ELECTRIC POWER
RESEARCH INSTITUTE

December 18, 2017

Ms. Sharon DeMeo
U.S. Environmental Protection Agency – Region 1
Office of Ecosystem Protection, Industrial Permits Branch
5 Post Office Square, Suite 100
Boston, MA 02109-3912

Subject: The Electric Power Research Institutes (EPRI) Technical Comments in Response to *Substantial New Questions and Possible New Conditions for the Merrimack Station Draft NPDES Permit that are Now Subject to Public Comment During the Comment Period Reopened by EPA under 40 C.F.R. § 124.14(b))*

Dear Ms. DeMeo:

EPRI appreciates the opportunity to provide comments to the U.S. Environmental Protection Agency Region 1 in response to the subject as requested by The New Hampshire Department of Environmental Services (NHDES) and the United States Environmental Protection Agency (EPA or the Agency) in Public Notice NH-008-17 dated August 2, 2017. The attached comments (and supporting references not currently in the Administrative Record) focus on two areas and three subjects:

- New Information Raising Substantial New Questions Pertaining to Permit Requirements for Cooling Water Intake Structures Under Clean Water Act (CWA) § 316(b) [specifically on wedge wire screens for fish protection];
- New Information Raising Substantial New Questions Regarding the Application of CWA § 316(a) and New Hampshire Water Quality Standards for Setting NPDES Permit Requirements for Merrimack Station's Thermal Discharges
    - New information concerning Merrimack Station's waste heat discharges and their effects on Merrimack River water temperatures; and
    - New information concerning the presence of the Asian clam, an invasive freshwater mollusk, in the Merrimack River in the vicinity of Merrimack Station

Please also note that EPRI is also separately submitting comments on EPA's draft determination of technology-based effluent limits for flue gas desulfurization (FGD) and bottom ash wastewater at Merrimack Station. Those comments will be submitted by my colleague Paul Chu.

If you have any questions on our comments, please contact me at ddixon@epri.com or 607-869-1025.

Happy Holidays,

Douglas A. Dixon, PhD
Technical Executive & Program Manager
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c: Jon Black, EPRI
Jessica Fox, EPRI

Technical Comments On: New Information Raising Substantial New Questions for Public Comment for Merrimack Station Draft NPDES Permit NH0001465

Technical Comments Submitted Electronically to:

Ms. Sharon DeMeo
U.S. Environmental Protection Agency – Region 1
Office of Ecosystem Protection, Industrial Permits Branch
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Boston, MA 02109-3912

Technical Comments On: New Information Raising Substantial New Questions for Public Comment for Merrimack Station Draft NPDES Permit NH0001465

Technical Comments, December 2017

The Electric Power Research Institute (EPRI) prepared this report

NOTE

ACKNOWLEDGMENTS

The Electric Power Research Institute (EPRI) prepared this report.

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1 INTRODUCTION

Background

The Electric Power Research Institute, Inc. (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States, and international participation extends to 40 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass. EPRI does not advocate regulatory or policy action, our objective is simply to document the technical implications of the regulation or policy or the scientific/engineering information that supports such actions. This document presents EPRI's comments on *Substantial New Questions and Possible New Conditions for the Merrimack Station Draft NPDES Permit that are Now Subject to Public Comment During the Comment Period Reopened by EPA under 40 C.F.R. § 124.14(b))* as requested by The New Hampshire Department of Environmental Services (NHDES) the United States Environmental Protection Agency (EPA or the Agency) in Public Notice NH-008-17 dated August 2, 2017 and subsequently discussed.

NHDES and EPA Region 1 have reopened the comment period for the draft National Pollutant Discharge Elimination System (NPDES) permit for the Merrimack Station power plant in Bow, NH (NPDES Permit No. NH0001465). The Merrimack Station power plant is owned and operated by Public Service of New Hampshire (PSNH), which is a subsidiary of Eversource Energy. EPA is working to reissue the NPDES permit under the Section 402 of the Clean Water Act (CWA).

EPA has determined that various data, information and arguments submitted during prior comment periods, or that were submitted or became known to EPA after the comment periods, raised substantial new questions concerning the Merrimack Station Draft Permit. In response, EPA reopened the comment period to provide the public with an opportunity to comment on the new information and the substantial new questions. EPA has also responded to the new information and questions by developing options for new (or revised) Draft Permit conditions, and by developing new (or revised) analyses in support of the Draft Permit conditions. In connection with the reopened comment period, EPA has prepared a Statement of Substantial New Questions for Public Comment to describe the new information, the substantial new questions, the potential new permit conditions, and the new supporting analyses, so that the public can review the material and comment on it to EPA. The technical areas and questions EPA is requesting public comment on and to which EPRI submits technical comments include:

- New Information Raising Substantial New Questions Pertaining to Permit Requirements for Cooling Water Intake Structures Under CWA § 316(b):
    a. [Question #3] New information regarding the efficacy of cylindrical wedgewire screen technology for reducing impingement mortality and entrainment by cooling water intake structures;
    b. [Question #4] New information concerning cylindrical wedgewire screen design (e.g., wedgewire "half-screens") that could facilitate deploying the technology at Merrimack Station;
- New Information Raising Substantial New Questions Regarding the Application of CWA § 316(a) and New Hampshire Water Quality Standards for Setting NPDES Permit Requirements for Merrimack Station's Thermal Discharges
    a. [Question #6] New information concerning data reflecting Merrimack Station's waste heat discharges and their effects on Merrimack River water temperatures;
    b. [Question #7] New information concerning the presence of the Asian clam, an invasive freshwater mollusk, in the Merrimack River in the vicinity of Merrimack Station;
    c. [Question #8] Questions about whether any of this new information (i.e., the thermal data and the Asian clam data) should lead to changes either to EPA's decision to deny PSNH's request for renewal of its existing thermal discharge variance under CWA § 316(a), 33 U.S.C. § 1326(a), or EPA's analysis of how to apply New Hampshire water quality standards to the regulation of Merrimack Station's thermal discharges;
- NOTE: New Information Concerning New Technology-Based Standards for FGD Wastewater, Bottom-Ash Wastewater, Combustion Residual Leachate, and Non-Chemical Metal Cleaning – specifically, EPRI comments on the draft determination of technology-based effluent limits for flue gas desulfurization and bottom ash wastewater at Public Service of New Hampshire Merrimack Station have been submitted separately by Paul Chu of EPRI.

Organization of EPRI's Technical Comments

Following this Introduction, EPRI has organized our technical comments into four major sections as follows:

- Section 2: Technical Comments on New Information Raising Substantial New Questions Regarding the Efficacy of Cylindrical Wedgewire Screen Technology for Reducing Impingement Mortality and Entrainment by Cooling Water Intake Structures
- Section 3: Technical Comments on New Information Raising Substantial New Questions Regarding the Application of CWA § 316(a) and New Hampshire Water Quality Standards for Setting NPDES Permit Requirements for Merrimack Station's Thermal Discharges
- Section 4: Technical comments on new information concerning the presence of the Asian clam, an invasive freshwater mollusk, in the Merrimack River in the vicinity of Merrimack Station

The final Section 5 contains a listing of new citations used in our comments and submitted to the Administrative Record.

2
TECHNICAL COMMENTS ON NEW INFORMATION RAISING SUBSTANTIAL NEW QUESTIONS REGARDING THE EFFICACY OF CYLINDRICAL WEDGEWIRE SCREEN TECHNOLOGY FOR REDUCING IMPINGEMENT MORTALITY AND ENTRAINMENT BY COOLING WATER INTAKE STRUCTURES

EPA invites public comment on all the issues and information concerning cylindrical wedgewire screens discussed in their Statement of Substantial New Questions for Public Comment, including the following:

EPA Question: *the extent to which wedgewire screens with different screen slot sizes can prevent mortality to aquatic life from entrainment and/or impingement and satisfy the BTA requirements of CWA § 316(b)*;

The broad EPA questions addressed by these comments are:

- New Technical Reports Assessing the Efficacy of Cylindrical Wedgewire Screen Technology for Reducing Impingement Mortality and Entrainment by Cooling Water Intake Structures.
- New Information Concerning Cylindrical Wedgewire Screen Design that Could Make the Technology Easier to Deploy at the Merrimack Station.

Additional and sub-questions expressed by EPA highlighted in italics below are also addressed.

EPRI Comment: The administrative record for the Merrimack Station NPDES permit contains ample evidence that cylindrical wedgewire screens (CWWS) of various slot widths can reduce entrainment and impingement at the station sufficient to satisfy BTA requirements. Although some of the evidence was not available at the time EPA reached its 2011 determination, for example AR-1401, AR-1402, AR-1403, AR-1418, AR-1420, AR-1421), the information developed in these recent research efforts expands and supports prior knowledge of CWWS efficacy, rather than supplants it.

That CWWS would act through a combination of modalities, i.e., physical exclusion, active avoidance, and hydraulic bypass, has been recognized, if not explicitly quantified, from the earlier studies of the technology.

A few key examples from the literature on the technology are:

Otto, R. G., T. I. Hiebert, and V. R. Kranz. 1981. The effectiveness of a remote profile-wire screen intake module in reducing the entrainment of fish eggs and larvae. Pp. 47-56 in Dorn and Johnson (1981).

This study examined efficacy of a 3-ft diameter, 13-ft long, 1-mm slot width CWWS in a side channel of the Mississippi River. The screen was oriented parallel to the ambient currents, which ranged from 1.2 to 2.7 fps, with through-slot velocity 0.4 fps, thus a velocity ratio of 3 to nearly 7. Densities of ichthyoplankton in water drawn through the screen was compared to densities in control samples collected with towed plankton nets and with nets fixed in place beside the CWWS.

Densities of eggs (primarily freshwater drum), and larvae of emerald shiner, carp, and freshwater drum were significantly lower in the CWWS samples than in either type of control samples. For all species of larvae, except crappie, Control sample densities were at least five times as high as the CWWS densities. In addition, larvae collected in CWWS samples were significantly smaller than larvae collected in the controls. For CWWS samples, few larvae were longer than 8 mm, although longer larvae were common in the plankton net controls. Crappie larvae exhibited similar densities in CWWS and net samples; but were smaller in size in CWWS samples.

The authors attributed the density reductions for eggs to exclusion, but concluded that exclusion could not explain the reduction of smaller larvae, particularly slender larvae, which could easily pass through the 1-mm slot. The authors attributed the reduced entrainment of smaller larvae through the CWWS to an ability to sense and react to the flow field perturbations induced by the entrainment flow, and for larvae larger than 8 mm to swimming ability which would allow them to escape entrainment even if they came in direct contact with the screen surface.

Zeitoun, I. H., J. A. Gulvas, and D. Roarabaugh. 1981. Effectiveness of fine-mesh cylindrical wedgewire screens in reducing entrainment of Lake Michigan ichthyoplankton. *Canadian Journal of Fisheries and Aquatic Sciences* 38:120-125.

This study examined two sizes of CWW screens at the bottom of Lake Michigan near the J. H. Campbell power plants. One screen was 14.5 in. in length, 18-in. in diameter, with a slot width of 2 mm. The other was 12 in. in length, 15 in. diameter, and a slot width of 9.5 mm (approximately the standard 3/8" mesh of traveling screens). Both screens were designed to withdraw at 0.5 fps. through-slot velocity at the flow rate used for the study. For comparison to CWWS samples, control samples were collected using a 6-in. diameter open pipe and using a towed 0.5 m plankton net.

Common taxa were Rainbow Smelt, Yellow Perch, Alewife, carp, whitefish, unidentified herring/smelt, and unidentified cyprinid minnows. For all larvae, there was no significant difference between larval densities entrained by the 2.0 mm and 9.5 mm screens. The mean density of larvae in the combined CWWS samples was about 68% of the density of larvae in the open pipe control samples, but only 8% of the density in the towed net samples. Egg densities in the CWWS samples and control pipe samples were much greater in the towed net samples.

The authors attributed the results for all but minnow larvae to active avoidance of the CWW screens and the open pipe by larvae. They concluded that about 90% of the native fish larvae at the site avoided entrainment and open pipe sampling, raising the issue of the appropriate control sampling methodology for comparison with the CWWS sample.

Jude, D. J., C. P. Madenjian, P. J. Schneeberger, H. T. Tin, P. J. Mansfied., T. L. Rutecki, G. E. Noguchi, and G. R. Heufelder. 1982. Adult, Juvenile, and Larval Fish Populations in the Vicinity of the James. H. Campbell Plant, 1981, with Special Reference to the Effectiveness of the Wedge-wire Intake Screens in Reducing Entrainment and Impingement of Fish. Special Report Number 96. Great Lakes Research Division, The University of Michigan, Ann Arbor.

This study examined entrainment through a working CWWS providing water to Unit 3 of the J. H. Campbell plant on Lake Michigan. The submerged intake draws water through a CWWS array of screens 48 in.-long, with a diameter of 48 in, and slot openings were 9.5 mm. Design through-slot velocity was 0.38 fps. The array was at a depth of 35 ft and surrounded by a riprap wall, which provided habitat for some local fishes. Sampling was performed in 1980 and 1981 to compare densities of fish eggs and larvae entrained through the CWWS to densities in Lake Michigan near the intake using towed plankton nets.

Although densities of fish larvae in CWWS samples were generally lower than in the lake samples, high sampling variability resulted in few statistically significant differences. Significantly higher densities in CWWS samples were found for Yellow Perch larvae and Slimy Sculpin. The authors attributed this to the riprap wall providing spawning habitat for these species at the edge of the CWWS array. Densities of Alewife larvae were significantly lower and lengths were significantly smaller in CWWS samples than in lake samples. Entrained Yellow Perch, Spottail Shiner, Trout-Perch, and Johnny Darter larvae were also smaller than larvae collected in lake samples. The authors attributed the reduced densities and size differences to active avoidance of the CWWS by larger larvae. Due to the location within the riprap wall, sweeping flows would be reduced, and with 9.5 mm slot width, exclusion of larvae and eggs would not occur.

Weisberg, S. B., W. H. Burton, E. A. Ross, and F. Jacobs. 1984. The effects of screen slot size, screen diameter, and through-slot velocity on entrainment of estuarine ichthyoplankton through wedge-wire screens. Prepared by Martin Marietta Environmental Systems, Inc. for Maryland Power Plant Siting Program.

Weisberg, S. B., W. H. Burton, F. Jacobs, and E. A. Ross. 1987. Reductions in ichthyoplankton entrainment with fine-mesh, wedge-wire screens. *North American Journal of Fisheries Management* 7:386-393.

In this study, CWWS were evaluated at the intake of the Chalk Point Steam Electric Station on the Patuxent River, MD. The screens ranged from 18 to 34 in. in length, and 21 to 30 in. in diameter, with slot widths of 1, 2, and 3 mm. CWWS samples were compared to control samples collected by pumping through an open-port pumped, and with plankton nets. Bay Anchovy and Naked Goby were the most common species collected.

Larval entrainment densities increased as slot width increased, however, the increase was not statistically significant due to low numbers captured in the CWWS samples. Consistent with other studies that used open-port and towed net control samples, higher densities in the plankton net samples indicated significant larval avoidance of the open ports. CWWS efficacy was near zero for small larvae (~4 mm), but for larger Bay Anchovy larvae efficacy ranged from 45% to 100% (open port controls) and 62% to 100% (plankton net controls), with higher efficacy for larger larvae. Naked Goby larvae showed a similar pattern with efficacy ranging from 41% to 97% (open port controls) and 81% to 97% (plankton net controls) as size increased. Except for the largest size class, efficacy declined slightly with increasing slot width. Efficacy for Bay Anchovy eggs was 66% for the 2-mm screens and 73% for the 1-mm screens.

Consistent with other studies, these results demonstrate: 1) CWWS efficacy is an increasing function of larval length, 2) avoidance of the screens is a significant modality of effectiveness, and 3) larval avoidance of open ports significantly biases efficacy estimates.

These results demonstrate that CWWS' mode of action is a combination of avoidance, bypass, and exclusion are consistent with the work done by EPRI (2005, 2006).

Electric Power Research Institute (EPRI). 2005. Field evaluation of wedgewire screens for protecting early life stages of fish at cooling water intake structures. Palo Alto, CA. EPRI Report 1010112.

EPRI 2006. Field evaluation of wedgewire screens for protecting early life stages of fish at cooling water intake structures: Chesapeake Bay studies. Palo Alto, CA. EPRI Report 1012542.

In 2005 and 2006, EPRI published results of field tests of CWW screen efficacy performed in Sakonnet River, RI, the Portage River, OH, and in Chesapeake Bay. The studies used small CWWS with slot width of either 0.5 or 1 mm. Intake velocities were 0.5 and 1 fps. Both studies compared densities of eggs and larvae entrained through CWWS to control densities collected by an intake with a 9.5 mm mesh and plankton net tows.

The 0.5 mm screens were more effective than the 1 mm screens at reducing entrainment. Larval length significantly influenced CWWS efficacy, consistent with exclusion of larvae with head widths larger than the slot widths. Efficacy estimates were based only on comparisons between CWWS densities and control intake densities, even though densities of larvae in towed net samples were often higher than control port densities. Large larvae were most common in the net samples.

Although not explicitly discussed in the reports, the results were consistent with avoidance of the CWWS by larger larvae being an important factor in CWWS efficacy.

These studies are all evidence of the multiple modes of effectiveness of CWWS beyond that of simple passive filters, which can allow high efficacy of CWWS with slot widths larger than 1 mm. The more recent studies (AR-1401, AR-1402, AR-1403, AR-1420, AR-1421) already in the administrative record have provided quantification of expected efficacy as a function of organism size, through-slot and sweeping current velocities, and slot widths.

One additional aspect of CWWS efficacy is that the more valuable, from a population perspective, members of the ichthyoplankton community receive the highest level of protection. The larger larvae and early juveniles, which typically have a far greater probability of surviving to adulthood, than eggs and smaller larvae, are protected by all three modes of effectiveness, while the less valuable stages may principally be protected by hydraulic bypass, and exclusion for small-slot screens. Thus, a strictly numerical view of effectiveness as percent reduction of total entrained ichthyoplankton may greatly underestimate the biological effectiveness of CWWS technology.

As a final point, it is important to note that physical exclusion of early life stages by CWWS may not have the protective effect that is desired. Recent work (EPRI 2017) on survival of eggs and larvae excluded by fine-mesh traveling screens has shown that it is better to let them be entrained, at least at the site studied, than to collect them on a traveling screen. The question of subsequent survival of eggs and larvae excluded by CWWS has not yet been investigated thoroughly.

EPA Question: *the likely expense of using wedgewire screens at Merrimack Station;*

EPRI Comment: EPRI has not investigated the expense of CWWS installation and use at Merrimack Station. However, the probable cost of the CWWS would be significantly less, as much as an order of magnitude, than a closed cycle cooling (CCC) alternative (EPRI 2012), and quantitative estimates of the cost should be far less uncertain for CWWS than for CCC due to the lower engineering complexity and lack of effect on the thermodynamic processes involved in electrical generation.

EPA Question: *if wedgewire screens are the BTA, or part of the BTA, at Merrimack Station, should wedgewire half-screens or standard wedgewire screens be used;*

EPRI Comment: Studies performed to date have used full cylindrical screens. However, for the Merrimack Station, the water depths are not sufficient to support a typical full-cylinder installation. There appears to be no reason to believe that half-screens would perform differently than full cylindrical screens if the same design principles are used to maintain even flow distribution and low slot velocities over the screen face.

EPA Question: *how the costs of using wedgewire screens compare to the benefits of using them, and how those costs and benefits compare to the costs and benefits of using closed-cycle cooling as part of the BTA;*

EPRI Comment: As commonly occurs, it is highly likely that the social costs of the CWWS alternative are far higher than the monetized benefits. Whether the costs of CWWS sufficiently outweigh the benefits to rule out CWWS as BTA is a social issue and EPRI offers no comment on that decision. However, in comparison, costs of a CCC alternative are likely to be far greater (EPRI 2012), and far more uncertain, than the CWWS alternative.

EPA Question: *which months (e.g., April 1 through August 31, April 1 through July 31), if any, should wedgewire screens be implemented as the BTA for controlling entrainment; and*

EPRI Comment: Entrainment BTA is only needed during the time when entrainable life stages are present. Although entrainment numbers are generally lower in August than in earlier spring and summer months, those organisms that would be entrained may be older (PYSL and early juvenile stages) and therefore more valuable from a population perspective. Thus, since CWWS would be installed already, it would make sense to operate them during August to the extent that river flow and debris fouling permit.

EPA Question: *whether Merrimack Station should be permitted to bypass the screens and if so, under what circumstances should this be allowed.*

EPRI Comment: Low river flows or screen fouling could trigger the need to bypass the system in order to obtain sufficient cooling water flow to maintain station operations. Without experience with CWWS on the Merrimack River, it is not possible to accurately determine the frequency or severity of fouling events that would require bypass of the CWWS system. If CWWS are selected as BTA for either entrainment and/or impingement, the station will be able to monitor conditions that necessitate bypass and report to EPA on bypass events.

EPA invites comments on the issues discussed above regarding the BTA for impingement mortality control at Merrimack Station, including the following:

EPA Question: *whether wedgewire screens, closed-cycle cooling, or some other technology or combination of technologies should be the BTA for controlling impingement mortality at the Facility?*

EPRI Comment: If wedgewire screens are designed to provide a maximum through-slot velocity of 0.5 fps or less, then they would meet criteria to be determined to be BTA under § 125.94 (c)(2). Even if through-slot velocity exceeded 0.5 fps, wedgewire screens would still provide impingeable fishes the opportunity to escape impingement, and the ambient currents would assist fish that are impinged in escaping from the screen surface. For these reasons, wedgewire screens alone could qualify as impingement BTA under (c)(6) or (c)(7).

EPA Question: if either wedgewire screens or closed-cycle cooling are the BTA, or part of the BTA, for controlling impingement mortality, should they be deployed all year or only during certain months and, if the latter, during which months should they be used?

EPRI Comment: The protective aspects of wedgewire screens for impingeable fish are that fish may not be impinged due to the low through-slot velocities, and that fish that may be impinged would be swept from the screen surface or assisted in escape from the screen surface by ambient currents. All of this occurs without fish being removed from their habitat. If CWWS technology is in place as BTA for part of the year, then use of some other technology during another part of the year, which would require additional capital costs and may not be as effective, would require strong justification. Occasional by-pass of the CWWS system during periods of extreme fouling would not constitute such justification unless bypass events are frequent and prolonged.

EPA Question: if wedgewire screens are used, will screen fouling by debris or frazil ice be a problem at certain times of the year and, if so, how and when should the problem be managed;

EPRI Comment: EPRI cannot provide comment on the expected frequency of CWWS fouling at the Merrimack station. However, EPRI's ongoing program on debris management at cooling water intakes (refs) would indicate that debris fouling is typically episodic and seasonal in nature. Prior history suggests that debris fouling would be triggered by high-flow events, particularly during spring and fall. Biofouling typically occurs during summer months when ambient river temperatures are high. Although systems can be installed to alleviate fouling, such as air burst and brush cleaning for debris/biofouling and warm water recirculation for frazil ice, there may still be occasions when a bypass system is required to maintain station operation.

EPA Question: if wedgewire screens are used, should PSNH be authorized to “bypass” the screens under certain conditions and, if so, should additional protective measures for impingement be required during those periods?

EPRI Comment: Without a bypass to allow maintenance of the plants heat sink, damage to the screens and to the plant could be catastrophic; i.e., the wedgewire screens could collapse requiring complete replacement and the plants condenser system could be severely damaged resulting in long-term (weeks, months) of outage to effect repairs. Plant outage may have local impacts on grid reliability and result in potential increase in rate payers cost. Bypasses are common at most plants including those with traveling water screens. Bypasses are typically actuated when pressure differential across the screen face reach a predetermined safety point.

3

TECHNICAL COMMENTS ON NEW INFORMATION RAISING SUBSTANTIAL NEW QUESTIONS REGARDING THE APPLICATION OF CWA §316(A) AND NEW HAMPSHIRE WATER QUALITY STANDARDS FOR SETTING NPDES PERMIT REQUIREMENTS FOR MERRIMACK STATION'S THERMAL DISCHARGES

Introduction

In September 2011, EPA Region 1 issued a draft National Pollutant Discharge Elimination System (NPDES) permit for the Merrimack Station that called for restrictions in the discharge of waste heat to protect the aquatic communities in the Merrimack River, the waterbody receiving Merrimack's thermal discharge. The need for these restrictions was based on a detailed analysis by EPA of the real and potential biological effects of Merrimack's thermal discharge that was described in Attachment D to this draft permit. Since the release of this draft permit, there has been extensive commenting on the conclusions reached in Attachment D as well as submittal of new information relative to the impacts of Merrimack's thermal discharge. As a result, on August 2, 2017, EPA reopened the comment period on this draft permit. With regard to thermal issues at Merrimack, EPA invited:

- *"… additional public comment addressing the … issues and materials relevant both to EPA's decision on PSNH's CWA § 316(a) variance application and to EPA's application of New Hampshire water quality standards with regard to thermal effects. In particular, EPA invites public comment on:*
- *the import of PSNH's new data submissions for EPA's application of CWA § 316(a) and New Hampshire's water quality standards in developing thermal discharge standards for the Merrimack Station permit;*
- *the question of how shorter-term and longer-term thermal data should be factored into the evaluation under CWA § 316(a) and New Hampshire's water quality standards of the effects of Merrimack Station's thermal discharges on the Hooksett Pool and the development of thermal discharge limits for the Merrimack Station permit; and*
- *EPA is considering the above-mentioned material from Dr. Barnthouse, AR-1352, Attachments 2 and 3, and invites the public to review and comment on the import of this new information.*
- *Moreover, additional public comment is solicited regarding any thermal discharge-related materials submitted to EPA since closure (on February 28, 2012) of the public comment period on the 2011 Draft Permit…"*

EPRI's comments begin with a brief review of background information relative to this topic including: (1) the regulation of thermal discharges from steam-electric power plants; (2) relevant standards and criteria relative to Merrimack's thermal discharge; and (3) the current NPDES permit limits for Merrimack. Next, we review and summarize the technical basis for EPA's revised thermal limits in Merrimack's draft permit (2011 and 2014 revision). Thereafter, we review and summarize relevant new technical information submitted subsequent to the 2011 draft permit. Finally, we provide a discussion of key technical issues relative to the potential thermal impacts that EPA may wish to consider in making a final permit determination for the Merrimack Station.

For clarity, throughout this section USEPA refers to the Environmental Protection Agency's Headquarters in Washington, D.C. while EPA refers to the Environmental Protection Agency's Region 1 Office (New England). EPA serves as the Regional Administrator for Merrimack's NPDES permit whereas USEPA provides oversight and guidance relative to the NPDES permitting program.

Background Information

Regulation of Thermal Pollution under Clean Water Act

The Clean Water Act clearly defines heat as a pollutant. Thus, the discharge of heat to the Nation's waters is prohibited unless explicitly authorized by a National Pollutant Discharge Elimination System (NPDES) permit. However, Congress recognized the unique nature of thermal pollution, including rapid dissipation and lack of accumulation, and included a special variance process in Section 316(a):

> *"With respect to any point source otherwise subject to the provisions of section 301 or section 306 of this Act, whenever the owner or operator of any such source, after opportunity for public hearing, can demonstrate to the satisfaction of the Administrator (or, if appropriate, the State) that any effluent limitation proposed for the control of the thermal component of any discharge from such source will require effluent limitations more stringent than necessary to assure the projection [sic] and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on the body of water into which the discharge is to be made, the Administrator (or, if appropriate, the State) may impose an effluent limitation under such sections on such plant, with respect to the thermal component of such discharge (taking into account the interaction of such thermal component with other pollutants), that will assure the protection and propagation of a balanced indigenous population of shellfish, fish and wildlife in and on that body of water."*

In September 1974 and May 1977, USEPA issued draft guidance for the § 316(a) variance process (USEPA 1974 and 1977). Although never finalized, these draft documents are still commonly used as guidance for the conduct of demonstration studies as part of the application for a § 316(a) variance.

What is a Balanced Indigenous Population?

40 CFR § 125.71 defines "balanced, indigenous population of shellfish, fish and wildlife" as synonymous with "balanced, indigenous community" meaning:

> *"a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack*

of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the Act; and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to section 316(a)." [§ 125.71]

The terms balanced, indigenous population (BIP) and balanced, indigenous community (BIC) are used interchangeably in the § 316(a) variance literature.

Applicable Water Quality Standards and Criteria for Merrimack

The State of New Hampshire defines the waters of the Merrimack River in the vicinity of the Station as Class B. Class B is the second highest quality, considered acceptable for fishing, swimming and other recreational purposes and, after adequate treatment, for use as water supplies.

The State does not have numeric temperature criteria for its surface waters. Instead, it relies on the following general narrative standard:

> *"There shall be no disposal of sewage or waste into said waters except those which have received adequate treatment to prevent the lowering of the biological, physical, chemical or bacteriological characteristics below those given above, nor shall such disposal of sewage or waste be inimical to aquatic life or to the maintenance of aquatic life in said receiving waters. "*

Further, with respect to discharge of heat, New Hampshire Code of Administrative Rules requires:

> *"Any stream temperature increase associated with the discharge of treated sewage, waste or cooling water, water diversions, or releases shall not be such as to appreciably interfere with the uses assigned to this class."*

Current NPDES Permit Requirements

The existing NPDES permit for the Merrimack Station was originally issued in 1992 and was administratively continued thereafter. The fact sheet for this permit reviews the regulatory history associated with § 316(a) decisions for the Station and concluded that:

> *"…the Regional Administrator granted a 316(a)-variance based upon the previous hydrological and biological studies and upon the absence of detectable environmental impacts upon the local indigenous fish during the during the operating history of the station. It is noted that neither the State nor EPA are aware of any fish kills associated with the thermal plume within the discharge canal or in the main stream of the river itself, since the station began operation."*

Further, this permit does not include limits on the thermal discharge but, instead, contains the following provision with regard to temperature:

"… power spray module system shall be operated, as necessary, to maintain either a mixing zone (station S-4) river temperature not in excess of 69ºF, or a station N-10 to S-4 change in temperature (Delta-T) of not more than 1ºF when the N-10 ambient temperature exceeds 68ºF."

This permit finally specified that thermal plume from the Station should not block the zone of fish passage, should not change the balanced indigenous population (BIP) of the receiving water, and should have minimal contact with the surrounding shorelines.

Relative to the use of 69ºF as a regulatory trigger, EPA offers the following explanation:

> *"The 69°F Tmix is recommended, for the present, since it represents the most environmentally conservative case under the State of New Hampshire's cold water fishery thermal limitations, i.e., 68°F ambient plus 1°F temperature rise."* [AR 681 p. 28].

EPA's Draft NPDES Permit

On September 30, 2011, EPA released a draft permit for the Merrimack Station (EPA 2011) for public review and comment[1]. This draft permit required, among other things, for the Merrimack Station to substantially reduce its thermal load to the river.

The stated reason for this requirement was that PSNH:

> *"…has failed to demonstrate that the plant's past and current thermal discharges have not resulted in prior appreciable harm to the balanced, indigenous population of shellfish, fish, and wildlife in Hooksett Pool of the Merrimack River.*

Further, based on its own extensive analysis of thermal data:

> *"EPA concludes that Merrimack Station has a significant capacity to thermally impact Hooksett Pool. This conclusion is based on the:*
>
> - *short length and shallow depths of Hooksett Pool;*
> - *significant fraction of shallow water habitat in the lower pool affected by the plume during summer months;*
> - *quantity of water withdrawn, heated, and discharged by Merrimack Station;*
> - *high and persistent temperatures above ambient associated with the plume under typical summer conditions;*
> - *plume's tendency to extend across the entire width of the river;*
> - *plume's demonstrated capacity to cause water column stratification, which can contribute to low dissolved oxygen events above Hooksett Dam low flows in Hooksett Pool typical during summer months (i.e., July, August, September)."*

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[1] AR – 618.

Finally, using fisheries data EPA concluded that:

> *"…the evidence as a whole indicates that Merrimack Station's thermal discharge has caused, or contributed to, appreciable harm to Hooksett Pool's balanced, indigenous community of fish."*

Based on the above information, EPA rejected PSNH's request for a § 316(a) variance continuation at the Merrimack Station and imposed the significantly reduced thermal loading limit in the draft permit.

The analysis of the effects of Merrimack's thermal discharge on the aquatic community consisted of a predictive and a retrospective (No Prior Appreciable Harm) assessment as described in EPA's Draft § 316(a) Technical Guidance. The predictive assessment was based on EPA's understanding of the thermal exposures together with information on thermal sensitivities of representative fish species. The retrospective assessment compared the current fish community to that reported from the Hookset Pool of the Merrimack River in the 1960s.

In April 2014, EPA issued a revised draft permit for Merrimack. This revision technology-based requirements limiting pollutant discharges from Merrimack Station's flue gas desulfurization (FGD) system. In this revised draft permit, EPA did not alter its analysis and conclusions with regard to thermal issues at the Station.

Relevant New Information

Since release of the draft NPDES permit for Merrimack in 2011, several reports and other information have become available that EPRI believes are relevant to the questions raised about the potential impacts of the Station's thermal discharge on the aquatic communities in the Merrimack River, particularly the Hooksett Pool. Relevant information from each of these items that EPRI has identified are discussed below.

Normandeau Associates, Inc. Comments on EPA's Draft Permit for Merrimack Station (Normandeau 2012)

In 2012, Normandeau Associates, Inc.[2] submitted comments on the draft 2011 draft permit for Merrimack. These comments were supported by five additional reports prepared by Normandeau and submitted in conjunction with these comments:

1. Merrimack Station Fisheries Survey Analysis of the 1972-2011 Catch Data;
2. Historic Water Quality and Selected Biological Conditions of the Upper Merrimack River, New Hampshire;
3. Changes in the Composition of the Fish Aggregation in Black Rock Pool in the Vicinity of Cromby Generating Station from 1970 to 2007;

[2] Normandeau Associates, Inc. was the principal biological consultant to PSNH for NPDES permitting at the Merrimack Station and conducted virtually all biological and water quality monitoring of the Merrimack River associated with addressing potential biological effects of Merrimack's thermal discharge.

4. Quantification of the Physical Habitat within Garvins, Hooksett and Amoskeag Pools of the Merrimack River;

5. Comparison of Benthic Macroinvertebrate Data Collected from the Merrimack River near Merrimack Station.

As part of these comments, Normandeau also conducted and extensive review of existing biological and thermal data and contrary to the findings of EPA in the draft 2011 permit for Merrimack, concluded:

> *"There have not been appreciable decreases in all coolwater fish species in Hooksett Pool over time.*
>
> *There have not been appreciable increases in warmwater species in Hooksett Pool over time.*
>
> *There have not been appreciable decreases in the diversity of species in Hooksett Pool over time. In fact, the Shannon Diversity Index value shows that the current fish population in Hooksett Pool is more diverse now than it was forty years ago.*
>
> *There have not been appreciable increases in the abundance of generalist feeders or pollution tolerant species in Hooksett Pool over time.*

When compared to Garvins Pool (the thermally uninfluenced impoundment immediately upstream from Hooksett Pool, and the proper reference to which to compare Hooksett Pool), the biocharacteristics of the fish population in Hooksett Pool in general, and of the individual species in Hooksett Pool in particular, indicate no appreciable harm to the BIP.

Review of Technical Documents related to NPDES Permitting Determinations for the Thermal Discharge and Cooling Water Intake Structures at Merrimack Station (Barnthouse 2016)

In 2015 and 2016, Larry Barnthouse, PhD. conducted an independent review of EPA's analysis of potential thermal effects that lead to their denial of the § 316(a) variance continuation in the draft 2011 permit. Dr. Barnthouse's report was submitted as an attachment to EverSource's letter to EPA on February 20, 2016 and concluded:

> *EPA's biological analysis of Merrimack Station's § 316(a) Demonstration contains three significant flaws that invalidate its conclusion that the operation of Merrimack Station with once-through cooling has caused appreciable harm to the BIP present in the Hooksett Pool of the Merrimack River. These flaws are:*
>
> - *Failure to account for the effects of historic water quality improvements when interpreting changes in the Merrimack River fish community;*
> - *Over-reliance on classification of fishes as "coolwater" or "warmwater" when interpreting population trends, and*
> - *Erroneous interpretation of Merrimack River temperature data when evaluating effects of thermal exposures on representative fish species.*

In his report, Dr. Barnthouse also analyzed existing biological data in the Merrimack River with regard to the potential impacts of the Station's thermal plume. Based on this analysis, Dr. Barnthouse concluded:

> *"The available benthic invertebrate community data support a conclusion that biological conditions in the Hooksett Pool have improved since the early 1970s, most likely as a result of improved sewage treatment. This improvement must be considered when interpreting data on changes in fish community composition over the past 40 years.*
>
> *The currently existing fish communities in Garvins Pool and Amoskeag Pool appear to me to be the most appropriate context for evaluating appreciable harm due to operation of Merrimack Station. All three pools have been influenced by the same historic water quality impacts, and subjected to the same influences of introduced (or naturally invading) species such as black crappie and bluegill. All three support roughly the same species, although the relative abundances vary."*

Finally, Dr. Barnthouse conducted a detailed review of thermal tolerance data for fish species common to the Hookset Pool and compared them to existing temperature data and concluded:

> *"A more in-depth review of thermal tolerance data for fish species discussed by EPA confirms that, consistent with their broad geographic distributions, these species have very broad temperature tolerances."*

and,

> *"EPA's attempt to define thermal tolerance criteria analogous to the toxicity-based water-quality criteria for chemicals is similarly unsupported by available information concerning the thermal tolerances of yellow perch and American shad."*

Exhibit G to AR-1369 Merrimack Station Capacity Factor Information (2016)

Since release of the draft NPDES permit for Merrimack in 2011, the energy supply market has changed substantially, especially in New England. Originally constructed as a baseload facility, Merrimack has been relegated to a peaking status as a result of competition from low cost natural gas fueled facilities and increasing air quality restrictions. This transition began around 2011 and has continued unabated as evidenced by the capacity factors graphs provided by PSNH in their submittal.

Anadromous Fish Restoration

Historically, the Merrimack River provided important habitat to anadromous fish species such as American Shad, river herring and Atlantic Salmon all the way up to Lake Winnipesaukee and beyond (Carpenter undated). However, River damming, deteriorating habitat and water quality and, possibly overfishing have all contributed to significant reductions in anadromous fish populations in the Merrimack. Some, like Atlantic Salmon, have even been extirpated (TCAFMMRB 1997).

As result of historic importance, considerable efforts have been expended at restoring viable runs of these anadromous species extending back more than 100 years. In recent years, fish ladders and other fish passage devices have been placed on dams allowing anadromous fish access to areas of the River up to the Hookset dam, immediately downstream of the Merrimack Station. In addition, Atlantic Salmon stocking has been conducted in an effort to restart a native run. While the restoration efforts utilizing fish passage have seen some success in the lower Merrimack River (especially in Massachusetts) for shad and river herring, there is no evidence that they are found in the vicinity of the Merrimack Station (Normandeau 2011). In addition, Atlantic Salmon stocking efforts in the Merrimack River were discontinued in 2015 owing to poor returns and budgetary concerns after a 38-year effort to restore salmon to the River (Lippa 2013).

Clarifications on Temperature Data

In its analysis of temperature data from the Merrimack River, EPA assumed that the temperature data provide in Normandeau (2007) reflected the 21-year average of the daily maximum temperatures for each day of the calendar year. However, as clarified by PSNH, the data represent the maximum of the daily averages that occurred on a given calendar day, possibly only one time, during the entire 21 years that monitoring data were collected (between 1984 and 2004).

After evaluating the new data received in response to its information request, EPA found that it did appear that the Agency had misunderstood the earlier temperature data because of confusing aspects of how it was presented.

Technical Issues Recommended for Consideration relative to Thermal Discharges from the Merrimack Station

Is There Evidence of an Adverse Impact from Merrimack's Thermal Discharge?

Based on their analysis of temperature and biological data, EPA concluded that Merrimack's thermal discharge "…caused, or contributed to, appreciable harm to Hooksett Pool's balanced, indigenous community of fish." Their analysis is consistent with a Type III demonstration (USEPA 1974) consisting of addressing Absence of Prior Appreciable Harm (Retrospective Analysis) and the Protection of Representative Species (Predictive Assessment). EPRI's comments on each are discussed below.

Retrospective Analysis

A retrospective analysis is another term for the No Prior Appreciable Harm Demonstration as defined in EPA's draft Technical Guidance. Such an analysis involves comparison of the existing aquatic community in areas exposed to the thermal plume (but outside allowable mixing zone) to that expected to occur if there was no thermal discharge.

What Is the Appropriate Balanced Indigenous Community for Merrimack?

The New Hampshire water quality standards require that the discharge of waste (including heat) not *"…be inimical to aquatic life or to the maintenance of aquatic life in said receiving waters."* This appears to be similar to (albeit potentially less restrictive than) the requirement in a § 316(a) variance to assure the protection and propagation of balanced indigenous population/community. Thus, by meeting the requirements for a § 316(a) variance, the NH water quality standards are also being met.

Accordingly, EPA's regulations provide for issuance of alternative thermal effluent limitations if *"…a balanced indigenous community of shellfish, fish, and wildlife"* (not necessarily particular populations within the community) will be maintained.[3] These regulations define a balanced indigenous community as:

> *"…a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species, and non-domination of pollutant-tolerant species."*

"Indigenous" generally refers to species that would normally be found at the site, although it is not restricted to only truly native species, since managed, introduced species are often included. The meaning of the term "indigenous" was explained by Congressman Clausen during House consideration of the Conference Report on the Clean Water Act on 4 October 1972:

> *"Indigenous" shall be interpreted to mean growing or living in the body or stretch of water at the time such determination is made.*[4]

EPA has interpreted the term more restrictively, but also acknowledges that "indigenous" does not mean communities that would exist in a water body only if it were in a pristine condition. In the preamble to its proposed 316(a) rules, EPA said:

> *An "indigenous" population may contain species not historically native to the area which have resulted from major irreversible modifications to the water body (such as hydroelectric dams) or to the contiguous land area (such as deforestation attributable to urban or agricultural development) or from deliberate introduction in connection with a program of wildlife management. To qualify for an exemption under Section 316(a), it is therefore not necessary to show that the discharge is compatible with a population which may have existed in a pristine environment, but which has not persisted.*[5]

EPA thus would make reversibility of environmental modifications the test for determining what communities should be considered "indigenous" to the area. If modifications "cannot reasonably be removed or altered," then an "indigenous" community will include resulting "species not historically native to the area."[6] On the other hand, "an altered community which has resulted from pollution that will be corrected by compliance by all sources with Section 301(b)" [i.e., effluent limitations and standards] will not be considered "indigenous."[7]

The term "balanced" derives from long-standing knowledge that most natural aquatic communities are composed of many species of organisms without an overwhelming number of any one of them. Ecologists have developed several formal indices of this community structure (e.g., indices of diversity, evenness, or richness). To be balanced, USEPA has indicated that an aquatic community must not be "dominated by pollution-tolerant species whose dominance is

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[3] 40 C.F.R., 125.73(a); 44 Fed. Reg. 32,952 (7 June 1979).

[4] Senate Comm. On Public Works, 93rd Cong., 1st Session, 1 A Legislative History of the Water Pollution Control Act Amendments of 1972 at 264 (Comm. Print 1973).

[5] 39 Fed. Reg. 11,435 (28 March 1974). See also USEPA, Proposed Guidelines for Administration of the 316(a) Regulations (Draft 18 April 1974)

[6] USEPA, 316(a Technical Guidance - Thermal Discharges (Draft 30 September 1974)

[7] 39 Fed. Reg. 36,178 (8 October 1974)

attributable to polluted water conditions."[8] However, species diversity at each trophic level is not required,[9] and some changes in species composition and abundance are consistent with a balanced community.

In EPRI's opinion, this definition makes it clear that the BIC is that would exist at the present time in the receiving waterbody absent the thermal discharge and, thus, reflect whatever hydraulic, chemical, habitat and other conditions exist at the time the permit is being issued. The community may include species that are introduced (either purposefully or not) provided that the occurrence of these species is not solely a result of the heated effluent.

At the Merrimack Station, the appropriate BIC would be that expected to occur in the Hooksett Pool if the Station had never been constructed but containing all other natural and manmade alternations existing at present. For existing facilities like Merrimack, the BIC is clearly a hypothetical construct. However, it appears reasonable that one could look to other areas of the River not affected by the thermal plume (but containing similar habitat and water quality). Ideally, it would be best to look at the aquatic community in the immediately upstream pool, taking into account differences between the two pools, to define the BIC. It might also be possible look at the community within the Hooksett Pool unaffected by the thermal discharge to define the BIC. However, in this case care would need to be applied to ensure that the thermal plume was not affecting motile organisms and thus, potentially affecting upstream areas as well.

In addition, a "balanced, indigenous community" appears directly analogous to "biological integrity" as included in New Hampshire's Water Quality Standards definitions:

> *"Biological integrity" means the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region." (Env-Wq 1702.08).*

This definition refers to a comparison *"…to that of similar natural habitats of a region*". This further reinforces the idea that in assessing the potential for a BIC, the comparison should be to contemporaneous community from another location with all other habitat characteristics being the same.

The Asian clam (*Corbicula fluminea*) identified in Hooksett Pool in 2011 downstream of the Station's discharge canal (see AR-870) is a nonindigenous aquatic species and not "historically native to the area". However, this species has also been recently identified upstream of the discharge canal, in one case 12 miles upstream, in addition to being confirmed in seven freshwater ponds in southern New Hampshire. Thus, a thermal discharge like Merrimack's is not a prerequisite for the Asian clam to become established and its presence in Hooksett Pool not necessarily solely the result of the Station's heated effluent. Evidence from Normandeau 2012 (see AR-870 and AR-872) and Barnthouse 2016 (see AR-1300) indicates that a BIC is present in Hooksett Pool and the biological integrity of the aquatic system is intact.

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[8] 39 Fed. Reg. 11,435 (28 March 1974). See also 40 C.F.R. 125.71(c), 44 Fed. Reg. 32,951-52 (7 June 1979).

[9] See 39 Fed. Reg. 36,178 (8 October 1974), explaining that USEPA's final 316(a) regulations were modified from the proposed regulations "to delete the suggestion that diversity must be present at all trophic levels."

What are the Appropriate Criteria to be used in Assessing Community Balance at Merrimack?

To demonstrate that a balanced indigenous community exists necessitates a case-by-case evaluation in the context of the waterbody and its biota. According to USEPA (1977), the following are evidence of community imbalance:

- Blocking or reversing short or long-term successional trends of community development.
- A flourishing of heat-tolerant species and an ensuing replacement of other species characteristic of the indigenous community.
- Simplification of the community and the resulting loss of stability.[10]

If a community is stable, not dominated by heat-tolerant species, and follows normal development patterns, it is balanced. In summary, a balanced, indigenous population (or community) is a stable, normally functioning community that is not dominated by heat-tolerant species and is consistent with the reasonably permanent environmental conditions of the water body, given potential water quality improvement.

Further, the legislative history of § 316(a) and the subsequent judicial and administrative decisions applying it make clear that the performance standard – the protection and propagation of a balanced, indigenous community – is not a complete lack of effects on that community. Some effects of added heat are to be expected. For example, EPA has recognized that "*[e]very thermal discharge will have some impact on the biological community of the receiving water*," and therefore that "*[t]he issue is the magnitude of the impact and its significance in terms of the short-term and long-term stability and productivity of the biological community affected.*" [11]

In general, EPA has determined that a community need not be protected from mere disturbance, but that communities will be adequately protected if "appreciable harm" is avoided.[12] [13] According to USEPA, "appreciable harm" occurs if a thermal discharge causes such phenomena as the following:

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[10] USEPA, 316(a)Technical Guidance - Thermal Discharges (Draft 30 September 1974) at 18-19.

[11] Boston Edison Company (Pilgrim Station Units 1 and 2), NPDES Permit Determination No. MA0025135 (Decision of the Regional Administrator, 11 March 1977) at 17.

[12] A draft 316(a) guidance document jointly prepared by USEPA, the Nuclear Regulatory Commission, and the U.S. Fish and Wildlife Service states: "The Regional Administrator (or Director) will find the demonstration successful if: 2. There is no convincing evidence that there will be damage to the balanced, indigenous community, or community components, resulting in such phenomena as those identified in the definition of appreciable harm." USEPA, NRC, and FWS, 316(a) Technical Guidance Manual (Draft 11 December 1975) at 100.

[13] USEPA's proposed 316(a) rules suggested that "appreciable harm" would occur whenever a balanced, indigenous population was "disturbed." Proposed 40 C.F.R. 122.8(a), 39 Fed. Reg. 11,437-38 (28 March 1974). Following the public comment period, USEPA revised this aspect of the rules, saying: "Comments from representatives of diverse interests suggested that the statute requires the inquiry to focus on harm to the community rather than to species; that 'disturbance', was a more rigorous test than called for by law. The regulations being promulgated today make it clear that the demonstration is concerned with the question of prior appreciable harm to--not 'disturbance' of--the community."

- Substantial increase in abundance or distribution of nuisance species or heat-tolerant community not representative of the highest community development achievable in receiving waters of comparable quality.
- Substantial decrease of formerly indigenous[14] species, other than nuisance species.
- Changes in community structure to resemble a simpler successional stage than is natural for the locality and season in question.
- Unaesthetic appearance, odor, or taste of the waters.
- Elimination of an established or potential economic or recreational use of the waters.
- Reduction of the successful completion of life cycles of indigenous species, including those of migratory species.
- Substantial reduction of community heterogeneity or trophic structure.[15]

Finally, the standard of proof under § 316(a) is one of reasonable assurance, not scientific certitude, because there are seldom, if ever, cases where such certitude is achievable in the quantification of environmental effects or their significance to biological communities. USEPA has described this standard of proof as follows:

> *The study must provide reasonable assurance of protection and propagation of the indigenous community. Mathematical certainty regarding a dynamic biological situation is impossible to achieve, particularly where desirable information is not obtainable. Accordingly, the Regional Administrator (or Director) must make decisions on the basis of the best information reasonably attainable. At the same time, if he finds that the deficiencies in information are so critical as to preclude reasonable assurance, then alternative effluent limitations should be denied.*[16]

USEPA has applied the “reasonable assurance” standard in numerous decisions implementing §316(a).[17]

Again, the guidance provided by USEPA for defining lack of appreciable harm appears to be similar to that used in New Hampshire Water Quality Standards:

> *“Differences from naturally-occurring conditions shall be limited to non-detrimental differences in community structure and function. (Env-Wq 1703.19)”*

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[14] The original meaning of this nonsensical term “formerly indigenous” may have been “formerly abundant indigenous species”

[15] USEPA, 316(a) Technical Guidance - Thermal Discharges (Draft 30 September 1974) at 23 (emphasis added); USEPA, NRC, and FWS, 316(a) Technical Guidance Manual (Draft 11 December 1975) at 105 (emphasis added).

[16] USEPA, 316(a) Technical Guidance - Thermal Discharges (Draft 30 September 1974) at 8.

[17] Public Service Company of New Hampshire (Seabrook Station Units 1 and 2), NPDES Appeal No. 76-7 (Decision of the Administrator, 10 June 1977) at 22; Public Service Company of New Hampshire, et al., (Seabrook Station Units 1 and 2), NPDES Appeal No. 76-7 (Decision on Remand, 4 August 1978) at 22; Boston Edison Company (Pilgrim Station Units 1 and 2), NPDES Permit Determination No. MA0025135, Decision of the Regional Administrator, 11 March 1977) at 15-16; Boston Edison Company (Pilgrim Station Units 1 and 2), NPDES Appeal No. 78-7 (Initial Decision, 26 July 1978) at 4-5.

Again, implying that some changes are allowed without adversely affecting biological integrity provided that they lead to "*…non-detrimental differences in community structure and function.*"

Characterization of Species into Thermal Tolerance Classes

The terms "warmwater", "coolwater" and "coldwater" for classifying fish species has a long history in the common vernacular. However, in the scientific literature, there are no generally accepted criteria for assigning fish species to these three classes. "Warmwater" generally refers to fish species that are best adapted to water temperatures >70°F (e.g., sunfishes and basses, catfishes) whereas "coldwater" species refer to those that are best adapted to water temperatures <60°F (e.g., trouts and salmons). The term "coolwater" is more nebulous and is often used to refer to species that do not cleanly fall into one of the other two categories.

Most fish species can be found over wide ranges in water temperatures and do not always fall into such neat categories as described above. Hence, there are often differences as to how fisheries scientists assign species to these categories. Hence, EPRI believes use of such categorizations in evaluating the protection and propagation of the BIC is fraught with uncertainty.

Predictive Assessment

A predictive assessment compares existing thermal exposures within the receiving waterbody to thermal tolerance data available for Representative Important Species (RIS) existing in the receiving waterbody.

What are the Appropriate RIS for Merrimack?

The EPA Draft 316(a) Guidance recognizes that it is impractical to study and assess in detail every species in the receiving waterbody. It is therefore necessary to select a smaller group to be representative of the BIC. These selected species are designated as RIS. Generally, 5 to 15 RIS are chosen to represent the community. According to the Draft 316(a) Guidance, criteria for selecting RIS include that the species are:

- Representative, in terms of their biological requirements, of a balanced indigenous community of fish, shellfish, and wildlife;
- Commercially and recreationally valuable;
- Threatened or endangered;
- Critical to the structure and function of the ecosystem (e.g., habitat formers);
- Potentially capable of becoming localized nuisance species; and
- Necessary in the food chain for the well-being of species determined above.

Other considerations for RIS selection include the species involvement with the thermal plume, the species thermal sensitivity, and the quantity and quality of information available for the assessment.

It is EPRI's opinion that the RIS selected for a predictive analysis of thermal effects at Merrimack should include only those aquatic species that currently reside in the Hooksett Pool or in the pools immediately upstream. Given the current lack of successful anadromous fish restoration efforts in the Hooksett Pool historically occurring species such as American Shad, river herring and Atlantic Salmon should not be included as there is virtually no likelihood of exposure to Merrimack's thermal discharges over the course of the new NPDES permit. Should restoration be successful, the potential impacts of Merrimack's thermal discharge can be addressed in future NPDES permits.

Assessing Thermal Exposures at Merrimack

The predictive assessment of Merrimack's thermal discharge begins with determining the magnitude and extent of potential exposures of the RIS to elevated temperatures from the discharge in the Merrimack River. EPRI believes that there are two important factors that should be considered in defining these exposures.

First, the potential thermal exposures should reflect likely operation of the Merrimack Station over the upcoming NPDES permit period (typically five years). As clearly demonstrated in ISO New England (2017), the Station no longer operates as a base-loaded facility as it had prior to 2010. Hence, temperature monitoring data collected prior to the draft NPDES permit (2011) does not reflect current conditions. The Merrimack Station operates principally as a peaking facility operating only when economic dispatch requires. A re-graphing of the generation data provided in ISO New England (2017) reveals a distinct seasonal pattern in operation (Figure 1). This graph clearly illustrates a substantial decline in the electrical generation at Merrimack since 2007 throughout the year except during winter. Hence, the magnitude and extent of thermal exposures to the aquatic community during most of the year are likely to be much lower than when Merrimack was operating as a baseload facility. During spring and summer, when biological productivity and potential for thermal stress is highest, Merrimack is typically operating at a capacity factor of less than 20 percent. That is only a small fraction of generating capacity of this facility prior to the 2011 draft NPDES permit. Only during winter, when natural gas availability constraints limit operation at other generating facilities is Merrimack called to run often. However, biological stresses from elevated temperatures at this time of the year should be minimal owing to low river water temperatures.

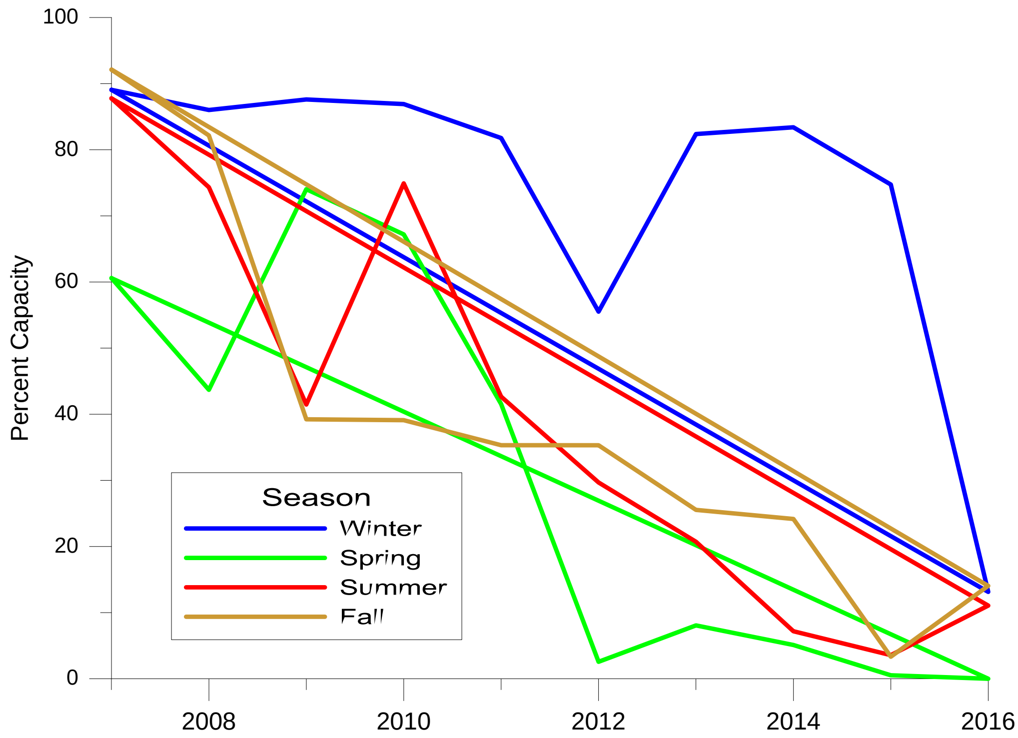

Figure 3-1. Trends in electrical generation by season at the Merrimack Station, 2007 - 2016.

Second, as in many states, NH Water Quality regulations allow for a mixing zone to all for discharged pollutants to mix with the receiving waters provided that the mixing zone:

"(a) Meets the criteria that surface waters shall be free from substances in kind or quantity that:

- *Settle to form harmful benthic deposits;*
- *Float as foam, debris, scum or other visible substances;*
- *Produce odor, color, taste or turbidity that is not naturally occurring and would render the surface water unsuitable for its designated uses;*
- *Result in the dominance of nuisance species; or*
- *Interfere with recreational activities;*

(b) Does not interfere with biological communities or populations of indigenous species;

(c) Does not result in the accumulation of pollutants in the sediments or biota;

(d) Allows a zone of passage for swimming and drifting organisms;

(e) Does not interfere with existing and designated uses of the surface water;

(f) Does not impinge upon spawning grounds or nursery areas, or both, of any indigenous aquatic species;

(g) Does not result in the mortality of any plants, animals, humans, or aquatic life within the mixing zone;

(h) Does not exceed the chronic toxicity value of 1.0 TUc at the mixing zone boundary; and

(i) Does not result in an overlap with another mixing zone. Within these designated mixing zones, water quality criteria do not apply. Use of mixing zones for thermal discharges is a very common practice and included in numerous NPDES permits at facilities nationwide.

While it is unclear if a formal mixing zone has been incorporated within Merrimack's NPDES permit, it is reasonable that one could be requested and granted. If this is the case, all evaluations of the potential for thermal effects (other than acute mortality) should be based on temperatures outside the mixing zone.

Application of Thermal Tolerance Information

The final step in the predictive assessment is comparison of the thermal exposures to thermal tolerance information for the RIS. Some key issues that EPRI believes need to be considered in applying thermal tolerance data include:

1. It is important to remember that most of the thermal tolerance data is based on laboratory studies. Numerous studies have found that laboratory-based studies do not accurately reflect effects observed in the real world (EPRI 2011).

2. Use of thermal tolerance information to predict thermal discharge effects do not consider the well-documented capability of motile organisms (e.g., fish) to avoid areas of thermal stress.

3. Predictive analyses presume that organisms are exposed to elevated temperatures continuously. Except for non-motile organisms, this is simply not the case. Aquatic organisms actively and passively move in and out of areas of higher temperatures. Hence, exposures to elevated temperatures are often short and can be substantially less than the durations used in thermal tolerance studies.

The peaking nature of Merrimack's current operation means that discharge temperatures can widely fluctuate following electrical demand, often over a 24-hour period. Hence, exposed organisms are afforded a recovery period between periods of thermal exposure. Bevelhimer and Fortner (2007) found: "Laboratory results suggest brief forays near critical temperatures are not necessarily harmful and recovery can be 100% after return to tolerable temperatures." Hence, the cycling nature of Merrimack's current operation might substantially reduce the biological effects of thermal discharges even though peak temperatures might approach those expected under baseline operation.

Setting Appropriate NPDES Permit Limits for Temperature at Merrimack

In addition to determining the acceptability of a 316(a) variance for Merrimack, the draft 2011 NPDES permit sets limits to the thermal discharges from the Station as none had been included in previous permits. EPRI believes there are some key issues that should be considered:

1. The thermal limits should account for allowable mixing zones and ensure protection of the BIC at the edge of the mixing zone but necessarily at Permit limits should be designed to protect the aquatic community being exposed within the Hooksett Pool at the present time, not species that might have inhabited the Pool in the past or might occur in the area in the future. Significant and adverse changes in the aquatic community, if any, that might occur in the future requiring more stringent thermal discharge limits should be addressed in future NPDES permit modifications. EPRI believes that given the recent detection of Asian clam in Hooksett Pool upstream and downstream of the thermal discharge, EPA should consider monitoring the species as part of future facility NPDES permit modifications. Further, that EPA may wish to study the Asian clam upstream and downstream of the thermal discharge for its potential direct correlation with the facility discharge, and its presence quantitatively assessed for adverse impacts to the BIC.

2. EPA may wish to consider numeric water quality criteria and/or permit limits established at for other thermal discharges to receiving waters with similar aquatic communities when establishing limits for Merrimack.

There is a wealth of new information relative to the assessment and regulation of thermal discharges in addition to the items listed above that has become available since the development of the 2011 draft NPDES permit. Much of this is summarized in EPRI (2012, 2016). We encourage consideration of all of this new information when setting appropriate NPDES permit limits for the Merrimack Station.

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4 NEW INFORMATION CONCERNING THE PRESENCE OF THE ASIAN CLAM, AN INVASIVE FRESHWATER MOLLUSK, IN THE MERRIMACK RIVER IN THE VICINITY OF MERRIMACK STATION

In their "Statement of Substantial New Questions for Public Comment", EPA observes that a new report submitted as part of the comments on the 2011 NPDES Draft Permit ("Comparison of Benthic Macroinvertebrate Data Collected from the Merrimack River near Merrimack Station During 1972, 1973, and 2011," dated January 2012. (Normandeau 2012)) the Asian clam was reported in the Hooksett Pool and that their concentration appears highest in areas affected by Merrimack's thermal discharge. Further:

> *EPA found this discovery worthy of further research because of the possibility that Merrimack Station's thermal discharge was contributing to the presence and/or prevalence of the Asian clam in the Hooksett Pool and the potential relevance of such a finding to regulating the Facility's thermal discharges under CWA § 316(a) and New Hampshire water quality standards. As explained in detail previously, CWA § 316(a) variance-based temperature limits must assure the protection and propagation of the balanced indigenous population of organisms, …, while New Hampshire water quality standards impose similar requirements for the protection of local aquatic life."*

The following provides EPRI's technical comments on this issue.

New Data and Information

The United States Geological Survey (USGS) Nonindigenous Aquatic Species (NAS) database is a searchable information resource established as a central repository for spatially referenced biogeographic accounts of introduced aquatic species. The program provides scientific reports, online/real-time queries, spatial data sets, distribution maps, and general information on a variety of introduced species. The geographical coverage for the database is the United States. One of the species catalogued in the NAS repository is the Asian clam (*Corbicula fluminea*). A link to the *C. fluminea* database can be found at: https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=92. The USGS cautions that all the NAS data are preliminary or provisional and are always subject to revision. Further, that the data should be reviewed carefully before using it for decisions or inclusion in scientific or technical publications and reports.

From the NAS database, clustered specimen records (CSRs) for *C. fluminea* are available for the Merrimack River drainage basin including the Merrimack River upstream and downstream of the Merrimack Station (Station) and several large ponds in southeastern New Hampshire in the counties of Hillsborough and Rockingham. The number of CSRs at any locale does not imply species abundance or dominance. The NAS data represent CSRs only and does not reflect the distribution or abundance of established populations within the Hooksett Pool, the Merrimack River or its drainage basin.

The CSRs listed in Tables 1 and 2 include new information on the occurrence of *C. fluminea* and add to the reports and information referenced in the EPA's Statement of Substantial New Questions and Possible New Conditions for Public Comment, Merrimack Station Draft NPDES Permit and, available at the electronic index to the Merrimack Station Administrative Record. A link to this new USGS NAS information can be found at: https://nas.er.usgs.gov/queries/CollectionInfo.aspx?SpeciesID=92&State=NH.

In its Statement for Public Comment, EPA notes that neither benthic sampling conducted by the New Hampshire Department of Environmental Services (NHDES) during 2013 (AR-1414), nor EPA dive investigations in 2014 (AR-1412), found evidence of Asian clams upstream of the Station in Hooksett Pool or Garvin's Falls Pool. As detailed in Table 1, two verified CSRs are available for the Merrimack River upstream of the Station's cooling water discharge in the reach of River located between the Gavin's Fall Dam and Hooksett Dam. The locations for these CSRs are upstream of the Station's discharge canal (N-0). Station N-10 from AR-870 (Normandeau, 2012) located in the Hooksett Pool was confirmed as an upstream control site for the assessment of the Station's potential thermal impacts to the macroinvertebrate community due to ambient water temperatures. One CSR is located approximately 3,800 feet upstream control Station N-10 and the other is located approximately 2,500 feet downstream of Station N-10. EPA notes that when the Station is operating, one of its most visible thermal effects can occur during periods in the winter when the river just upstream of the discharge canal is completely ice-covered, but the river is ice-free for miles downstream of the discharge canal, including in the waters of Amoskeag Pool just downstream of the Hooksett Dam.

The CSR recorded on July 12, 2017 (NAS sighting report) is from the west bank of the River, approximately 2,000 feet upstream of mouth of the Station's cooling water canal; the second CSR (NAS siting report) recorded on April 13, 2016 is from the east bank, approximately one mile upstream of mouth of the cooling water canal. Based on the reported latitudes and longitudes for the CSRs, specimen verifier (Dr. Terry Richardson, University of North Alabama) and CSR location descriptions, these two CSRs are not located at the same benthic macroinvertebrate stations sampled by Normandeau Associates in 2011 or by others in prior years and evaluated in Normandeau' s 2012 report for PSNH (see AR-870).

A third CSR recorded in 2016 is for a location approximately 12 miles north of the Station on the east bank of the River just south of the confluence with the Contoocook River near Penacook. The Hall Street Wastewater Treatment Plant is located on the opposite bank of this CSR location. This CSR was verified by the New Hampshire Dept. of Environmental Services (Smagula, A. P., NHDES) in 2016. *C. fluminea* at this location in the River, well upstream of the Station, indicates that this species can establish outside of the influence of a thermal discharge like that of the Station, provided that other habitat requirements for survival are fulfilled (. e.g., well oxygenated water, ambient temperatures of 2 – 36^{o}C, sand or gravel bottoms). Water quality and habitat data for this CSR location are not available from the USGS NAS database.

The fourth CSR for the River is from 2012 for a location approximately 4 miles downstream of the Station (downstream of the Hooksett Dam) in Merrimack. The status of *C. fluminea* at this location is listed as "unknown" and therefore not verified. The source reported by USGS is "map derived" from a June 2012 article in a local newspaper (Toole, J., Eagle Tribune). This CSR is located about mid-river near the Hooksett Wastewater Treatment Facility located at 1 Egawes Drive in Hooksett. Given that this CSR location is nearly 2 miles downstream of temperature monitoring Station A-0 (Amoskeag Pool) which Normandeau described as “representing the mixed in-river water temperature conditions found in the Hooksett Dam tailwaters” (see AR-872), *C. fluminea* at this CSR is likely not solely attributable, if at all, to the Station’s thermal discharge.

Table 4-1. USGS Nonindigeneous Aquatic Species (NAS) Database Records, *C. fluminea* CSRs from Merrimack River, NH

Scientific Name	State	County	Locality	Latitude	Longitude	Source	Accuracy	Drainage Name	Year	Month	Day	Status	Record	Type
Corbicula fluminea	NH	Merrimack	Merrimack River, east shore, approximately one mile upstream of mouth of cooling water canal	43.15493	-71.483	reported	Accurate	Merrimack River	2016	4	13	established	NAS sighting report	T. Richardson, U. of North Alabama
Corbicula fluminea	NH	Merrimack	Merrimack River, west shore, approximately 2000 feet upstream of mouth of cooling water canal	43.14261	-71.4682	reported	Accurate	Merrimack River	2017	7	12	established	NAS sighting report	T. Richardson, U. of North Alabama
Corbicula fluminea	NH	Merrimack	Merrimack River, east shore, approximately 12 miles upstream of facility near Penacook	43.28382	-71.5832	reported	Accurate	Merrimack River	2016			established	Literature	Database, NHDES, Amy Smagula
Corbicula fluminea	NH	Merrimack	Merrimack River, mid channel, between Bow and Merrimack, approximately 4 miles downstream of facility and Hooksett Dam	43.07165	-71.4647	Map derived	Accurate	Merrimack River	2012			unknown	Literature	News, Eagle Tribune

An additional eight CSRs for *C. fluminea* from the NAS database are reported from seven freshwater ponds in souutheast New Hamphire. The earliest record is June 2012 and the most recent is August 2017. These seven ponds, although not connected to the Merrimack River, are within the River's drainage basin. The physio-chemical conditions of the ponds are not provided in the USGS CSR database. Although *C. fluminea* is usually found in moving water because it requires high levels of dissolved oxygen, the species is documented to occur in lakes and streams of all sizes with silt, mud, sand, and gravel substrate (see AR-1408).

Table 4-2. USGS Nonindigenous Aquatic Species (NAS) Database, *C. fluminea* CSRs Ponds in Hillsborough and Rockingham Counties, NH

Scientific Name	State	County	Locality	Latitude	Longitude	Source	Accuracy	Drainage Name	Year	Month	Day	Status	Record	Type
Corbicula fluminea	NH	Hillsborough	Long Pond	42.70076	-71.3666	reported	Accurate	Merrimack River	2016	NR	NR	established	Literature	Database, NHDES, Amy Smagula
Corbicula fluminea	NH	Hillsborough	Little Island Pond [E of Pelham]	42.73186	-71.2922	reported	Accurate	Merrimack River	2017	8	17	established	NAS sighting report	T. Richardson, U. of North Alabama
Corbicula fluminea	NH	Rockingham	Cobbetts Pond, Windham	42.79787	-71.2878	GNIS	Accurate	Merrimack River	2012	6	5	unknown	Literature	News, Eagle Tribune
Corbicula fluminea	NH	Rockingham	Great Pond Kingston NH at public access launch facility off Main Street off NH SR 111	42.91393	-71.0617	reported	Accurate	Merrimack River	2017	8	16	established	NAS sighting report	T. Richardson, U. of North Alabama

*Personal communication with Dr. Terry Richardson, November 3, 2017.

Table 4-3 (Continued). USGS Nonindigenous Aquatic Species (NAS) Database, *C. fluminea* CSRs Ponds in Hillsborough and Rockingham Counties, NH

Scientific Name	State	County	Locality	Latitude	Longitude	Source	Accuracy	Drainage Name	Year	Month	Day	Status	Record	Type
Corbicula fluminea	NH	Rockingham	Wash Pond	42.88679	-71.1777	reported	Accurate	Merrimack River	2016			established	Literature	Database, NHDES, Amy Smagula
Corbicula fluminea	NH	Rockingham	Cobbetts Pond	42.79353	-71.2893	reported	Accurate	Merrimack River	2016			established	Literature	Database, NHDES, Amy Smagula
Corbicula fluminea	NH	Rockingham	Canobie Lake, at public access boat launch at Hayes Hart Road	42.80574	-71.2526	reported	Accurate	Merrimack River	2017	8	17	established	NAS sighting report	T. Richardson, U. of North Alabama
Corbicula fluminea	NH	Rockingham	Beaver Lake, NE of Derry, at public access boat launch on Water Street off NH SR 102 Chester Road	42.90489	-71.3025	reported	Accurate	Merrimack River	2017	8	18	established	NAS sighting report	T. Richardson, U. of North Alabama*

In addition to the USGS CSRs described in Tables 1 and 2, a diver survey was performed in September 2015 for the state-endangered brook floater mussel (*Alasmidonta varicose*) near three bridge structures in Hooksett (Oak Hill Environmental Services, 2015). The approximate location of the study area was 2,500 feet downstream of the Hooksett Dam. Approximately 80 percent of the substrate in the study area was characterized as having large boulders, a large glacial erratic, and numerous large rocks throughout. Scattered about were small patches of pebble, cobble and coarse sand substrate ranging in size from 2 to 5 feet-wide along with many smaller patches of sand on top of deeper boulders. The substrate in the remaining 20 percent of the study area was described as coarse sands (Oak Hill Environmental Services, 2015). The survey did not find live specimens or empty shells of the brook floater mussel in the study area. The survey did identify 70 live specimens of the eastern elliptio mussel (*Elliptio complanate*) and observed "many" Asian clams. Data sheets that might indicate the abundance and exact location of the observed *C. fluminea* specimens are not provided in the 2015 Phase I survey report.

Discussion

From AR-1406 and AR-1405 and references cited therein, *C. fluminea* is documented to have rapid growth, earlier sexual maturity, a short life span, and high fecundity; adult Asian clams are hermaphrodites (can self-fertilize), mature quickly, and produce large numbers of offspring. During the reproductive period, an adult Asian clam can produce from 97 to 570 juveniles per day (McMahon and Bogan 2001). Thus, *C. fluminea* is adapted for rapid colonization of new habitats and population recovery after die-offs. Studies done in the Connecticut River associated with the Connecticut Yankee nuclear power station suggested that low densities of native clams and mussels in the Connecticut River provided opportunity and a niche for Corbicula to colonize (Morgan et. al. 2004). All these factors have aided the rapid dispersal of the Asian clam throughout the U.S. and more recently, the northeast. As provided in AR-1405 and AR-1406, this species is also associated with human activities such as freshwater systems influenced by thermal discharges, particularly power plants. Many factors have been reported to affect population density and distribution of *C. fluminea* such as high or low water temperatures, low pH, silt, hypoxia, pollution, inter- and intraspecific competition, and predation. These factors could individually and synergistically contribute to the establishment of *C. fluminea* populations within and beyond the influence of a thermal discharge. USGS NAS data for locations upstream of the Station, and especially data from 2016 and 2017 for the seven ponds investigated in Rockingham and Hillsborough counties, suggests that a thermal discharge is not a prerequisite for *C. fluminea* to become established.

In AR-1405, the authors note one of the keys to the establishment of *C. fluminea* in the Connecticut River is the species ability to colonize refugia from winter temperatures and high spring flows that often result in high clam mortality. Citations noted in AR-1406 (see McMahon 2002) report that the success and subsequent dispersion of. *fluminea* relies more on their natural characteristics than in its physiological tolerance. When compared with other fresh-water bivalve species, *C. fluminea* appears to be less tolerant to environmental fluctuations such as elevated temperatures, hypoxia, emersion, low pH and low calcium concentrations (see AR-1406). In other words, *C. fluminea* is found in clear water with good water quality and they are intolerant of high nutrient levels (see AR-1408). From AR-870 (Table 1) surface dissolved oxygen (DO) concentrations throughout the benthic habitat study area in October-November 2011 ranged from

10.0 to 13.5 mg/L; DO concentrations at five feet ranged from 10.2 to 13.5 mg/L. Well-oxygenated waters, among other factors, are one of the important physiochemical habitat requirements for this species (see AR-1406 and Pereira et. al., 2017).

In AR-872, Normandeau (2012) notes that degraded habitat conditions that might be caused by continued exposure to the Station's thermal discharge in Hooksett Pool should result in a consistent pattern of reduced diversity and increased abundance of pollution-tolerant species over time (1970s to present). Benthic samples, collected by Ponar grab sampler during 1972, 1973 and 2011 at Monitoring Stations N-10, S-0, S-4 and S-17, showed indications of improved river conditions leading Normandeau to conclude that "the Station's thermal discharge has not resulted in appreciable harm to the BIP in Hooksett Pool, and that the thermal discharge limits in the existing Permit adequately assure the protection and propagation of that BIP".

In his review of Normandeau 2011 fish data (see AR-871), Barnthouse (see AR-1300) notes that the percent of fish species classified as pollution-tolerant has varied over the years within Hooksett Pool but has not noticeably changed. Further, that the fish community-level results reported in 2011 by Normandeau (see AR-871) support a conclusion that there has been no appreciable harm to the BIP due to the operation of the Merrimack Station.

C. fluminea is clearly found downstream of the Station's discharge canal (Station S-0) within the thermally-affected area of the Hooksett Pool. Qualitative sampling by EPA in 2014 revealed higher densities of Asian clams and larger individuals near the mouth of the Station's discharge canal, as compared to Asian clams collected farther downstream in Hooksett Pool, and in Amoskeag Pool below the Hooksett Dam. Neither benthic sampling conducted by NHDES during 2013 (see AR-1414), nor EPA dive investigations in 2014 (see AR-1412), found evidence of Asian clams upstream from the plant in Hooksett Pool or Garvin's Falls Pool.

However, recent (2016 and 2017) USGS CSR records show that the species is also documented at locations upstream of the thermal discharge, in one case nearly 12 miles upstream, in addition to being present in seven large freshwater ponds unaffected by the Station's thermal discharge. EPA notes in its Statement for Public Comment that of the 18 samples taken by a Ponar grab-sampler at or downstream of the plant's discharge canal in 2011 (stations S-0, S-4, S-17), Asian clams were the dominant taxon in 14 in samples, ranging in relative abundance from 58 to 94 percent, with a mean of 78.6 percent at the sites where they were dominant. New data from the USGS NAS post 2011 document CSRs for two locations upstream of the discharge canal within the Hooksett Pool indicating that factors, other than elevated water temperatures from the Station's thermal discharge, may be contributing the establishment of Asian clam populations that are outside of the thermal mixing zone. In their study of the effects of the Connecticut Yankee nuclear power plant thermal discharge on the population dynamics of *C. fluminea* and their effects on native bivalves, the authors note that the success of Corbicula in more northerly ranges of New England may not always be associated with the thermal plumes from industrial facilities, but could also result from other thermal refugia such as groundwater seeps that are above 2°C (Morgan, et. al. 2004)

Finally, although *C. fluminea* is established downstream of the Station's thermal discharge in Hooksett Pool, none of the historical data assembled for the Merrimack Station Administrative Record suggests that indigenous mollusk species, including the state-endangered brook floater mussel (*Alasmidonta varicose*), have been displaced by it. The absence of data for the Asian clam in the Station's thermal mixing zone from 1973 to 2011, or other native mussel or clam species for that matter, suggests that *C. fluminea* has likely come to dominate sandy bottom areas previously devoid of native bivalve species. In the Connecticut River, Morgan et. al notes that while Corbicula quickly became the dominant bivalve in the River, there was little change in native bivalve abundance found in the same sediments (Morgan et. al. 2004).

Documents AR-1406 and AR-1407 speculate on potential negative ecological impacts that could be caused by large populations of the Asian clam (e.g., alterations to aquatic food web, biogeochemical processes, and impacts to native bivalve species). AR-1406 further points out that the presumptions of negative impacts of *C. fluminea* to native fauna are often speculative and further manipulative research is needed to clarify these ecological interactions and impacts. In Pereira et. al 2017, Asian clams in that study showed no major effects on the biological water quality or on benthic macroinvertebrate assemblages, possibly because of their recent invasion in that study area, or because the system studied was modified to the extent that the effects of *C. fluminea* on native species were masked. In the Hooksett Pool, Normandeau (AR-872) and Barnthouse (AR-1300) have independently concluded that a BIP of macroinvertebrates and fish is present. None of the evidence collected to date suggests that *C. fluminea* in Hooksett Pool has adversely impacted the BIP or ecosystem functions of the aquatic community.

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