Unit	Type of impact	Maximum flow with existing sluice	Maximum flow with upgraded sluice	Reduced flow with upgraded sluice	Percent reduction due to reduced flow alone	Total percent reduction
Unit 1	Impingement mortality	371	202	22	89.3	94.2
	Entrainment	7,167	7,167	437	93.9	93.9
	Total	**7,537**	**7,368**	**459**	**93.8**	**93.9**
Unit 2	Impingement mortality	282	141	11	92.1	96.1
	Entrainment	10,027	10,027	241	97.6	97.6
	Total	**10,308**	**10,167**	**253**	**97.5**	**97.6**
Both units combined	Impingement mortality	653	342	33	90.4	95.0
	Entrainment	17,193	17,193	679	96.1	96.1
	Total	**17,846**	**17,536**	**711**	**95.9**	**96.0**

Attach. 6, Table 6-12 Impingement mortality reduction potential for operational measures that reduce intake flows at Units 1 and 2 of Merrimack Station in combination with an upgraded fish return sluice (recommended Best Technology Available option), assuming existing intake screens.

	June 2005-June 2006		July 2006-June 2007		June 2005-June 2007	
	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]	Estimated[d]	Adult Equivalents[e]
UNIT 1						
Number of fish impinged at maximum flow[a]	1,775	648	365	93	2,141	742
Number of fish impinged at reduced flow[b]	1,350	480	282	71	1,632	551
Impingement reduction (%)	*23.9*	*26.0*	*22.8*	*23.9*	*23.8*	*25.7*
Screen survival (#)[c]	823	275	174	42	997	317
Screen survival (%)	*60.9*	*57.3*	*61.9*	*59.5*	*61.1*	*57.6*
Screen + upgraded sluice survival (#)[f]	627	226	125	26	752	251
Upgraded sluice survival (%)	*76.3*	*82.1*	*71.7*	*60.3*	*75.5*	*79.2*
Total mortality reduction (%)[g, h]	**59.3**	**60.8**	**57.1**	**51.2**	**58.9**	**59.6**
UNIT 2						
Number of fish impinged at maximum flow[a]	5,460	367	941	197	6,400	564
Number of fish impinged at reduced flow[b]	2,897	221	671	133	3,568	354
Impingement reduction (%)	*46.9*	*39.8*	*28.7*	*32.7*	*44.3*	*37.3*
Screen survival (#)[c]	1,905	172	493	98	2,398	270
Screen survival (%)	*65.8*	*77.9*	*73.5*	*73.8*	*67.2*	*76.3*
Screen + upgraded sluice survival (#)[f]	1,577	116	409	80	1,986	196
Upgraded sluice survival (%)	*54.4*	*52.7*	*61.0*	*60.1*	*55.7*	*55.5*
Total mortality reduction (%)[g, h]	**75.8**	**71.5**	**72.2**	**73.1**	**75.3**	**72.1**

[a]Numbers impinged estimated from 24-hour sample collections (June 2005-June 2007, adjusted for collection efficiency; Normandeau 2007) and based on maximum Merrimack Station intake flow.

[b]Flow reductions include (1) head loss due to river level fluctuation, (2) maintenance outages for Unit 2 in the spring and Unit 1 in the fall, (3) single-pump operation at Unit 2 during 15 December-15 March, and (4) recirculation of 8 MGD at Unit 1 and 13 MGD at Unit 2 during 15 December-15 March.

[c]Based on average seasonal latent 24-hour screen survival tests using golden shiner (Normandeau 2007).

[d]Estimated impingement calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)

[e]Adult equivalents calculated for species representing 90% of total impingement at Merrimack Station (bluegill, black crappie, pumpkinseed, largemouth bass, yellow perch, spottail shiner; Normandeau 2007)

[f]Return sluice counts adjusted for survival based on results of Indian Point sluice survival test (See sluice survival table).

[g]Percent reduction in mortality rates resulting from operational measures to reduce flow in conjunction with installation of an upgraded fish return sluice at Merrimack Station, compared to impingement at maximum flow with the existing fish return sluice, based on Merrimack Station impingement rates for June 2005 to June 2007.

[h]Assumes an existing sluice survival rate of zero.

ASSUMPTIONS

Existing screens operated continuously during April-December with a state-of-the-art fish return system. Impingement mortality 100% during January-March due to ice preventing operation of fish return system. Cooling water pumping rate reduced to 48,000 gpm at Unit 1 and to 130,000 gpm at Unit 2 due to head loss resulting from river level fluctuations. Unit 1 maintenance outages of 4 weeks in October every 2nd year, with every 3rd biennial outage extended 4 additional weeks in September. Unit 2 maintenance outages ending 15 June every year, 4 weeks long except 8 weeks long every 5th year. Unit 2 operated at 50% flow (1 circulating water pump off) during 15 December-15 March each year. River withdrawal reduced by 8 MGD at Unit 1 and by 13 MGD at Unit 2 during 15 December-15March each year by recirculating discharge flow into the intake.

Normandeau (Normandeau Associates Inc.). 2007. Entrainment and Impingement Studies at Merrimack Generating Station: Draft Report June 2005-June 2007. September 2007.

Attach. 6 Table 6-13. Summary of potential reductions in impingement mortality and entrainment at Merrimack Station Unit 1 and Unit 2 with maintenance outages scheduled to reduce cooling water flow during peak entrainment periods, in combination with an upgraded fish return system, expressed as adult equivalents per year.

Unit	Type of impact	Maximum flow with existing sluice	Maximum flow with upgraded sluice	Reduced flow with upgraded sluice	Percent reduction due to reduced flow alone	Total percent reduction
Unit 1	Impingement mortality	371	202	194	3.7	47.7
	Entrainment	7,167	7,167	7,167	0.0	0.0
	Total	**7,537**	**7,368**	**7,361**	**0.1**	**2.3**
Unit 2	Impingement mortality	282	141	125	11.1	55.6
	Entrainment	10,027	10,027	5,340	46.7	46.7
	Total	**10,308**	**10,167**	**5,465**	**46.3**	**47.0**
Both units combined	Impingement mortality	653	342	319	6.8	51.1
	Entrainment	17,193	17,193	12,506	27.3	27.3
	Total	**17,846**	**17,536**	**12,826**	**26.9**	**28.1**

Attach. 6 Table 6-14. Summary of potential reductions in impingement mortality and entrainment at Merrimack Station Unit 1 and Unit 2 with single-pump operation of Unit 2 during 15 December-15 March, in combination with an upgraded fish return system, expressed as adult equivalents per year.

Unit	Type of impact	Maximum flow with existing sluice	Maximum flow with upgraded sluice	Reduced flow with upgraded sluice	Percent reduction due to reduced flow alone	Total percent reduction
Unit 1	Impingement mortality	371	202	202	0.0	45.6
	Entrainment	7,167	7,167	7,167	0.0	0.0
	Total	**7,537**	**7,368**	**7,368**	**0.0**	**2.2**
Unit 2	Impingement mortality	282	141	105	25.2	62.6
	Entrainment	10,027	10,027	10,027	0.0	0.0
	Total	**10,308**	**10,167**	**10,132**	**0.3**	**1.7**
Both units combined	Impingement mortality	653	342	307	10.4	53.0
	Entrainment	17,193	17,193	17,193	0.0	0.0
	Total	**17,846**	**17,536**	**17,500**	**0.2**	**1.9**

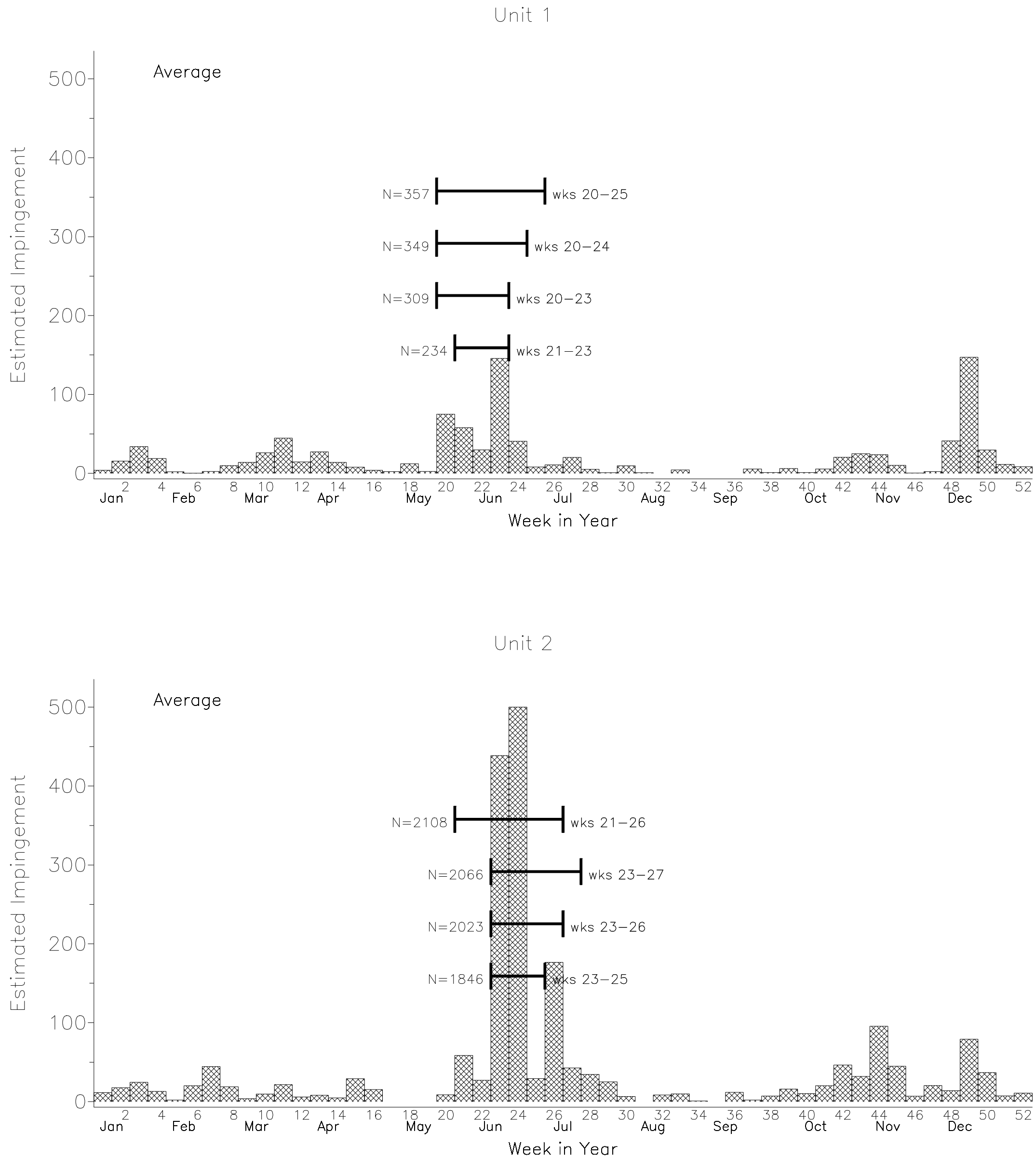


Figure 1a. Weekly total impingement of fish at Units 1 and 2 of Merrimack Station based on average daily impingement estimates from late-June 2005 through late-June 2007. Brackets represent maximum estimated impingement for 3, 4, 5, and 6 consecutive weeks. Note week 52 represents last 8 days of a year.

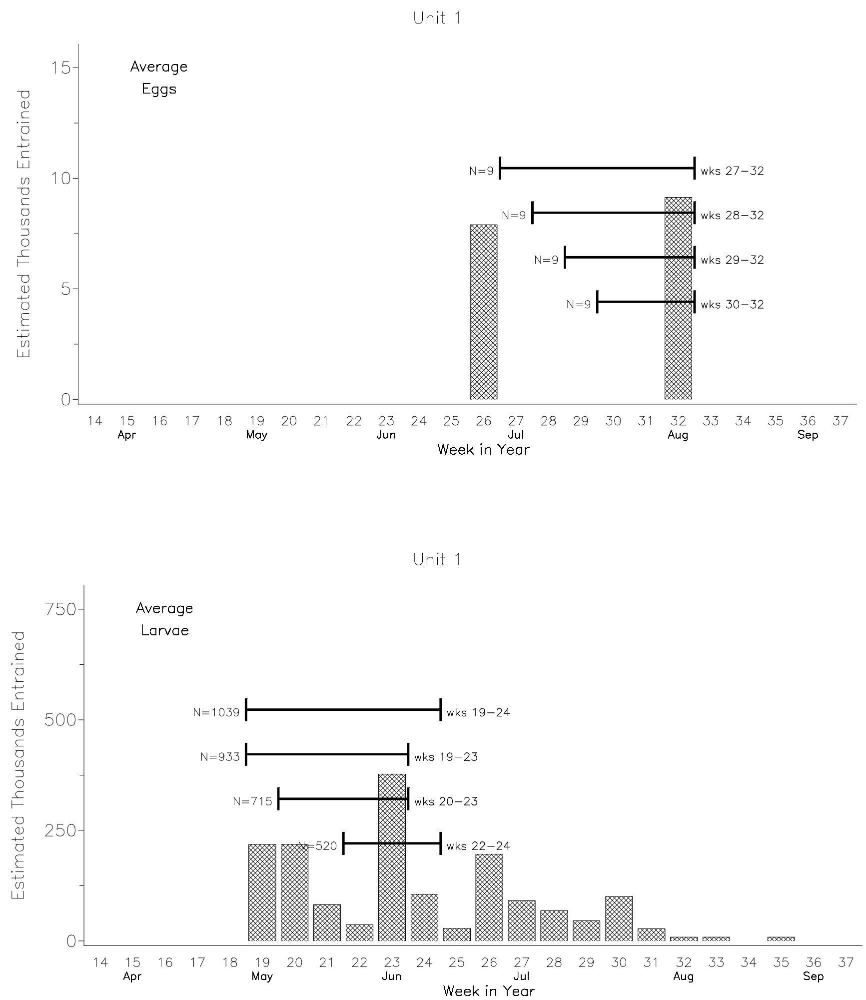
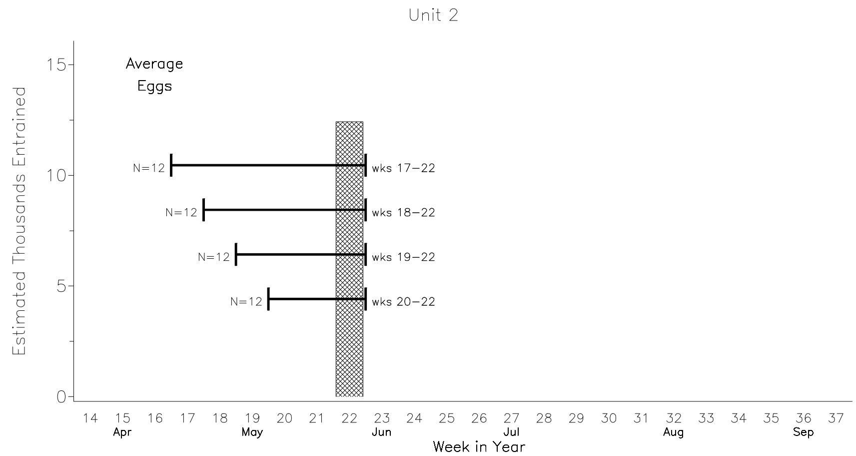


Figure 1b (Unit 1). Estimated weekly entrainment of fish eggs (top) and larvae* (bottom) at Unit 1 from April through mid-September at Merrimack Generating Station. Brackets indicate maximum entrainment for periods of 3, 4, 5, and 6 consecutive weeks.

* includes yolk-sac larvae, post-sac larvae, young-of-the-year, and unidentified.

Note: Entrainment is assumed to be zero or negligible during other months due to the absence of larval stages of local fish species.



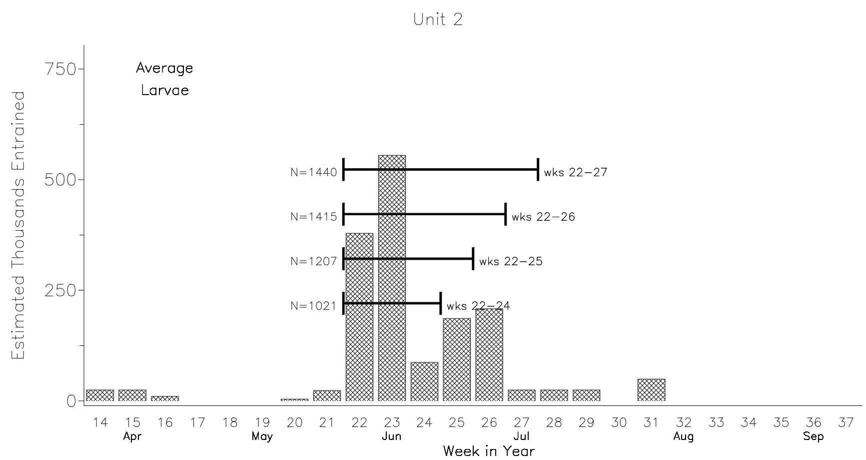


Figure 1b (Unit 2). Estimated weekly entrainment of fish eggs (top) and larvae* (bottom) at Unit 2 from April through mid-September at Merrimack Generating Station. Brackets indicate maximum entrainment for periods of 3, 4, 5, and 6 consecutive weeks.

* includes yolk-sac larvae, post-sac larvae, young-of-the-year, and unidentified.

Note: Larval entrainment is assumed to be zero or negligible during other months due to the absence of larval stages of local fish species.

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Table A. Percent reductions of selected species at Merrimack Station for a range of exclusionarly mesh widths for entrainment estimates based on actual plant flow.

	Egg diameter (mm)				2006 Estimated Entrainment				2007 Estimated Entrainment			
Species	**Range**	**Average**	**YSL Width (mm)**	**PYSL Width (mm)**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**
White sucker	**2-3.6**	**2.8**	**1.5**	**1.7**	0	0	1,160,036	1,160,036	0	0	1,120,929	1,120,929
Yellow perch	**2.3-3.5**	**2.9**	**1.0**	**2.0**	0	0	49,671	49,671	0	0	443,750	443,750
Spottail shiner	1.0-1.4	1.2	0.8	1.0								
Carp and Minnow Family	**1.0-1.4**	**1.2**	**0.8**	**1.0**	0	49,556	956,166	1,005,722	7,899	162,284	422,449	592,632
Bluegill		0.38	1.1	1.1								
Pumpkinseed	0.3-1.0	0.7	0.7	0.8								
Black crappie		0.9		1.3								
Largemouth bass	1.4-2.0	1.7	1.5	2.3								
Smallmouth bass	1.8-2.8	2.3	1.8	2.9								
Sunfish Family		**1.2**	**1.3**	**1.7**	0	43,103	345,373	388,476	0	44,205	143,892	188,097
OVERALL ENTRAINMENT REDUCTION (%)					0	92,659	2,511,246	2,603,905	7,899	206,489	2,131,020	2,345,408

	2.0 mm								1.5 mm							
	2006 % Reduction				2007 % Reduction				2006 % Reduction				2007 % Reduction			
Species	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**
White sucker			0%	0%			0%	0%			100%	100%			100%	100%
Yellow perch			50%	50%			50%	50%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	0%	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		0%	0%	0%	0%	0%	0%	0%		0%	100%	89%		0%	100%	76%
OVERALL ENTRAINMENT REDUCTION (%)				1%				9%				60%				73%

	1.0 mm								0.8 mm							
	2006 % Reduction				2007 % Reduction				2006 % Reduction				2007 % Reduction			
Species	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**
White sucker			100%	100%			100%	100%			100%	100%			100%	100%
Yellow perch			100%	100%			100%	100%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	50%	48%	100%	0%	50%	37%		50%	100%	98%	100%	50%	100%	86%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%
OVERALL ENTRAINMENT REDUCTION (%)				80%				84%				99%				97%

Table B. Percent reductions of selected species at Merrimack Station for a range of exclusionarly mesh widths for entrainment estimates based on the design flow (maximum capacity).

	Egg diameter (mm)				2006 Estimated Entrainment				2007 Estimated Entrainment			
Species	**Range**	**Average**	**YSL Width (mm)**	**PYSL Width (mm)**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**
White sucker	**2-3.6**	**2.8**	**1.5**	**1.7**	0	0	1,320,727	1,320,727	0	0	1,381,150	1,381,150
Yellow perch	**2.3-3.5**	**2.9**	**1.0**	**2.0**	0	0	53,556	53,556	0	0	541,671	541,671
Spottail shiner	1.0-1.4	1.2	0.8	1.0								
Carp and Minnow Family	**1.0-1.4**	**1.2**	**0.8**	**1.0**	0	53,438	1,071,716	1,125,154	11,246	196,686	520,325	728,257
Bluegill		0.38	1.1	1.1								
Pumpkinseed	0.3-1.0	0.7	0.7	0.8								
Black crappie		0.9		1.3								
Largemouth bass	1.4-2.0	1.7	1.5	2.3								
Smallmouth bass	1.8-2.8	2.3	1.8	2.9								
Sunfish Family		**1.2**	**1.3**	**1.7**	0	49,267	425,485	474,752	0	105,924	184,208	290,132
OVERALL ENTRAINMENT REDUCTION (%)					0	102,705	2,871,484	2,974,189	11,246	302,610	2,627,354	2,941,210

	2.0 mm								1.5 mm							
	2006 % Reduction				2007 % Reduction				2006 % Reduction				2007 % Reduction			
Species	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**
White sucker			0%	0%			0%	0%			100%	100%			100%	100%
Yellow perch			50%	50%			50%	50%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	0%	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		0%	0%	0%	0%	0%	0%	0%		0%	100%	89%		0%	100%	76%
OVERALL ENTRAINMENT REDUCTION (%)				1%				9%				61%				72%

	1.0 mm								0.8 mm							
	2006 % Reduction				2007 % Reduction				2006 % Reduction				2007 % Reduction			
Species	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**	**Eggs**	**YSL**	**PYSL**	**TOTAL**
White sucker			100%	100%			100%	100%			100%	100%			100%	100%
Yellow perch			100%	100%			100%	100%			100%	100%			100%	100%
Spottail shiner																
Carp and Minnow Family		0%	50%	48%	100%	0%	50%	37%		50%	100%	98%	100%	50%	100%	86%
Bluegill																
Pumpkinseed																
Black crappie																
Largemouth bass																
Smallmouth bass																
Sunfish Family		100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%
OVERALL ENTRAINMENT REDUCTION (%)				80%				84%				99%				97%

ASSUMPTIONS, ETC.

1. Spottail shiner is representative for the carp and minnow family due to its high abundance in Hooksett Pool
2. Took average of 5 common centrarchid species to represent the entrainment catch that was identified to sunfish family
3. If a mesh size and egg/larvae diameter are the same value, it is assumed that 50% of the entrainment catch will pass through the screen
4. Mesh sizes of 3mm and 2.5 mm offer 0 % reduction in entrainment
5. Table A presents entrainment values based on actual plant flows, Table B presents entrainment values based on the design flow (maximum capacity) of Units 1 & 2 (59,000 gpm and 140,000gpm, respectively) as obtained from the Merrimack Station PIC.

Table 10 - Normandeau Calculation of Entrainment Reduction for Fine Mesh Wedgewire Screens

Attachment 7

Construction Schedule

Construction Schedule

Conversion Of Both Units At Merrimack Station To Closed-Loop Cooling

The construction schedule on the following page is based on a one year overall construction timeframe and a seven week two-unit plant outage. Although the one year construction time period is somewhat arbitrarily due to inherent flexibility in man-loading, the seven week outage time period is considered largely inflexible due to the severe complexities and man-power loading restrictions associated with the outage critical-path activities, including tying-in the circulating water return piping to the existing cooling water intake structures (CWISs).

These complexities partly stem from the fact that the circulating water return flows for each unit must split shortly before reaching their respective CWISs so that both pumps in each CWIS are supplied an equal amount of flow. This task is further complicated by the fact that the Unit 1 54" circulating water return piping and another large bore pipe carrying half the circulating water return flow for Unit 2 must pass under the existing large bore Unit 2 circulating water piping. In addition, half of the Unit 1 circulating water return flow must pass under the existing large bore Unit 1 circulating water piping. This excavation and undermining of the existing large bore piping cannot be performed while the units are on line.

Other tasks at the intakes that must be performed while offline are the cutting of penetrations into the sides of the CWISs for final tie-in, creating a leak-tight tie-in of the circulating water return piping to the new penetrations, upgrading the existing sluice gates that isolate the pumps from the river, and installing tower makeup pumps and valves that will draw makeup water from the river and into the pump wells. Some preparatory work at the CWISs such as sheet piling coffer dam creation and dewatering can be performed in the period leading up to the outage.

Additional tasks that must be completed during the seven week two-unit outage include:

- High-voltage tie-ins at each Unit's switchyard to supply the new substations.
- Condenser tube-cleaning system tie-ins
- Installation of face/bypass valves on the circulating water discharge lines to supply the new booster pumping station
- Testing of newly installed components at the CWIS and booster pumping station prior to placement into service

It is believed that the 7 week outage duration is conservative, representing best-case construction scenarios, and that emergent issues and/or weather based delays may extend the projected outage duration considerably. Likewise, it is believed that the proposed overall construction schedule may extend beyond the duration indicated, as it is based on heavy man-loading and best-case construction conditions.

Activity ID	Activity Name	Physical % Complete	Remaining Duration	Start	Finish	Total Float
PSNH - Closed-Loop Conversion			240	Jan-01-09 A	Dec-02-10	0
Design Engineering			41	Jan-01-09 A	Feb-26-10	199
0001	Design Engineering	0%	41	Jan-01-09 A	Feb-26-10	199
Cooling Tower Conversion Construction Schedule			240	Jan-01-10	Dec-02-10	0
Mobilization			10	Jan-01-10	Jan-14-10	0
0100	Mobilization	0%	10	Jan-01-10	Jan-14-10	0
General Site Modifications			25	Jan-15-10	Feb-18-10	0
0200	Clearing, Grubbing, Fencing, Storm Drainage, etc.	0%	25	Jan-15-10	Feb-18-10	0
Units Online - Construction			185	Jan-15-10	Sep-30-10	45
Cooling Tower			65	Jan-15-10	Apr-15-10	165
0300	Construct Tower (CT) Basin	0%	20	Jan-15-10	Feb-11-10	0
0301	Erection of Cooling Tower	0%	40	Feb-12-10	Apr-08-10	0
0302	Install Automated Control System	0%	5	Apr-09-10	Apr-15-10	165
New Cooling Water Discharge and Supply Piping			180	Jan-15-10	Sep-23-10	50
0400	Cooling Water Discharge & Supply Piping	0%	180	Jan-15-10	Sep-23-10	50
Electrical			80	Mar-19-10	Jul-08-10	105
0500	Const Substation for CT & Booster Pumping Station	0%	40	Mar-19-10	May-13-10	0
0501	Install Feeds from Substation to Cooling Tower	0%	20	May-14-10	Jun-10-10	0
0502	Install Electrical On Tower	0%	10	Apr-09-10	Apr-22-10	160
0503	Install Feeds from Substation to Booster Pumping Station	0%	20	Jun-11-10	Jul-08-10	0
Existing CWIS's Mods			75	Jun-18-10	Sep-30-10	0
0600	CWIS Mods	0%	75	Jun-18-10	Sep-30-10	0
Booster Pumping Station			120	Feb-19-10	Aug-05-10	85
0700	Construct Pump House	0%	110	Feb-19-10	Jul-22-10	85
0701	Install Booster Pumps & Piping	0%	10	Jul-23-10	Aug-05-10	85
Units Offline - Construction			40	Oct-01-10	Nov-25-10	5
0800	U1 C.W. Piping Tie-In to Existing Screewell	0%	35	Oct-01-10	Nov-18-10	0
0801	U2 C.W. Piping Tie-In to Existing Screenwell	0%	25	Oct-01-10	Nov-04-10	10
0802	Booster Pumping Station Piping Tie-In	0%	10	Nov-05-10	Nov-18-10	10
0803	Electrical High-Voltage Tie-Ins at Switchyard	0%	10	Oct-01-10	Oct-14-10	35
0804	Condenser Tube Cleaning System Tie-Ins	0%	20	Oct-01-10	Oct-28-10	5
0805	Testing & Commissioning	0%	10	Nov-12-10	Nov-25-10	5
Demobilization			10	Nov-19-10	Dec-02-10	0
0900	Demobilization	0%	10	Nov-19-10	Dec-02-10	0