RESPONSE TO ENVIRONMENTAL PROTECTION AGENCY'S DRAFT NPDES PERMIT

PSNH MERRIMACK STATION
UNITS 1 & 2
BOW, NEW HAMPSHIRE

Prepared for
Public Service Company of New Hampshire

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Executive Summary

Public Service Company of New Hampshire's (PSNH's) Merrimack Station electrical generating facility in Bow, New Hampshire is seeking a renewal of its existing National Pollutant Discharge Elimination System (NPDES) permit. To this end, several engineering and biological assessments have been prepared by Enercon Services, Inc. (ENERCON) and Normandeau Associates, Inc. (Normadeau) and submitted by PSNH to the United States Environmental Protection Agency (EPA) to respond to EPA's requests for certain technology and fisheries information to support development of the new permit for Merrimack Station. In September 2011, EPA issued a draft NPDES permit for Merrimack Station. This report is prepared in response to the draft NPDES permit issued by EPA.

The specific issues discussed in this report may have a significant impact upon the EPA's conclusions reflected in the draft permit. The issues raised in this draft permit response include the availability of alternative technologies:

- A passive fine-mesh, cylindrical wedgewire (CWW) screen system is available for seasonal operation to reduce impingement and entrainment mortality to satisfy CWA §316(b) requirements.
- CWW screens are available for seasonal use in the Merrimack River despite claims of both low river velocities and shallow water depths in the draft permit.
- The Gunderboom Marine Life Exclusion System (MLES) aquatic microfiltration barrier is an available technology for seasonal operation.

Additionally, this draft response addresses some of the problems and a lack of rigor associated with the analysis and conclusions within the draft permit:

- EPA's inaccurate discussion concerning the evaporation rate of water in a cooling tower configuration as compared to the existing cooling system. According to a report to the U.S. Department of Energy, closed-cycle systems typically evaporate 2 to 3 times more water than open-cycle systems [Ref. 6.13].
- EPA's misuse of conceptual cost estimates as the bounding budget for the project in its analysis. Past experience has shown that preliminary cost estimates contain large amounts of uncertainty, and are often significantly lower than actual project costs. In addition, EPA fails to address the potential impacts of the new interferences created by the wet flue gas desulphurization system (i.e., scrubber system) that has been installed at Merrimack Station to reduce sulfur dioxide and mercury emissions.
- The increased air emissions that would result from cooling tower installation; including both increased stack emissions and particulate emissions resulting from cooling tower drift.
- EPA's failure to utilize or request use of any models, such as SACTI (Seasonal Annual Cooling Tower Impacts), to more precisely quantify the icing/fogging effects of a cooling tower before issuing a permit that assumes it is not an issue. PSNH has previously expressed icing/fogging as a public safety concern, and EPA has dismissed this concern without any rigorous analysis or quantifiable information.

- EPA's misuse of the 2007 Response estimates for closed-cycle generating capacity impacts as bounding values. These numbers were provided as initial estimates and were not intended to be used as inputs to final decisions by EPA. EPA should have utilized or requested use of a more sophisticated tool such as PEPSE (Performance Evaluation of Power System Efficiency) to more precisely predict the generating capacity impact to Merrimack Station.

As discussed in this report, seasonal use of CWW Screens or a Gunderboom MLES Aquatic Filter Barrier (AFB) would be available for reductions in impingement and entrainment mortality at Merrimack Station that are comparable to closed-cycle cooling. Alternatively, conversion to closed-cycle cooling at Merrimack Station would introduce construction and operational obstacles and higher costs than anticipated based on EPA's conclusions. The specific issues mentioned above may have a significant impact in the determination of closed-cycle cooling as the "best technology available" (BTA) for Merrimack Station and warrant additional consideration by EPA before the final NPDES permit is issued. A 2010 report to the Department of Energy noted the potential benefits of CWW screens over closed-cycle cooling [Ref. 6.13]:

> *...Given the evolution of alternative technologies such as wedgewire screens, fine mesh screens, velocity caps, deep water intakes, etc., it is becoming increasingly obvious that these less expensive and more flexible alternatives are equivalent (if not superior) to cooling tower technology, in situations where no other motivation (such as water resource or temperature issues noted above) exists to justify rejecting once-through cooling. [Ref. 6.13, Page 7-2]*

Additionally, as part of the original Phase II § 316(b) Rule, EPA identified the "addition of passive fine-mesh screen system (cylindrical wedgewire) near shoreline with mesh width of 1.75 mm" as the most appropriate technology for Merrimack Station [Ref. 6.16].

The results of Normandeau's analysis show that the 2004 Phase II §316(b) Rule's performance standards could be attained at Merrimack Station by installing CWW screens with any of five slot sizes evaluated (1.5 mm through 9 mm), operating them from April through July of each year, and installing and operating a state-of-the-art fish return sluice (in combination with the existing traveling screens) continuously from August through November and intermittently from December through March, as there would be personnel safety issues associated with maintaining the fish return system when ice is present [Ref. 6.2]. The preferred alternative technology option – seasonal operation of CWW screens in combination with the use of upgraded fish return systems – is expected to satisfy CWA § 316(b) with regard to impingement mortality and entrainment as follows:

- Reduce impingement mortality by approximately 84% from baseline.
- Reduce entrainment from baseline ranging from approximately 73% for 9 mm CWW screens to approximately 79% for 1.5 mm CWW screens.

In order to minimize both entrainment and fouling, a range of slot sizes from 9 mm to 1.5 mm has previously been evaluated by ENERCON and Normandeau. The lowest slot size in this range is smaller, and thus potentially more protective of aquatic organisms, than the 1.75 mm slot size of EPA's identified compliance technology for the Station [Ref. 6.16]. Given that smaller slot sizes may increase the likelihood of fouling, the optimum slot size would have to be determined for Merrimack Station. This would allow CWW screens to provide the maximum biological effectiveness while eliminating any fouling concerns. Once the optimum slot size is determined, seasonal use of CWW screens with upgraded fish return systems for the existing cooling water intake structures is recommended as the "best technology available" (BTA) for minimizing adverse environmental impact for Merrimack Station.

1 Background, Introduction, and Scope

1.1 Background and Introduction

Public Service Company of New Hampshire's (PSNH's) Merrimack Station electrical generating facility in Bow, New Hampshire is seeking a renewal of its existing National Pollutant Discharge Elimination System (NPDES) permit. To this end, an engineering and biological assessment was prepared by Enercon Services, Inc. (ENERCON) and Normandeau Associates, Inc. (Normandeau) and submitted by PSNH to the United States Environmental Protection Agency (EPA) in November 2007 that responded to EPA's request for certain technology and fisheries information to support development of the new permit for Merrimack Station.

The November 2007 Response to United States Environmental Protection Agency Clean Water Act (CWA) § 308 Letter (2007 Response) reflects the information requested by EPA and contained the following:

- All fisheries data collected during entrainment and impingement sampling conducted from 2005 to 2007.
- A detailed description of Merrimack Station's cooling system.
- Response regarding projected retirement date for Merrimack Station's existing coal-fired operation.
- A description of the processes employed at Merrimack Station with regard to the operation of the boiler, condenser, cooling water intake structure (CWIS), and effluent treatment.
- A description of the engineering analysis involved with converting the Merrimack Station cooling system from the current once-through cooling to the following cooling scenarios:
    - Mechanical draft cooling towers for use in a recirculating (or "closed-cycle") cooling system for both generating units
    - Mechanical draft cooling towers for use in a recirculating (or "closed-cycle") cooling system for one generating unit
    - Mechanical draft discharge cooling towers that would be used to reduce thermal discharges by Merrimack Station.
- An analysis of alternate CWIS screening systems, including a discussion of the major components and major modifications that would be required to retrofit Merrimack Station with this technology.
- A discussion of the most cost-effective means by which Merrimack Station could meet the evaluated scenario whereby the temperature differential between Stations N10 and S4 in the Hooksett Pool is limited to 5°F.

Following a meeting with PSNH, Normandeau, and ENERCON regarding the 2007 Response in December 2008, EPA requested that PSNH further evaluate the following technologies in more detail and submit a supplement to the 2007 Response:

- **Option 1** - Seasonal use of wedgewire screens in front of the Station's cooling water intake structures (CWISs).
- **Option 2** - Seasonal deployment of an Aquatic Filter Barrier (AFB) in front of the Station's existing intake structures.
- **Option 3** - Installation of fine mesh traveling screens to replace the Station's existing coarse mesh traveling screens.

The 2009 Supplemental Alternative Technology Evaluation (2009 Report) presented this additional information that EPA asked PSNH to provide. In particular, the 2009 Report responded to EPA's request by evaluating, on a conceptual basis, the following for each technology option:

- **Conceptual Design** - Listed the major components and major modifications that would be required to retrofit Merrimack Station with each technology option, including preliminary site layouts.
- **Operational Features and Maintenance Requirements** - Described the general operational and preventative maintenance requirements associated with each conceptual technology option.
- **Construction Factors** - Developed a conceptual planning schedule that included a conservative estimate for outages due to construction activities.
- **Cost Estimates** - Provided conservative estimations of projected initial costs (capital costs and lost generation costs), annual operational and maintenance (O&M) costs (including contingencies), and estimated useful life for major equipment associated with each conceptual technology option.
- **Impingement Mortality/Entrainment Reduction Assessment** - Determined the potential reduction of impingement mortality and entrainment (IM&E) from the established baseline that would result from implementation of each conceptual technology option.
- **Environmental Considerations** - Evaluated each conceptual technology option's potential impact on the use of the Merrimack River, aesthetics, and greenspace / potential habitat.

In addition, after review of PSNH's 2007 Response, EPA determined that PSNH needed to further respond to the items below:

- An estimate of the most stringent thermal discharge limits that Merrimack Station would be able to comply with utilizing the cooling tower technologies in question.
- An estimate of the most stringent cooling water withdrawal flow and thermal load limits that the facility would be able to comply with utilizing the cooling tower technologies in question.

As a result, EPA submitted a request for information which in some cases explained items in previous EPA requests, and in other cases requested additional information not previously requested to ensure items were presented clearly. In addition, EPA also requested information regarding certain assumptions and/or calculations that were used as the basis for the information provided in the 2007 Response.

The information request was submitted by PSNH to EPA in January 2010. ENERCON created a report (2010 Response) which individually reviewed each information request, provided clarification of the information provided in the 2007 Response, and, where necessary, conducted new analysis to respond to EPA's information request.

After receiving the documentation described above, EPA issued a draft NPDES permit for Merrimack Station in September 2011. The public comment period for the draft NPDES permit began on September 30, 2011 and has been extended until February 28, 2012. During this time, EPA shall receive and review all comments received pertinent to the Merrimack Station draft NPDES permit.

1.2 Scope

Under requirements of the CWA § 301, the permit limits for thermal discharge must be consistent with those levels that are achievable using the Best Available Technology (BAT) that is economically achievable. The Best Technology Available (BTA) for minimizing adverse environmental impacts at Merrimack Station is based on a Best Professional Judgment (BPJ) basis under CWA § 316(b). In the draft NPDES permit, EPA has proposed that the BAT for Merrimack Station is the conversion of Merrimack Station to closed-cycle cooling using wet or wet-dry hybrid mechanical draft cooling towers. Similarly, the draft permit has also indicated that the BTA for Merrimack Station involves closed-cycle cooling using wet or wet-dry hybrid mechanical draft cooling towers from April through August and fish return system improvements to be installed and operated on a year round basis.

This report is prepared in response to the draft NPDES permit issued by EPA. While closed-cycle cooling is expected to be technologically feasible at Merrimack Station, there are issues associated with closed-cycle cooling that are not addressed in the draft permit, and there are several other available technologies for Merrimack Station that warrant further consideration. These alternative technologies would provide similar environmental benefits to closed-cycle cooling without some of the associated drawbacks. More specifically, the issues raised in this draft permit response include the availability of alternative technologies:

- A passive fine-mesh screen system, Cylindrical Wedgewire screens, is available for seasonal operation to reduce impingement and entrainment mortality to satisfy CWA § 316(b) requirements.
- Cylindrical Wedgewire (CWW) screens are available for seasonal use in the Merrimack River despite claims of both low river velocities and shallow water depths in the draft permit, as discussed in Section 2.2.
- The Gunderboom Marine Life Exclusion System (MLES) aquatic microfiltration barrier is an available technology for seasonal operation.

Additionally, this response addresses several inaccuracies and a lack of rigor associated with the analysis and conclusions within the draft permit, as summarized below.

- EPA's inaccurate discussion concerning the evaporation rate of water in a cooling tower configuration as compared to the existing cooling system. A closed-cycle cooling system typically evaporates about 2 to 3 times as much water as an open-cycle system [Ref. 6.13].

- EPA's misuse of the cost estimates as the bounding budget for the project in its analysis. Past experience has shown that preliminary cost estimates contain a large degree of uncertainty, and are often significantly lower than actual project costs. In addition, EPA fails to address the potential impacts of the new interferences created by the wet flue gas desulphurization system (i.e., scrubber system) that has been installed at Merrimack Station to reduce sulfur dioxide and mercury emissions.
- The increased air and particulate emissions resulting directly from cooling tower drift and indirectly from decreased power output.
- EPA's failure to utilize or request use of available models (such as SACTI) to more precisely quantify the icing/fogging effects of a cooling tower. EPA has issued a draft permit that dismisses icing/fogging as a concern, but uses only preliminary estimates based on wind directions as its basis. PSNH has previously expressed icing/fogging as a public safety concern, and EPA has failed to take advantage of and/or utilize available tools for more precisely predicting cooling tower impacts.
- EPA's misuse of the 2007 Response estimates for closed-cycle generating capacity impacts as bounding values. These numbers were provided as initial estimates and were not intended to be used as inputs to final decisions by EPA. EPA should have utilized or requested use of a more sophisticated tool (such as PEPSE) for predicting the generating capacity impact to Merrimack Station.

2 Response to Conclusions Regarding Alternative Technologies

Alternative technologies to closed-cycle cooling have undergone significant advancements since the 1970's and 1980's, when the lower intake flow rate associated with closed-cycle operation was generally considered the best way to reduce adverse environmental impact [Ref. 6.13]. Since then, a number of alternative technologies have been improved through research, refinements, and operating experience from a number of operational installations. There are alternative technologies currently available that have shown environmental benefits comparable to closed-cycle cooling [Ref. 6.13]. CWW screens and Gunderboom MLESs are examples of alternative technologies that are available for use at Merrimack Station. These technologies would not adversely impact the generating capacity of the Station, can provide similar environmental benefits approaching closed-cycle cooling, and should be feasible to implement from an engineering standpoint.

2.1 CWW Availability

2.1.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] dismisses the use of a passive fine-mesh screen system (CWW screens) for seasonal operation to reduce impingement and entrainment mortality to satisfy CWA § 316(b):

[Regarding closed-cycle cooling] ...There is no other technology that can achieve similar entrainment reductions while allowing the facility to continue generating essentially the same amount of electricity. [NH 001465, Page 167]

and

Having reviewed PSNH's submissions, as well [as] relevant technical and scientific literature, EPA concludes that PSNH's 2009 wedgewire screen proposal would not satisfy the BTA standard of CWA § 316(b) at Merrimack Station. Furthermore, EPA concludes that the rates of entrainment and impingement mortality reduction that the company predicts for its proposal are not supported... [NH 001465, Page 275]

2.1.2 Engineering Response

The draft permit states that there is no technology that provides similar entrainment reduction to that of a closed-cycle cooling tower while allowing the Station to generate the same amount of electricity. It should be noted that conversion to closed-cycle cooling would significantly decrease the Station's power generating capacity. It was also demonstrated in the 2009 Report that CWW screens would allow the Station to generate approximately the same amount of electricity while providing similar entrainment reductions to that of a closed-cycle cooling system. A 2010 report to the Department of Energy noted the potential benefits of CWW screens over closed-cycle cooling [Ref. 6.13]:

...Given the evolution of alternative technologies such as wedgewire screens, fine mesh screens, velocity caps, deep water intakes, etc., it is becoming increasingly obvious that these less expensive and more flexible alternatives are equivalent (if not superior) to cooling tower technology, in situations where no other motivation (such as water

resource or temperature issues noted above) exists to justify rejecting once-through cooling. [Ref. 6.13, Page 7-2]

Additionally, the UK Environment Agency issued this statement in a best practice guide concerning screening intakes and outfalls [Ref. 6.25]:

Passive wedge-wire cylinder (PWWC) screens are a tried and tested solution and are generally regarded in Britain as the best available technology for juvenile and larval fish protection [Ref. 6.25, Page 45].

CWW screens would not incur any new operational efficiency losses to Merrimack Station, which would allow the gross power output from the Station's generators to remain unchanged. Additionally, implementation of CWW screens would incur significantly less parasitic power losses when compared to a conversion to closed-cycle cooling. This is because CWW screens are passive and do not typically require as significant additional resources to operate as closed-cycle cooling. As discussed in the 2009 Report, it is assumed that the airburst system (ABS) compressor motors would run 24-hours per day from April to July and once per week for 4-hours from August to March[1]. Additionally, power requirements were also assumed for continuous operation of the existing coarse mesh traveling screens and upgraded fish return systems from August through November and intermittent operation from December through March, as there would be personnel safety issues associated with maintaining the fish return system when ice is present. These would result in parasitic power losses of approximately 202 MW-hr per year [Ref. 6.2]. However, this impact is minimal, only about 0.34% of the estimated parasitic losses of approximately 58,700 MW-hr per year associated with the new circulating water booster pumps and cooling tower fans that would be necessary to operate the Station in a closed-cycle configuration [Ref. 6.3]. The estimated additional parasitic loss from closed-cycle cooling equates to the amount of electricity required to power approximately 5,500 households in the United States for one year according to 2001 statistics [Ref. 6.18].

In addition to the parasitic losses, conversion to closed-cycle cooling would result in condenser efficiency losses[2]. As discussed in the 2007 Response, conversion of Merrimack Station to closed-cycle cooling would result in an increase in the temperature of the cooling water entering the Station's condensers. Based on the preliminary estimates given in the 2007 Response, this would reduce the capacity of the condenser to condense steam, which would result in a reduction in the power output from the turbine and generator [Ref. 6.3]. The additional condenser efficiency power loss of 26,000 MW-hr per year from closed-cycle cooling corresponds to the yearly amount of power required for approximately 2,440 households in the United States [Ref. 6.18]. These represent estimated operational losses and would require a PEPSE model to more precisely quantify the impacts. Additional power would have to be provided by other sources, and 71% of New England's generating capacity comes from power plants that consume either natural

[1] Although the CWW screens would only be operated on a seasonal basis, year-round operation of the ABS system would allow for removal of any growth on the screens during the inoperative period.

[2] Condenser efficiency losses (also called operational efficiency losses) refer to lost generating capacity resulting from the reduced thermodynamic properties of the power steam cycle at higher circulating water temperature.

gas, oil, or coal [Ref. 6.20]. Conversely, installation of CWW screens would allow the Station to provide the same water amount and temperature to the condenser as it does currently; therefore there would be no condenser efficiency impact. As such, it is concluded that installation of CWW screens will not significantly impact the overall operation of the Station.

In the 2009 Report [Ref. 6.2], Normandeau demonstrated that seasonal use of 1.5 mm slot width CWW screens would reduce annual impingement mortality by 88% and annual entrainment by 79%. The study assumed operation of CWW screens from April to November and modeled larvae avoidance as a function of larval length. The CWW screens would operate only during these months to avoid complications due to ice formation. These results are supported by a 2009 study that was carried out by Normandeau, technical experts in the field [Ref. 6.22].

Another proposed option in the 2009 Report was to operate the 1.5 mm slot width CWW screens from April to July due to possible concerns over screen fouling during traditional low river flow months of late summer. In this instance, upgraded Fish Return Systems would operate from August to November to remove impinged organisms from CWIS when CWW screens are not operating. This option was studied and was found to reduce annual impingement mortality by 84% and annual entrainment by 79%. The study assumed the same larvae avoidance model as above.

This information was given in response to the 2004 Phase II § 316(b) Rule performance standards of a 60-90% reduction in entrainment and an 80-95% reduction in impingement. Both of these options were studied by Normandeau, and were found to satisfy the aforementioned performance standards. Additionally, in the 2004 Phase II § 316(b) Rule EPA identified the "addition of passive fine-mesh screen system (cylindrical wedgewire) near shoreline with mesh width of 1.75 mm" as the most appropriate technology for Merrimack Station [Ref. 6.16]. Since the original Phase II § 316(b) Rule was promulgated in 2004, the amount of information available concerning CWW screens and the confidence in the technological feasibility has increased.

As discussed in the 2009 Report [Ref. 6.2], the results of Normandeau's analysis show that the 2004 Phase II §316(b) Rule's performance standards could be attained at Merrimack Station by installing CWW screens with any of five slot sizes evaluated (1.5 mm through 9 mm), operating them from April through July of each year, and installing and operating a state-of-the-art fish return sluice (in combination with the existing traveling screens) during August through November. The optimal slot size for Merrimack Station would have to be determined such that biological effectiveness was maximized, while eliminating any fouling concerns.

As noted in the 2009 Report [Ref. 6.2], the U.S. Army Corps of Engineers (USACE) and any other applicable regulatory agencies would have to be contacted regarding the permit restrictions associated with the use of the evaluated wedgewire screens and any impacts resulting from their implementation. While these agencies have not been contacted regarding permitting CWW at Merrimack Station, there are comparable installations that have previously been approved and implemented. Johnson Screens installed several CWW Screens on the Allegheny River at the Olean Wastewater Treatment Plant in Olean, NY

[Ref. 6.10]. The plant is located in a region where the Allegheny River is not more than 300 feet wide.

From a river navigation standpoint, the Merrimack River is not considered a navigable waterway. The Garvin's Falls Dam is approximately 2.5 miles upstream of the Station, and the Hooksett Dam is approximately 2 miles downstream of the Station. Neither of these dams utilizes locks, hence preventing navigation along the Merrimack River in this region. Installation of CWW screens would result in a minimal reduction in available recreational space in front of the Station, but would not significantly impact the navigability of the Merrimack River. A more detailed design would be required to be submitted to the USACE for formal approval.

2.2 CWWs – Low River Velocity and Shallow Water Depth

2.2.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] determines CWW screens are not available due to both low river velocities and shallow water depths within the Merrimack River:

One key condition, given the "passive" nature of wedgewire screen technology, is that sufficient ambient current velocity must exist to sweep eggs, larvae, and fouling debris past the screens. Yet, it is evident that sweeping currents in Hooksett Pool are insufficient at critical times. [NH 001465, Page 275]

and

Yet, it is unclear whether adequate water depths exist in Hooksett Pool to accommodate an effective wedgewire screen installation. [NH 001465, Page 277]

2.2.2 Engineering Response

CWW screens are an available technology for seasonal use at Merrimack Station. These screens would be installed within the Merrimack River, and provide a method by which water can be taken directly from the river for use in the condenser.

2.2.2.1 CWW Implementation at Other Sites

Johnson Screens, the leading manufacturer of CWW screens, has manufactured these screens for approximately 2,000 installations worldwide, and at least 487 within the United States. Of these installations, approximately 55 retrofits have been done for open-cycle electric generating stations within the United States [Ref. 6.10]. There are several examples of electric generating stations that have successfully utilized CWW screens; in addition, there are installations of CWW screens at various industrial facilities within the state of New Hampshire [Ref. 6.10].

Eddystone Generating Station is located in Eddystone, Pennsylvania along the Delaware River. Eddystone has been using CWW screens since the 1980s and has not had any significant operating issues associated with them. The Eddystone CWIS includes sixteen 72-inch diameter CWW screens. EPA's own Technical Development Document [Ref.

6.7] for development of a national BTA standard under CWA § 316(b) states that Eddystone has operated CWW screens "with minimal operational difficulties." The Technical Development Document also states that "the Wedgewire screens have generally eliminated impingement at Eddystone" [Ref. 6.7].

J.H. Campbell Station Unit 3, located on Lake Michigan, is another example of an electric generating station that has successfully installed CWW screens. Campbell Unit 3 features fourteen 84-inch diameter screens. Like Eddystone, these CWW screens have also been in operation since the 1980s. The Technical Development document (TDD) issued by EPA also notes that Campbell has operated its CWW screen array "with minimal operational difficulties." The Technical Development Document also states that impingement of various species of fish is "significantly lower than Unit 1 and 2 that do not have Wedgewire screens" [Ref. 6.7].

The largest example of a CWW screen installation is Oak Creek Power Plant, which is also located on Lake Michigan near Milwaukee, WI. Oak Creek has recently installed twenty-four 96-inch diameter CWW screens approximately one mile off the shore of Lake Michigan. This installation was completed in January 2009. In summary, there is a long list of CWW screen installations that have proven successful.

An installation of CWW screens at Merrimack Station would not present anything that could be considered unprecedented, as was suggested in the draft permit. Eddystone's intake flow is approximately 440,000 gpm, and Campbell Unit 3 has an intake flow of about 400,000 gpm. Meanwhile, Oak Creek's intake flow is over 1,500,000 gpm. Considering these successful installations, Merrimack Station's intake flow of approximately 200,000 gpm (for both Units combined) is not an unprecedented technological challenge. Regarding river size, Johnson Screens has installed several CWW Screens on the Allegheny River at the Olean Wastewater Treatment Plant as previously mentioned [Ref. 6.10]. The plant is located in a region where the Allegheny River is not more than 300 feet wide.

2.2.2.2 Low River Velocities

As mentioned previously, Oak Creek and Campbell Unit 3 are located along the shores of Lake Michigan. While the water in Lake Michigan is by no means stagnant, there is not a prevailing current in the lake as there is in the Merrimack River. Johnson Screens has installed CWW screens in over 80 locations characterized as a lake or reservoir that have little to no sweeping flow. Examples of such installations include Granbury Water Treatment Plant in Granbury, TX, Freestone Energy Center in Streetman, TX, Bradbury Dam in Santa Barbara, CA, and in Beal Lake in Mohave Valley, AZ [Ref. 6.10]. With regard to sweeping flows, the Merrimack River is an environment that is more conducive to favorable CWW screen performance than any of the aforementioned examples. Therefore, not only should the Merrimack River be an acceptable location for installing CWW screens from a flow standpoint, it is potentially a more ideal environment than many other locations that have operated successfully.

The 2009 Report [Ref. 6.2] indicated that axial (also called "sweeping") velocities in the Merrimack River may be less than 1 fps during the late summer months. However, according to Normandeau the period with the greatest entrainment potential is late May through late June. Therefore, the CWW screens could be operated from April to July to reduce the entrainment by the amounts stated in Section 2.1.2. During these months, it is expected that the screens would experience ≥1 fps axial velocity. According to Normandeau, from August through November, there are only a very small amount of organisms capable of becoming entrained present in the river. The CWW screens would not operate during this time period, and an improved fish return system would remove impinged organisms from the travelling water screens and send them back to the river.

The CWW screening system discussed in the 2009 Report was designed considering the EPA's TDD [Ref. 6.7] recommended sweeping velocity of 1 fps. One of the CWW vendors (EIMCO Water Technologies) also recommended the use of a sweeping velocity of two times the through-slot velocity, or 1 fps [Ref. 6.2, Attachment D1]. The 2009 Report did show that there may be periods during the late summer months in which the sweeping velocity provided by the Merrimack River would be less than 1 fps. However, this concern should be alleviated as the CWW screens would be operated only from April through July as stated above. Discussion in the draft NPDES permit concerning CWW screens has been based on the assumption that CWW screens can only be operated effectively if sweeping flows ≥ 1 fps are present. However, as discussed above, this is not an accurate assumption given the successful history of CWW screen installations in lakes and reservoirs. Therefore, while the 1 fps is an appropriate design goal and can assist in the removal of debris from the screens, it is not required for successful use of a CWW screening system, particularly one utilizing an ABS.

The draft permit states that sweeping currents are insufficient "at critical times." As previously stated, Normandeau has indicated that the period with the greatest entrainment potential is late May through late June. Review of the river flow data from 1984-2005 shows that these are not the months where flow tends to be the lowest. In fact, May is the month with the second highest average river flow, when the monthly flow is averaged over all years in the data set. As mentioned previously, Normandeau has also stated that the entrainment potential is very low from August to November. Review of the river flow data shows that the months of August to November demonstrate below average river flow, with August and September being the two months with the least river flow on average. Therefore, the conclusion that flow is insufficient at "critical times" is not supported.

In addition, an installation of CWW screens for Merrimack Station would include an ABS to periodically remove debris from the screens. Johnson Screen's ABS, called Hydroburst, is designed specifically for CWW screen installations in which there is no sweeping velocity at all. Johnson Screens has installed CWW screens of this type in 80 different locations characterized as a lake or reservoir. In these instances, there is little to no sweeping flow whatsoever, and the ABS has operated effectively in removing debris. Direct correspondence with Johnson Screens has indicated that fouling and debris removal is not an issue for screens installed in stationary water that use an ABS, as long as the screen is installed in open water and not in a small, contained area where the debris has nowhere to go (Attachment 1, Section 1).

Given the examples of successful installations in locations where there is little or no sweeping flow discussed above, CWW screens should be acceptable for use at

Merrimack Station from a sweeping flow perspective. Additionally, there are ways to adjust the CWW screen array design to compensate for lower sweeping flow and maintain optimum operating efficiency. For example, the through-slot velocity can be lowered below the typical 0.5 fps value. Since the biological effectiveness of the CWW screens is predominantly determined by the ratio of sweeping velocity to through-slot velocity, the through-slot velocity can be lowered to increase the effectiveness of the screen. According to Normandeau, laboratory studies have indicated that larvae exposed to CWW screens in a flume of flowing water were less likely to be entrained if the sweeping flow equaled or exceeded the through-slot flow [Ref. 6.23; Ref. 6.24]. A small fish larva (e.g., 5-15 mm long) may be able to swim faster than the through-slot velocity of a CWW screen, but only for a short distance. After many repeated escape attempts, a larva may eventually become exhausted and become entrained. If there is sufficient sweeping flow past the screen, however, the sweeping flow can transport the larva beyond the screen's influence after a few escape attempts. It generally appears that the best chance of larval avoidance occurs when sweeping velocity exceeds through-slot velocity. In the Hooksett Pool of the Merrimack River, river flow is highly variable with season. The fastest river currents typically occur during the spring, which is also the season of greatest larval abundance, a coincidence favorable for larval avoidance of CWW screens. The summer is often a time of reduced river flow, but by that time most larvae have grown large enough that they are no longer small enough to be entrained through narrow-slot CWW screens. The larger larvae or juveniles present in the summer also have greatly increased swimming ability, enabling them to easily avoid contact with CWW screens with a low through-slot velocity, even in weak sweeping flows.

The aforementioned Eddystone, Campbell Unit 3, and Oak Creek have all installed CWW screen arrays with a 0.5 fps through slot velocity. It is possible that CWW screens could be installed at Merrimack Station that would have a lower through slot velocity. This would increase the ratio of sweeping flow to through-slot velocity, thereby increasing screen effectiveness. There have been successful installations of CWW screens with through-slot velocities of 0.25 fps. Such installations include Willamette River Water Treatment Plant in Wilsonville, Oregon and Bethlehem Energy Center in Glenmont, New York [Ref. 6.10]. Both installations utilized an ABS system [Ref. 6.10].

2.2.2.3 Shallow Water Depths

In the draft permit, EPA also concludes that the Merrimack River is too shallow for CWW screens. The 2009 Report [Ref. 6.2] indicated that a CWW screen diameter of 24 inches was chosen for the design of Merrimack Station to take into account the mean low water level of 4 ft. Correspondence with Johnson Screens, the leading CWW screen manufacturer, indicates that one half diameter of clearance must be provided above and below the outer edge of the screen [Ref. 6.2]. The Product Application Guide from Johnson Screens [Ref. 6.19] also gives this spacing requirement, shown in Figure 1. For a 24-inch diameter screen, this signifies a requirement of one foot of water above the top of the screen, and one foot of water between the bottom of the screen and the bottom of the river. Therefore, 24-inch diameter CWW screens can be designed to operate in as little as 4 ft of water.

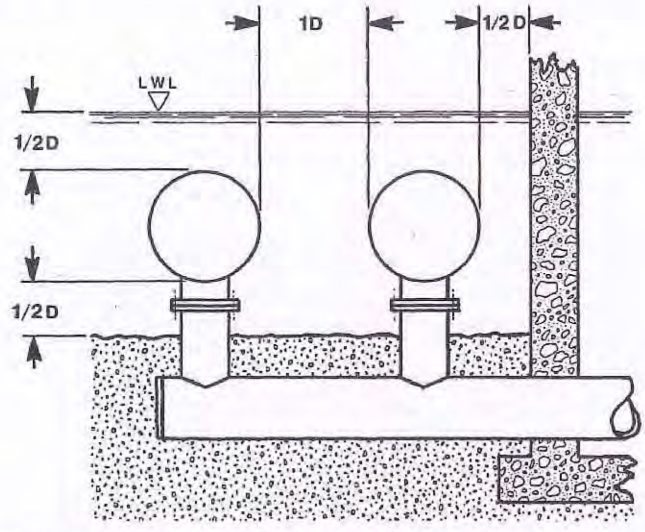

Figure 1: Spacing Criteria for Johnson CWW Screens [Ref. 6.19]

The 2009 Report presented a preliminary layout of CWW screens. This preliminary layout showed CWW screens being installed from approximately 60 ft to approximately 95 ft offshore in front of the existing Unit 1 and 2 screen houses [Ref. 6.2]. As discussed in the 2009 Report, the mean low water level in the vicinity of the CWW screens is 4 to 6 ft, with an average depth of 6 to 10 ft. Crude bathymetry data provided by Normandeau for the lower Hooksett Pool demonstrated water depths of approximately 7-15 ft along this transect in the region closest to where the CWW screens would be installed (Attachment 1, Section 2). This data is obtained from the N-5 transect, located just south of the intake structure [Ref. 6.11]. More detailed bathymetry data would be necessary to confirm the depths of the river in this area, but currently available data suggests that water depth would not be an issue for a 24-inch diameter CWW screen installation.

2.3 Seasonal Use of Aquatic Microfiltration Barriers

2.3.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] states that the Gunderboom MLES has been used to significantly reduce entrainment, but raises concerns about biofouling, anchoring the barrier, and closing off a large area of the river:

One type of aquatic microfiltration barrier, a Gunderboom Marine Life Exclusion System (MLES), has been used at a power plant on the Hudson River, in New York (Lovett Station). Although there have been problems anchoring the device, the system has been reported to significantly reduce entrainment at that plant, though concerns about biofouling undermining performance have also been raised. [NH 001465, Page 292]

and

...Enclosing a substantial portion the riverine habitat – Hooksett Pool is approximately five-miles long – would prevent movement of fish and other aquatic organisms into and out of this area for up to five months. This could have unintended adverse effects on fish spawning success, migration, and/or foraging opportunities. EPA also shares PSNH's

concern about such a large barrier interfering with public uses of a large proportion of the river. [NH 001465, Pages 294-295]

2.3.2 Engineering Response

The 2009 Report [Ref. 6.2] discussed the option of using the Gunderboom Marine Life Exclusion System (MLES) aquatic microfiltration barrier (AFB) in conjunction with an upgraded fish return system to significantly reduce entrainment and impingement mortality. The Gunderboom MLES is susceptible to damage from ice formation; hence it could only operate from April through November. Since, according to Normandeau, the time period with the highest observed levels of entrainment is late May through late June, and there are very few organisms in the Merrimack River from August through November that are capable of becoming entrained, the optimum deployment period for the evaluated MLES at Merrimack Station would be April through July. The operation of an upgraded fish return system, combined with the fact that there are very few organisms in the Merrimack River capable of being entrained from August through November, would minimize the adverse environmental impact. Normandeau concluded that seasonal use of an MLES (April through July) and an upgraded fish return system would reduce impingement mortality by 78%, while reducing entrainment by 82% [Ref. 6.2].

Normandeau also evaluated the option of operating Merrimack Station with a Gunderboom MLES from April through November, and found that impingement mortality would be reduced by 82%, while entrainment would be reduced by 83%. Although fouling concerns would be present during the late summer months (July through November), a site-specific study could alleviate these concerns, especially as an automatic ABS (AirBurst) cleaning system would be installed to periodically clean the fabric panel. An AirBurst cleaning system should keep the fabric panel in good operating condition such that the reductions stated above would be achieved. In tests conducted for the Electric Power Research Institute (EPRI), this cleaning system effectively cleaned various AFB intake configurations after only a few cycles [Ref. 6.4]. Another study confirmed that the MLES could operate and be maintained over extended periods, and that the automatic Airburst system allowed the MLES to operate unattended [Ref. 6.17].

The Gunderboom MLES is held in place by flotation billets on the surface of the water and by anchors on the bottom surface of the river. Given these supports, the Gunderboom MLES is ideal for lower velocity applications. In the draft permit, EPA cites anchoring problems in the Lovett Station MLES installation on the Hudson River in New York as justification for ruling out the MLES as the BTA. The Lovett Station anchoring problems occurred during developmental testing for the Gunderboom MLES in the 1990s [Ref. 6.17]. The Gunderboom MLES development program continually improved and refined the MLES through six years of in-situ research and development at Lovett Station [Ref. 6.17]. The design of the anchorage system was strengthened such that by the end of the program, the Gunderboom MLES could be anchored in the high currents of the Hudson River [Ref. 6.17]. The Lovett Station Gunderboom MLES installation is shown below in Figure 2. Anchoring difficulties would likely only occur in areas of high velocity flow; therefore this should not be used as justification for ruling out the Gunderboom MLES as an available technology for Merrimack Station, especially if CWW screens are ruled out due to low river velocities. If the Merrimack River is too slow for CWW screens (despite knowledge of successful installations in still water), it is necessarily a more favorable environment for anchorage of a Gunderboom MLES AFB.

Figure 2: Gunderboom MLES at Lovett Station [Ref.6.17]

The draft permit also cites the large area that the Gunderboom MLES would occupy as justification for rejecting it as the BTA. As discussed in the 2009 Report [Ref. 6.2], the potential river width usable for recreational purposes could be reduced by up to 50% adjacent to Merrimack Station. However, the design parameters for the Gunderboom MLES in the 2009 Report were chosen given a range of preliminary specifications provided by Gunderboom and the currently available bathymetry. Upon further review of these conservative parameters, and given a more detailed bathymetry in the Merrimack River, it is possible that a Gunderboom MLES could take up a smaller portion of the Merrimack River. Also, it is still uncertain how large a river area would be affected by a cooling tower plume. It is possible that fog from the cooling tower plume could at times occupy as much or more of the river than the Gunderboom MLES, and the cooling tower would operate all months of the year. Given currently available information, it is unknown at this time whether or not fog from the cooling tower plume would have as much impact. Additionally, a cooling tower installation would cause an incremental increase in the noise pollution and visual impact of the Station, which could deter additional members of the public from using the river in areas close to the Station.

Use of a Gunderboom MLES would not impact the Station's efficiency and generating capacity, unlike a conversion to closed-cycle cooling. Similar to CWW screens, the water temperature of the condenser cooling water would not be affected by the deployment of a Gunderboom MLES. As a result, there would be little to no condenser efficiency impact. In addition, as discussed in the 2009 Report, it is assumed that the AirBurst compressor motors would run 4 hours per day from April to July and once per week for 4 hours from August to March. Additionally, power requirements were also assumed for continuous operation of the existing coarse mesh traveling screens and upgraded fish return systems from August through November and intermittent operation from December through March, as there would be personnel safety issues associated with maintaining the fish return system when ice is present. Based on these assumptions, the additional parasitic losses associated with the operation of the evaluated MLES™ option would be approximately

204 MW-hr per year [Ref. 6.2]. However, just as with CWW screens, this impact is minimal, only about 0.35% of the estimated parasitic losses of approximately 58,700 MW-hr per year associated with the new circulating water booster pumps and cooling tower fans that would be necessary to operate the Station in a closed-cycle configuration [Ref. 6.3]. The additional parasitic loss resulting from a conversion to closed-cycle cooling equates to the amount of electricity required to power approximately 5,500 average households in the United States for one year according to 2001 statistics [Ref. 6.18]. The additional condenser efficiency power loss of 26,000 MW-hr per year from closed-cycle cooling corresponds to approximately 2,440 households in the United States for one year [Ref. 6.18]. The Gunderboom MLES would not create any additional condenser efficiency losses, as the temperature of the condenser cooling water would remain unchanged from current operation.

3 Response to Conclusions on Closed-Cycle Cooling

Many of the conclusions reached in the draft permit result from insufficient analysis or incorrect interpretation of analysis conclusions, and are not technically accurate. In addition, there are several examples in which preliminary estimates from the 2007 Response have been incorrectly used as final, bounding values in the permit. These issues require further consideration and more precise estimates given the magnitude of potentially converting Merrimack Station to closed-cycle cooling, and the significant changes to the Station since 2007, including implementation of the scrubber.

3.1 Water Usage

3.1.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] discounts the additional evaporation losses due the implementation of closed-cycle cooling. The permit implies that the evaporation resulting from the Power Spray Modules (PSMs) and the thermal plume in the river from the current system may equate to a similar loss of water:

Assuming for the sake of argument that this estimate is otherwise correct, EPA notes that it does not account for the evaporation that occurs with the station's current open-cycle/discharge canal/PSM cooling system and therefore errs to the high side to an unknown extent. Indeed, by increasing water temperatures, the thermal discharge probably increases evaporation rates from the Hooksett Pool itself. In other words, under the current system, Merrimack Station withdraws a larger volume of water from the river, heats it up substantially, and then discharges it through its lengthy discharge canal while periodically using the PSMs. This contributes a thermal plume to the river. With a closed-cycle system, water withdrawals and thermal loadings would be reduced by more than 95 percent. In light of these considerations, it is unclear which cooling system would ultimately result in greater overall evaporative losses. [NH 001465, Page 163]

3.1.2 Engineering Response

The current open-cycle cooling system withdraws water from the Merrimack River and returns it back to the river via a discharge canal. The discharge canal is elongated for the purpose of allowing some heat exchange to occur with the ambient atmosphere before the effluent is returned to the river. Power spray modules (PSMs) are installed in the canal, which spray the effluent a few feet into the air. This encourages cooling of the water through convective heat transfer and a small amount of evaporation.

In the draft permit, EPA states that the PSNH estimation of the impact of additional evaporation upon the Merrimack River errs on the high side because it does not take into account evaporation already occurring in the existing cooling system. Although this statement is technically correct (the evaporation resulting from operation of the current system was not included in the estimation), the current cooling system evaporates only a very small amount of water, especially when compared to the evaporation that would occur using a wet or hybrid cooling tower. Unlike cooling towers, the primary mechanism by which the PSMs cool water is convection, and not evaporation. Additionally, the existing

PSMs are only operated under certain thermal conditions, and do not operate all of the time. Therefore, the PSMs do evaporate a small amount of water, but they are not considered to be significant contributors to evaporation.

There is an incremental increase in the amount of evaporation that occurs within the Hooksett Pool as a result of elevated water temperatures. This evaporation loss is not attributed to operation of the PSMs, but is the result of naturally occurring heat transfer due to higher ambient water temperatures. While the exact amount of additional evaporation loss that occurs is difficult to determine, it is known that more water loss occurs in a closed-cycle system using cooling towers than one using a cooling pond. This is because cooling ponds transfer a larger percentage of waste heat to the atmosphere via radiative heat transfer, a method that produces less evaporation [Ref. 6.13]. Because cooling towers reject heat primarily by evaporating water, closed-cycle systems evaporate 2 to 3 times more water than open-cycle systems [Ref. 6.13]. This negates the possibility that the evaporation occurring in the river due to increased temperatures exceeds that of cooling towers.

The 2007 Response indicated that evaporation loss from the Hooksett Pool due to a cooling tower was a concern. It was estimated that the total loss of river water due to installation of a cooling tower would be 4.79 million gallons per day. This represents a significant loss of water from the Hooksett Pool daily. While small compared to evaporation losses, the water loss from cooling tower drift could still represent measurable water losses over time. According to SPX Cooling Technologies (SPX) "Cooling Tower Fundamentals" [Ref. 6.8], drift rate can be estimated by multiplying the total water flow rate by 0.02%. Given a total combined flow rate of 199,000 gpm for Units 1 and 2, this represents over 57,000 gallons per day of additional water lost from the Hooksett pool. Using state-of-the-art drift eliminators, the drift rate of the cooling tower could potentially be restricted to 0.001% of the total water flow rate, reducing the amount of water lost to drift daily to 2,880 gallons per day, as conservatively estimated in the 2007 Response [Ref. 6.3].

Simplified schematics of the closed-loop and open-loop cooling water system configurations are shown in the Figures below; Figure 3 depicts the existing open-cycle configuration, while Figure 4 shows a potential closed-cycle configuration. It is estimated that the closed-cycle cooling system would consume approximately 3,325 gpm of water. This amount of water loss is equivalent to approximately 2,640 Olympic-sized swimming pools per year [Ref. 6.21]. Note that several smaller miscellaneous loads (e.g., slag sluice, de-icing recirculation, travelling screen wash, equipment cooling, fire water, etc.) are not included in the schematic diagrams below for simplicity.

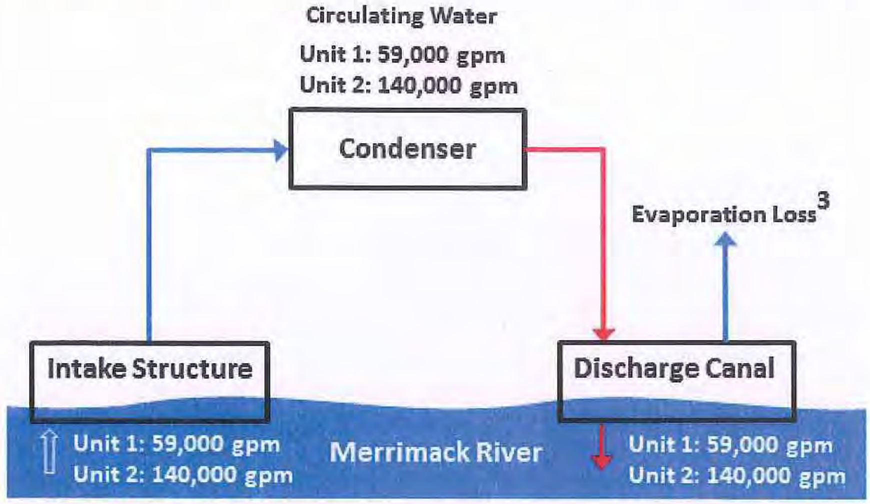

Figure 3: Existing Open-Cycle Cooling Flows at Merrimack Station

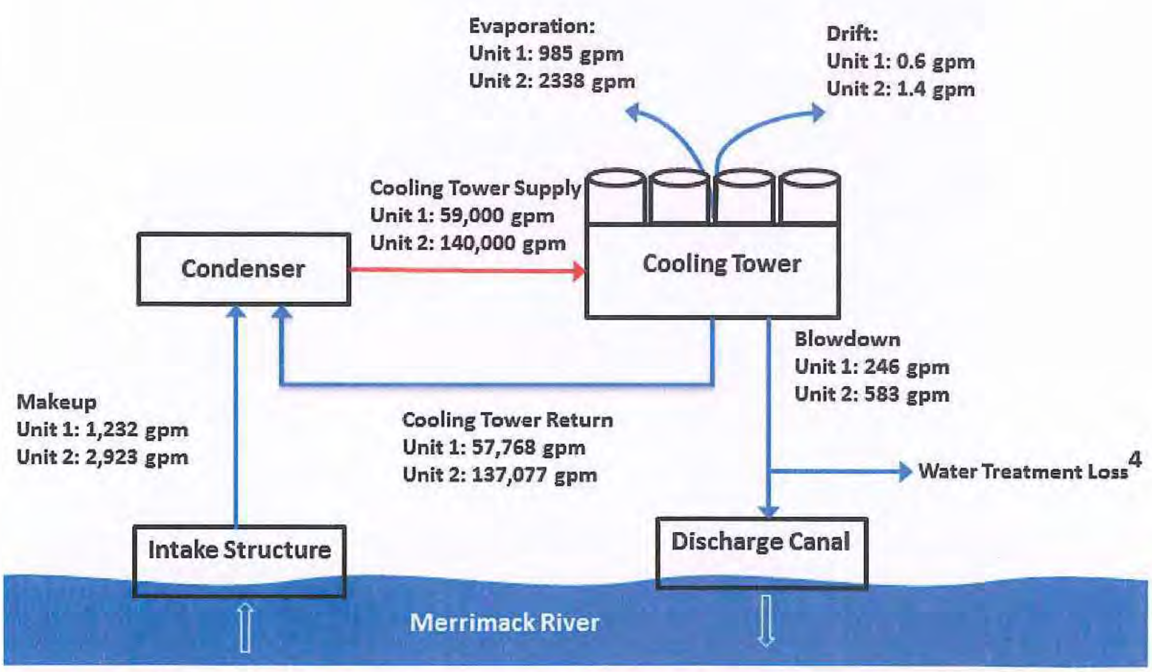

Figure 4: Closed-Cycle Cooling Flows at Merrimack Station

It is important to note that while a closed-cycle cooling system draws significantly less water from the river than an open-cycle cooling system, it consumes significantly more

[3] For typical once-through applications, it is generically estimated that approximately 1% of the water used is lost due to evaporation [Ref. 6.15].

[4] In a closed-cycle system, not all of the water from the cooling tower blowdown will be returned to the Merrimack River. Water will be lost during treatment of the blowdown [Ref. 6.27].

water [Ref. 6.13, 6.14]. While the open-cycle system draws in a higher volume of water from the river, all of the water is returned to the river and only a small amount of water is evaporated. The closed-cycle system draws in significantly less water (5.98 million gallons per day), but returns only the blowdown (initially estimated to be approximately 1.19 million gallons per day) to the river [Ref. 6.3]. A report to the U.S. Department of Energy indicated that the typical closed-cycle cooling system consumes between 70-90% of the water withdrawn [Ref. 6.13]. Thus, closed-cycle cooling systems consume approximately 2 to 3 times more water than open-cycle cooling systems on average [Ref. 6.13]. It should be noted that the estimate of 1.19 million gallons per day is preliminary in nature and should not be viewed as a final, bounding value as stated in the 2010 Request for Additional Information (RAI) Response [Ref. 6.31]:

It should be noted that a higher rate of evaporation, drift, or blowdown is possible dependent on the final design of the cooling towers and further investigation in river water quality and absolute maximum ambient wetbulb temperature...

A survey of State Water Managers across the United States was conducted to estimate their opinions on the likelihood of water shortages during the next 10 years under "Average Conditions" for their state. The State Water Managers responded with their estimate of the types of water shortages they expected to see. They could either respond with "None", "Local", "Regional", or "Statewide." The State Water Manager for New Hampshire indicated an expectation for "Regional" water shortages during the next 10 years under average conditions. This designates New Hampshire as one of the more concerned States, as only one State responded with a more negative outlook [Ref. 6.13]. In 2007, several power plants in the Southeastern United States had to either shut down or reduce operation due to water shortages [Ref. 6.14]. The increased frequency of water shortages is only compounded by increased population growth, and a need for more water and electricity. It has been suggested that it is not beyond the realm of possibility for a plant retrofitted with closed-cycle cooling being required to return the plant to open-cycle operation for water conservation purposes in the future [Ref. 6.13].

Concerning water usage and power generation, closed-cycle cooling produces less electricity and consumes more water than open-cycle cooling. Use of alternative technologies, such as CWW screens, would not increase water consumption nor significantly reduce the generating output of the Station.

3.2 Cost Considerations

3.2.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] claims that the 2007 PSNH cost estimates may be too high, and then states (based on the 2007 estimates) that the project is economically feasible for PSNH:

In summary, while not specifically endorsing PSNH's cost estimates (and having identified certain reasons why PSNH's cost estimates may be biased high), EPA agrees with PSNH that retrofitting mechanical draft wet or hybrid wet-dry cooling towers at Merrimack Station in a closed-cycle configuration for both units would entail significant one-time and annually recurring costs. Nevertheless, using PSNH's cost estimates for *purposes of this evaluation, EPA concludes for the purpose of determining the BAT under the CWA, that the costs for these options are reasonable and economically achievable. [NH 001465, Pages 155-156]*

3.2.2 Engineering Response

The level of expected accuracy for a typical cost estimate can be expected to increase as a project becomes more well-defined during the life-cycle of the project. Early in a project's life-cycle, the scope generally will not be as well-defined, thus, there can be considerable inaccuracies present within a cost estimate made early in the project. Near the time of construction, however, a detailed engineering design is typically in place, and costs can be estimated with a much higher degree of accuracy. The USACE Engineering Guide Engineering Regulation (ER) 1110-2-1150 "Engineering and Design for Civil Works Projects" defines five project phases for a typical project [Ref. 6.30]:

1. Reconnaissance Phase
2. Feasibility Phase
3. Preconstruction Engineering and Design Phase
4. Construction Phase
5. Operation, Maintenance, Repair, Replacement, Rehabilitation Phase

Given that there is no detailed design yet in place for Merrimack Station, it is clear that any project to modify Merrimack Station's CWIS is still in a very early phase. USACE ER 1110-2-1150 gives the following description of an engineering assessment of alternatives during the Reconnaissance Phase [Ref. 6.30]:

Detailed engineering studies and analyses are generally not required during the reconnaissance phase. The engineers on the [Project Delivery Team] PDT must participate in assessing one or more potential alternatives to only determine whether they will function safely, reliably, efficiently, and economically. Effort shall be applied only to alternatives considered to have potential. In addition, PDT members shall jointly assess whether potential alternatives adequately address environmental and [hazardous, toxic, radioactive waste] HTRW issues to determine if the alternatives are practical [Page 6].

Given the above description, it is reasonable to assume that the project of retrofitting Merrimack Station's CWIS is in this reconnaissance phase of alternative assessments, as there are still various alternatives that are being evaluated on a high-level, conceptual basis. The USACE ER 1110-2-1302, "Civil Works Cost Engineering", gives guidelines and requirements for estimating costs for civil works projects [Ref. 6.29]. The ER gives different guidelines and requirements for cost estimates at various phases of a project. The ER includes the following description of cost estimates at the reconnaissance phase [Ref. 6.29]:

Cost estimates for the reconnaissance phase may be developed using quotes, calculations, unit price, or historical data as backup [Page 11].

The ER gives five cost estimate classifications, based on level of project definition and the end usage of the estimate. The cost estimate Classes are arranged from 1-5, with Class 5 estimates being the most preliminary and Class 1 estimates being the most well-defined. As expected, Class 5 estimates contain the highest uncertainty and Class 1 estimates have the smallest uncertainty [Ref. 6.29]. Alternative Studies in the Reconnaissance Phase correspond to Class 4 estimates, per Table 2 in ER 1110-2-1302 [Ref. 6.29]. Class 4 estimates are bound on either side by Class 5 or Class 3 estimates. Class 5 estimates are generally described as "Rough Order of Magnitude" estimates [Ref. 6.29]; it is safe to say that estimates provided by PSNH in the 2007 Response are more well-defined than order of magnitude estimates. However, Class 3 estimates are those that correspond to the Preconstruction Engineering and Design Phase [Ref. 6.29], which is beyond the scope of what was provided in the 2007 Response. Thus, it can be reasonably concluded that the cost estimates provided by PSNH regarding closed-cycle cooling in the 2007 Response are Class 4 cost estimates.

Table 1 of ER 1110-2-1302 [Ref. 6.29] provides Expected Accuracy Index Range Indexes for the various estimate classes. The percentage uncertainty decreases as the project becomes more well-defined. For a Class 4 estimate, an expected accuracy from +30/-15% to +120/-60% is given [Ref. 6.29]. This means that Class 4 estimates can be expected to potentially underestimate costs by a factor of 30-120%. Therefore, the cost estimates provided in the 2007 Response can also be expected to contain similar uncertainty. In addition to the considerable uncertainty present within a cost estimate made at such an early stage, there are new conditions present at Merrimack Station that may affect the cost of implementing closed-cycle cooling.

The 2007 Response [Ref. 6.3] provided conceptual (preliminary) estimates of both initial and annual recurring costs of a conversion to closed-cycle cooling for both Units. The estimated initial cost was $67,980,500 and the estimated annual cost was $6,505,800. These costs were estimated based on a preliminary conceptual design, and not a detailed final design that would account for additional costs due to various interferences with existing Station equipment. Therefore, the cost estimates provided for conversion to closed-cycle cooling at both Units are not precise and include a large amount of uncertainty, as mentioned above. Specifically, the estimated cost of implementation requires updating before any determination can be made upon the economic feasibility of a BTA. In the draft permit, EPA took the estimates in the 2007 Response and applied a multiplying factor to account for inflation of the dollar. However, the 2007 cost estimates need further refining beyond the addition of an inflation factor.

To achieve more accurate material and implementation costs, a more detailed design is required. Additionally, there are new interferences related to existing piping at the Station that must be examined. Merrimack Station has been in the process of implementing a wet flue gas desulphurization (FGD) system to remove sulfur dioxide and mercury from the flue gas. Updated piping and equipment layouts from these modifications are required for a more accurate estimation of the cost, as the space available for installation of closed-cycle piping may have been reduced. In the conceptual design, the cooling towers were proposed to be located on the south side of the Station on the island between the discharge canal and the river. While some of the existing piping may be suitable for use in the conversion to closed-cycle cooling, there will need to be significant amounts of new piping installed. This aspect could appreciably impact the duration of the forced outage for implementation, contributing greatly to overall project cost and schedule. These considerations require further engineering to create a more detailed design resulting in a more accurate determination of the costs of implementation. In addition to the uncertainty present within a conceptual cost estimate, the potential for cost overruns must be accounted for by adding contingency into the estimate itself. The inherent risks associated with such a large scale project increase the potential for cost overruns, and necessitate the addition of considerable contingency factors.

It is well-acknowledged in the power industry that project costs can significantly increase between the conceptual design stage and the detailed design stage. Further, these costs typically also increase from the design stage to the implementation stage as there are many unforeseen difficulties that can arise during implementation of large projects. It is not possible to predict all of the unforeseen changes and setbacks that may occur, even with a detailed design, and especially from a conceptual design. The contingency multipliers provided in the 2007 Response [Ref. 6.3] and discussed in the draft permit [Ref. 6.1] are not intended to cover these unforeseen issues. The estimated design costs from the 2007 Response [Ref. 6.3] were scaled based on actual design costs taken from previous, similar applications, procurement costs were based on vendor budgetary estimates whenever available, and construction costs were derived utilizing established construction cost estimating tools. However, none of this captures the full scope of work, as would be possible if the final detailed design were completed, all associated bill of materials developed, and vendor quotes obtained for all materials. For this reason, contingency multipliers (25%) were added to all cost estimates. However, the aforementioned changes and setbacks encountered during implementation would add to the project cost above what is estimated and accounted for in the 25% multiplier. The additional costs incurred by such setbacks are unpredictable and can be difficult to estimate. Several studies have been conducted on typical cost overruns of large scale projects at coal-fired power plants. One study showed that average project costs exceed projections by a factor of 1.55 [Ref. 6.5]. Thus, the 25% multiplier likely underestimates the actual project cost due to unforeseen setbacks and difficulties. As such, an additional multiplier of at least 30% would be required to attempt to estimate the final project costs based on the initial cost estimates and the aforementioned study [Ref. 6.5]. These extensive cost increases would not be inconsistent with other similar projects within the industry. There are many recent examples of coal-fired power plant projects that have been significantly hampered by increases from initial cost estimates.

For example, PSNH's recent experience with the construction of a wet flue gas desulphurization system ("FGD" or "scrubber system") at Merrimack Station provides an illustration of the price differential between a preliminary conceptual estimate and a more detailed engineering design estimate. PSNH received a preliminary estimate in 2005 for $250 million for the construction of a scrubber system at Merrimack Station. The estimate of $250M was based on the vendor's experience and knowledge of direct costs of existing FGD designs and installations in the United States. For purposes of the conceptual estimate, it was assumed that a typical scrubber targeting SO_2 emission reductions would be constructed.

In early 2008, a detailed engineering design estimate for the Merrimack Station scrubber was provided based on site-specific conditions and known operational challenges as well as highly detailed engineering specifications and preliminary bids from vendors for major components—this second, more detailed estimate was for $457M. The price difference between the two estimates was due to a number of factors not accounted for in the earlier 2005 conceptual estimate, including the following:

- The Merrimack scrubber system had to target mercury emissions as its top priority as the result of a state law; to ensure this was accomplished, PSNH required the contractor to provide what is believed to be the first-in-the-industry guarantee regarding mercury reductions. There was a significant cost associated with this guarantee.
- There were a number of operational challenges at the site which increased the cost, including the requirement that two generation units with pressurized cyclone-design furnaces of differing sizes must connect into one scrubber system. In addition, there were certain site-specific constraints not accounted for in the first estimate.
- PSNH required additional performance guarantees and equipment guarantees with associated warranties for all major components. It also became apparent that certain equipment adjustments and enhancements should be added to optimize the performance of the system.
- The original conceptual estimate did not include internal costs or significant AFUDC (Allowance for Funds Used During Construction) or owner-supplied systems and equipment (such as the expanded substation).
- During the two years between the two estimates, the market experienced an unforeseen demand for scrubber systems and for the limited workforce with the requisite experience. The increased demand on the limited supply increased the costs to construct major components.
- Similarly, during the two-year intervening time period, the global economy experienced an unprecedented escalation in commodity and material costs. The cost of steel alone went up approximately 50% during that time.
- PSNH was required by state law to construct and operate the scrubber system "as soon as possible" to provide early emissions reductions. There were costs associated with an expedited project timeframe.

The Merrimack scrubber system was successfully brought online well ahead of schedule: Unit 1 in September 2011 and Unit 2 in November 2011. The final cost of the project is currently estimated to be $422M, an increase of nearly 70% over the preliminary conceptual estimate. These types of cost increases are not limited to just Merrimack Station and have been seen at other locations across the country.

In the summer of 2006, Duke Energy's cost estimate for the two unit Cliffside Project was approximately $2 billion. In the fall of 2006 (only a few months later), Duke indicated that the cost of the project had increased by approximately $1 billion. The project was forced to be downsized due to permitting issues, such that only one unit could be built. After the decision to build only one unit, the cost of the unit was then estimated to be $1.53 billion. By May 2007, the estimate for the cost to build the single unit had risen another 20% to $1.8 billion, not including financing costs. Hence, the cost estimate for a single unit ended up being almost equal to the original estimate for two units [Ref. 6.6].

In June 2008, Wisconsin Power & Light (WPL) announced that the estimated cost of its proposed Nelson Dewey 3 coal-fired power plant had increased by 40% over the original cost estimate proposed in late 2006 [Ref. 6.6]. In April 2008, Duke Energy Indiana announced that the estimated cost of its proposed Edwardsport coal plant had risen 18% since the spring of 2007, which is only a year's time. In its Petition to the Indiana Regulatory Commission, Duke noted that this projected increase in cost "is consistent with other recent power plant project cost increases across the country." [Ref. 6.6]

A 2007 assessment of American Municipal Power Ohio's (AMP-Ohio) proposed coal-fired power plant noted [Ref. 6.6]:

> *Recent experience on large U.S. coal projects indicates that the major EPC Contractors are not willing to fix price the entire project cost. This is the result of volatile costs for materials (alloy pipe, steel, copper, concrete) as well as a very tight construction labor market. When asked to fix the price, several EPC Contractors have commented that they are willing to do so, but the amount of money to be added to cover potential risks of a cost overrun would make the project uneconomical. [Page 4]*

Tenaska Energy has planned to build a coal-fired plant in Oklahoma, but cancelled its plans due to rising construction prices. Tenaska Energy cited "dramatically" increasing prices for its decision, stating: "it just wouldn't be a prudent business decision to build it" [Ref. 6.6].

Appalachian Power Company (APCo) was denied in its request to the Virginia State Corporation Commission to build a coal-fired power plant in West Virginia. In denying the request, the Virginia Commission found that the cost estimates for building the plant were almost two years old, and had not been updated. In its Final Order, the Commission stated [Ref. 6.6]:

> "...There are no meaningful price or performance guarantees or controls for this project at this time. This represents an extraordinary risk that we cannot allow the ratepayers of Virginia in [APCo's] service territory to assume."

In summary, there are many examples of coal-fired power plant projects that have encountered costs that significantly exceeded initial estimates. These increases in cost estimates are the result of unforeseeable circumstances and issues encountered during planning and implementation. These same unforeseeable circumstances would likely significantly raise costs for a large project at Merrimack Station. While unforeseeable costs can be expected for Merrimack Station, there is already a known circumstance that will significantly raise costs that has yet to be evaluated. The configuration of Merrimack Station is substantially different now than in 2007, when the conceptual design and resulting cost estimates were completed. Since 2007, a scrubber system (FGD system) has been installed at Merrimack Station to reduce sulfur dioxide and mercury emissions. This was a very large construction project, and the available free space on site has been significantly altered from 2007. As such, space that was assumed to be available for new piping additions in the conversion to closed-cycle cooling may no longer be available. A new conceptual design is required in light of these significant Station modifications. The updated cost estimates may more accurately reflect the cost of converting the site to a closed-cycle cooling system, although significant project unknowns will still exist prior to detailed design and implementation.

3.3 Air Emissions

3.3.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] states that significant air emissions are not anticipated, but remarks that any cooling towers would be subject to air pollution control laws and provides guidelines for properly controlling significant air emissions:

In sum, EPA does not anticipate significant air pollutant emissions from the cooling towers. That said, any cooling towers would be subject to federal and state air pollution control laws that will ensure that any air emissions are properly controlled. [NH 001465, Page 156]

3.3.2 Engineering Response

The 2007 Response discussed the additional air emissions that would result per unit of electricity produced resulting from implementation of a closed-cycle cooling system. The air emissions would be increased by two different sources: increased stack emissions, and new air emissions from cooling towers. The content of the stack emissions would be unaffected, but the quantity would increase as a result of:

- Increased Station parasitic losses resulting from the cooling tower's electricity demands.
- Reduced efficiency of the turbine and condenser as a result of warmer condenser water.
- Increased coal consumption to make up for newly incurred operational efficiency losses.

These factors would all contribute to the Station generating additional air emissions as a result of a conversion to closed-cycle cooling. It is also likely that other power generating stations would have to increase their electricity production to compensate for a reduction in electrical output from Merrimack Station. This could increase air emissions occurring in the region, as 71% of New England's generating capacity comes from power plants burning either natural gas, oil, or coal [Ref. 6.20]. Thus, adverse air quality impacts resulting from converting Merrimack Station to closed-cycle cooling would not necessarily be limited to the region immediately surrounding Merrimack Station.

There would also be an increase in air emissions resulting from the operation of new cooling towers. Cooling towers are known air emitters that are subject to regulatory air pollution controls. In certain PM 10 and PM 2.5 non-attainment zones where air pollution is a concern, new cooling towers will not be permitted. Merrimack Station is not located in such a zone, but the effects of installing new cooling towers are the same. The evaporation process within a cooling tower concentrates particulate matter and other impurities within the water that is left behind, which can eventually be emitted as drift from the top of the tower. In the draft permit, EPA states that high quality drift eliminators were specified in the preliminary design, thereby dismissing particulate emissions from the cooling tower as a serious concern. However, even state-of-the-art drift eliminators in excellent condition would still allow some drift to occur. As discussed in the 2007 Response [Ref. 6.3] and Section 3.1.2 of this Response, with the use of state-of-the-art drift eliminators, the drift rate of the cooling tower could potentially be restricted to 0.001% of the total water flow rate, theoretically reducing the amount of water lost to drift daily to as little as approximately 2880 gallons per day. The concentrations of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) within the Merrimack River would dictate whether particulate emissions were a concern in constructing the cooling tower. It is possible that additional water treatment equipment would have to be installed in order for any cooling tower to be operated and/or permitted. This would lead to significantly increased costs, additional implementation effort, and increased parasitic losses to the Station.

An additional factor to consider when analyzing the potential air emissions resulting from closed-cycle cooling is the "air washing" effect of cooling towers. Cooling towers are designed to maximize the contact between air and water; hence the quality of the water quickly begins to reflect the quality of air that surrounds it. The water droplets passing through the fill adhere to impurities and particulates contained in the air circulating the tower. As a result, the water leaving the tower contains much higher levels of impurities than the water entering. These impurities are then further concentrated the next time through the cycle as a portion of the water evaporates. Given currently available information, it is unknown at this point what effects "air washing" would have upon the water quality within the closed-cycle system.

It should be noted that installation of CWW screens or Gunderboom MLES would not increase air emissions (either by stack or cooling tower) or require installation of additional water treatment equipment and increased water treatment chemicals and concentrations.

3.4 Icing / Fogging Concerns

3.4.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] fails to base its analysis upon available models, such as SACTI, that would quantify the icing/fogging effects of a cooling tower. Instead, EPA assumes icing/fogging not to be an issue in the permit. PSNH has previously expressed icing/fogging as a public safety concern, and EPA has dismissed this concern without any rigorous analysis or quantifiable information:

Based on current information, EPA finds an insufficient basis to conclude that there is a significant threat of a traffic safety problem posed by the possibility of fogging or icing being caused by cooling towers at Merrimack Station. In addition, EPA also finds that if fogging or icing seems likely, it would likely be relatively infrequent and limited in geographic extent to areas quite close to the plant. Moreover, any such effects could be mitigated by reasonable traffic safety measures, as needed. [NH 001465, Pages 164-165]

3.4.2 Engineering Response

The 2007 Response [Ref. 6.3] outlined several potential impacts of the cooling tower plume. Even if a hybrid cooling tower were installed, a plume could still exist under certain environmental conditions. The following potential negative effects of a cooling tower plume could be a significant issue at Merrimack Station based on the prevailing wind direction:

- Visibility could be significantly reduced in areas surrounding the Station, which could pose a safety concern.
- Driving on nearby roads and highways could be significantly impacted, with the possibility of 'black ice' formation during the winter months. It should be noted that winter would be the most likely season in which to expect a plume from a hybrid tower.
- Mineral and/or impurity content of the entrained moisture could damage vegetation in the vicinity of the station.
- Heat content of the tower plume could degrade station heating, ventilating, and air conditioning (HVAC) systems.
- Potential for increased corrosion of Station equipment resulting from plume presence over a period of time.
- Ice accumulation on electrical equipment within the Station may bridge gaps that are required to be clear. This ice accumulation could lead to electrical arcing, resulting in unsafe conditions and increased maintenance requirements as well as switchyard disruptions/outage.

The conclusions in the 2007 Response [Ref. 6.3] were based on prevailing wind directions and predictions of the impact that would occur as a result. However the 2007 Response [Ref. 6.3] discusses the fact that these are simply estimates and not the result of any rigorous analysis or modeling. A more rigorous analysis or modeling effort could be utilized to more precisely qualify and quantify the actual icing/fogging impacts.

In the draft permit, EPA concluded that the 2007 Response analysis was insufficient to prove that icing and fogging would be a concern as a result of the cooling tower plume. However, the draft permit also notes that icing / fogging could be a concern with respect to nearby traffic, but states that it could be mitigated by traffic safety measures. Given that this is a public safety concern with potentially considerable consequences, the estimates provided by PSNH in 2007 should have been used as a foundation for more rigorous analysis or modeling (such as SACTI), and not as a basis for a final decision. These estimates contain considerable uncertainty and should not be used as a bounding assessment of icing/fogging impacts.

PSNH is concerned about the possibility of icing and fogging resulting from installation of cooling towers at Merrimack Station. The Station already experiences issues with freezing and black ice during large portions of the year. EPA has failed to utilize or request any analysis or modeling that will provide more precise resolutions to these possible public safety concerns. Instead, EPA has based its permit decisions upon a preliminary estimate by PSNH using wind directions, which was not intended to be used as final, bounding analysis. A SACTI or similar model should be either utilized or requested by EPA before a decision is made regarding icing/fogging impacts.

It is important to note that there are other technologies available for use at Merrimack Station that would not raise safety concerns related to ice deposition and excessive fogging. Installation of CWW screens would not cause any additional icing or fogging to occur at the Station. Likewise, installation of the Gunderboom MLES would not result in additional ice deposition or fogging.

3.5 Power Generation Losses

3.5.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] determines the potential loss to power generation based the preliminary estimates of the condenser efficiency (operational efficiency) impact of closed-cycle cooling system installation from the 2007 Response [Ref. 6.3], and not on any modeling analysis that would have given a more rigorous estimate of this impact:

> *...Cooling system modifications also have the potential to affect air emissions because changing from open-cycle to closed-cycle cooling reduces condenser efficiency. This reduces the maximum electrical output of the generating units in warm weather and decreases the overall efficiency with which the units can convert coal into electricity. PSNH has estimated the reduction in electricity output as 2.98 MW for both units combined on an annualized average basis... [NH 001465, Page 157]*

3.5.2 Engineering Response

The 2007 Response [Ref. 6.3] provided conceptual (preliminary) estimates of Station efficiency losses resulting from a conversion to a closed-cycle cooling system. These efficiency losses are divided into two categories: operational efficiency (condenser) losses and parasitic losses. Operational efficiency losses are reductions in the amount of power generated by the Station resulting from the higher cooling water inlet water temperatures provided to the condenser. Parasitic losses are reductions in the net electrical power output resulting from increased electricity requirements to operate the Station and the closed-cycle equipment. Both types of losses would reduce the Station's electrical generating capacity without reducing the Station's emissions if the Station were converted to closed-cycle cooling. According to the preliminary estimates given in the 2007 Response, the amount of lost generating capacity equates to approximately 7,900 average American households [Ref. 6.18]. This estimate is preliminary and would require analysis or modeling to more precisely quantify. The lost capacity would have to be made up by other generating facilities in the region. This could increase air emissions in the region, as 71% of New England's generating capacity comes from power plants that consume either natural gas, oil, or coal [Ref. 6.20].

The 2007 Response estimated average operational efficiency losses of 2.98 MW for Units 1 and 2 combined and average parasitic losses of 6.7 MW for Units 1 and 2 combined. These losses would result in an average annual estimated loss of approximately 10 MW power output from the Station, with losses of up to 22 MW during peak summer load conditions [Ref. 6.3].

As stated previously, the power generation losses resulting from implementation of closed-cycle cooling eliminate enough electricity from the grid to power 7,900 average American households, according to the preliminary estimates in the 2007 Response [Ref. 6.18]. This number includes 5,500 lost households due to estimated parasitic loss, and another 2,440 households due to estimated operational efficiency losses. These estimates are preliminary in nature and would require a PEPSE model to more precisely quantify. If conversion to closed-cycle cooling became the standard for all power plants in the United States, the generating capacity of the Nation's fleet would be substantially impacted. Assuming all open-cycle power plants in the United States were required to be converted to closed-cycle cooling, it is estimated that approximately 166 million MW-hr per year of generating capacity would be lost [Ref. 6.26]. This represents enough electricity to power approximately 15.5 million average American households [Ref. 6.18]. Approximately 40 power generating stations the size of Merrimack Station would have to be built to make up the lost generating capacity.

It is important to note that the estimates provided in the 2007 Response were preliminary in nature and are not a result of a detailed evaluation or modeling. The exact impact to the generating capacity (given constant coal consumption) of the Station with a conversion to closed-cycle cooling has not been precisely determined thus far. Nevertheless, EPA has based much of its analysis on these estimates, and has not conducted more precise analysis or modeling to determine an exact generating capacity impact. A more rigorous analysis should be undertaken before any decision is made that will impact the generating capacity of Merrimack Station, as preliminary estimates contain too much uncertainty to be used as final, bounding values. Lost generating capacity is an especially important parameter, because it is used as an input to many of the justifications within the permit. Many of the evaluations, assumptions, and conclusions of the draft permit are directly linked to the generating capacity impact to the Station, including but not limited to:

- Annual recurring cost estimates are affected by the amount of electricity that the Station can produce.
- Annual recurring cost estimates are affected by the additional amount of coal the Station chooses to consume to attempt to make up some of the lost generating capacity.
- Air emissions can be affected by an increase in coal consumption by the Station.
- Estimates on the grid impact, and the number of megawatts required to be made up by other generating stations, is affected by Station efficiency determinations.
- Estimates on the evaporation rate of any cooling tower depend on the heat load imposed on it, which itself is dependent upon the efficiency of the steam cycle operation.

The efficiency penalty is usually higher for plants that are retrofitted with closed-cycle cooling than for plants originally designed for closed-cycle cooling [Ref. 6.13]. For these reasons, any decision made within a final NPDES permit should be based upon a more precise calculation of the lost generating capacity, and not on the preliminary estimates provided in the 2007 Response. A PEPSE model of Merrimack Station would provide a more rigorous estimate of the impact to the generating capacity and overall plant efficiency, and thus, giving a better basis upon which the aforementioned items can be evaluated. A larger than estimated efficiency impact could make other open-cycle options (that do not significantly affect Station efficiency) more feasible alternatives.

4 Cooling Tower Blowdown Water Quality

4.1.1 Draft NPDES Conclusion

The EPA Draft NPDES Permit NH 0001465 [Ref. 6.1] states that "No Detectable Amount" of any of the 126 priority pollutants is allowed from Outfall 003D (Cooling Tower Blowdown).

4.1.2 Engineering Response

Successful long-term operation of a cooling tower requires very specific water conditions. The chemistry of the circulating water in a closed-cycle system must be tightly controlled to prevent long-term damage to the tower and other associated components. Improper chemical control of a closed-cycle system can result in biofouling, scale formation, or corrosion [Ref. 6.8]. Chlorine and other chemicals are usually added to prevent biofouling, while sulfuric acid can be added to prevent scale formation [Ref. 6.8]. To prevent corrosion, the levels of pH, dissolved oxygen, and carbon dioxide must be kept within acceptable ranges [Ref. 6.8]. Because such specific conditions must be present within the circulating water for the long-term successful operation of a cooling tower, there are certain chemicals that must be continuously added to the water. These chemicals would be discharged to the Merrimack River as part of the cooling water blowdown.

To facilitate evaporation, cooling towers attempt to maximize the surface area contact between air and water. The significant amount of contact taking place between air and water causes an "air-washing" effect to occur [Ref. 6.8]. Any impurities present in the air can be quickly transferred to the water as it passes through the fill. This is similar in concept to a wet scrubber, which removes particles from flue gas by maximizing the surface area contact between the flue gas and a liquid. The particles in the flue gas become attached to the wet liquid; thus the flue gas is cleaned at the expense of the liquid. Unfortunately for a cooling tower, a portion of this liquid would be emitted from the top of the tower as drift. Most of the contaminants, however, would be discharged from the tower and into the Merrimack River through the blowdown. The level of effort that would be required to purify the cooling tower blowdown is unknown at this time, but it could require significant effort.

It should be noted that no new water quality issues would result from implementation of CWW screens or a Gunderboom MLES.

5 Response Summary and Engineering Conclusions

The specific issues discussed in this report may have a significant impact upon the EPA's conclusions reflected in the draft permit. As discussed previously, the issues raised in this draft permit response include the availability of alternative technologies:

- A passive fine-mesh, cylindrical wedgewire (CWW) screen system is available for seasonal operation to reduce impingement and entrainment mortality to satisfy CWA § 316(b) requirements.
- CWW Screens are available for seasonal use in the Merrimack River despite claims of both low river velocities and shallow water depths in the draft permit.
- The Gunderboom Marine Life Exclusion System (MLES) aquatic microfiltration barrier is an available technology for seasonal operation.

Additionally, this draft response addresses some of the problems and a lack of rigor associated with the analysis and conclusions within the draft permit.

- EPA's inaccurate discussion concerning the evaporation rate of water in a cooling tower configuration as compared to the existing cooling system. A closed-cycle cooling system typically evaporates about 2 to 3 times as much water as an open-cycle system [Ref. 6.13].
- EPA's misuse of the cost estimates as the bounding budget for the project in its analysis. Past experience has shown that preliminary cost estimates contain large amounts of uncertainty, and are often significantly lower than actual project costs. In addition, EPA fails to address the potential impacts of the new interferences created by the wet flue gas desulphurization system (i.e., scrubber system) that has been installed at Merrimack Station to reduce sulfur dioxide and mercury emissions.
- The increased air emissions that would result from cooling tower installation; including both increased stack emissions and particulate emissions resulting from cooling tower drift.
- EPA's failure to utilize or request use of any models (such as SACTI) to more precisely quantify the icing/fogging effects of a cooling tower before issuing a permit that assumes it not to be an issue. PSNH has previously expressed icing/fogging as a public safety concern, and EPA has dismissed this concern without any rigorous analysis or quantifiable information.
- EPA's misuse of the 2007 Response estimates for closed-cycle generating capacity impacts as bounding values. These numbers were provided as initial estimates and were not intended to be used as inputs to final decisions by EPA. EPA should have utilized or requested use of a more sophisticated tool (such as PEPSE) for predicting the generating capacity impact to Merrimack Station.

As discussed in this report, seasonal use of CWW Screens or a Gunderboom MLES AFB would be available for the reduction of impingement and entrainment mortality at Merrimack Station. In addition, conversion to closed-cycle cooling at Merrimack Station would introduce construction and operational obstacles and higher costs that anticipated based on EPAs conclusions. The specific issues mentioned above may have a significant impact determination of closed-cycle cooling as the BTA for Merrimack Station and warrant additional consideration by EPA before the final NPDES permit is issued.

As discussed in the 2009 Report, the preferred alternative technology option – seasonal operation of CWW screens in combination with the use of upgraded fish return systems – is expected to satisfy CWA § 316(b) with regard to impingement mortality and entrainment as follows:

- Reduce impingement mortality by approximately 84% from baseline.
- Reduce entrainment from baseline ranging from approximately 73% for 9 mm CWW screens to approximately 79% for 1.5 mm CWW screens.

In order to minimize both entrainment and fouling, a range of slot sizes from 9 mm to 1.5 mm has previously been evaluated by ENERCON and Normandeau. The lowest slot size in this range is smaller, and thus potentially more protective of aquatic organisms, than the 1.75 mm slot size of EPA's identified compliance technology for the Station [Ref. 6.16]. Given that smaller slot sizes may increase the likelihood of fouling, the optimum slot size would have to be determined for Merrimack Station. This would allow CWW screens to provide the maximum biological effectiveness while eliminating any fouling concerns. Once the optimum slot size is determined, seasonal use of CWW screens with upgraded fish return systems for the existing cooling water intake structures is recommended as the "best technology available" (BTA) for minimizing adverse environmental impact for Merrimack Station.

6 References

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Attachment 1 Correspondence

Section 1	**Email from Mike Ekholm, dated June 29, 2011**
Section 2	**Email from Mark Mattson, dated August 7, 2007**

From: Ekholm, Mike R [mailto:Mike.Ekholm@johnsonscreens.com]
Sent: Wednesday, June 29, 2011 12:22 PM
To: Richard Clubb; Watson, Mark E (Johnson Screens)
Cc: 'Sam Beaver'
Subject: RE: Urgent Wedgewire Screen Question

Richard,

In follow-up to the earlier email with the video, we have used these screens successfully in perfectly still water (reservoirs and interior basins), so in many cases a consistent sweeping velocity is not required. Any agitation or motion in the water will reduce impingement on the screen. In all cases, debris is immediately removed from the airburst event. The only possible issue is when the screen is in a contained area such as a small basin where there is nowhere for debris to go after the airburst. In these cases, the material will eventually reattach to the screen. In open water installations, this is not an issue.

Michael Ekholm

From: Mark Mattson
Sent: Tuesday, August 07, 2007 3:08 PM
To: 'Sam R Beaver'; 'Sue Polyak'; 'RClubb'
Cc: Drew Trested; PSNH - Allan Palmer
Subject: FW: 95 Thermal Bathymetry Data

Sam, Sue, Richard,

Attached is a file with crude bathymetry for lower Hooksett Pool. Each transect is named with respect to distance north (N) or south (S) of the discharge canal (S0) confluence into Hooksett Pool. The attached text describes how to determine the longitudinal transect spacing and distances with respect to the discharge canal (S0). Drew describes the station designations within each location in his email below and how to use the data to obtain one meter depth contour information at points laterally along each transect. Please also note that normal headpond elevation at Hooksett Dam is approximately 190 ft.

This is the only Hooksett Pool bathymetry that I am aware of. Hopefully you will find it sufficient to assist in the technology evaluation for Merrimack Station. Let me or Drew know if you have any questions.

Take care.

Mark

Attachment 2 Additional NPDES Permit Comments

1. Nearly as Effective Available Technologies

In its justification for choosing wet or hybrid towers in a closed-cycle configuration as the BTA, EPA states in the draft permit [Ref. 2]:

EPA determined that the most effective available means of reducing entrainment by Merrimack Station would be to convert both the Unit 1 and Unit 2 cooling systems to closed-cycle cooling using wet or hybrid wet-dry cooling towers. This would reduce water withdrawal volumes and, as a result, entrainment by 95 percent, saving 3.616 million eggs and larvae (out of 3.8 million). No other "available" approach (such as converting to closed-cycle cooling at only one unit or installing a modified screening system) was nearly as effective... [Page xvi]

One of the primary intents of this response is to state the availability of CWW screens for seasonal operation at Merrimack Station. It is stated in the 2009 Report that this option would reduce entrainment by 79%. This reduction in entrainment approaches that of closed-cycle cooling. It should be noted that the estimated costs of implementing closed-cycle cooling are significantly greater than the costs of installing CWW screens [Ref. 5, 7]. Additionally, unlike closed-cycle cooling, CWW screens would not significantly impact the generating capacity of Merrimack Station nor increase air emissions.

2. Reasonable Progress Towards Zero Discharge

In the draft permit, EPA states that its purpose is to set limits that correspond with progress towards the elimination of the discharge of pollutants [Ref. 2]:

EPA must set limits corresponding to the use of the best pollution control technologies that are technologically and economically achievable and will result in reasonable progress toward eliminating the discharge of the pollutant(s) in question. [Page 125]

Additionally, the draft permit states that it is Congress' intent that the EPA [Ref. 2]:

...Use the latest scientific research and technology in setting effluent limits, pushing industries towards the goal of zero discharge as quickly as possible... [Page 127]

It should be stated that from a thermodynamics perspective, a power generating cycle that produces no waste heat is impossible. This heat can only be re-directed from the river into the atmosphere. The rejection of this heat to the atmosphere through use of cooling towers requires consumption of a large volume of water that would otherwise not be necessary. Additionally, cooling towers create new air emissions from drift. Closed-cycle cooling towers in particular can also increase air emissions indirectly, as a result of lost generating capacity. From this perspective, any reduction in the water impacts of the Station comes at the expense of additional air impacts. Any dormant contaminants within the Merrimack River would be emitted into the atmosphere, affecting areas and populations that may not have been previously impacted by the Station. When compared to current operations, the use of cooling towers would also increase the magnitude of chemical pollutants discharged to the Merrimack River (as explained in Section 4.0 of this response). In summary, installation of cooling towers at Merrimack Station would create additional pollutant discharges to both the air and water.

3. Undisputed Availability of Closed-Cycle Cooling

EPA states in the draft permit that closed-cycle cooling is a technology that has undisputed availability at Merrimack Station [Ref. 2]:

...Given PSNH's expressed position and given the undisputed availability of other cooling tower technologies equally effective... [Page 140]

and

In addition, given the undisputed availability of other cooling tower technologies... [Page 143, Ref. 2]

and

EPA agrees that retrofitting mechanical draft cooling towers in a closed-cycle configuration to Merrimack Station would present a complicated construction project, but the Agency concludes that it would be feasible. [Page 173, Ref. 2]

To use such language, EPA feels strongly about the feasibility of a project that still has many large unknowns associated with it. Piping interferences, site layout constraints, operating parameters, permitting issues, water and air quality issues, and budgetary concerns are just the beginning of all the unknowns associated with what would be a large-scale project. Due to the recent substantial changes at Merrimack Station, implementation of closed-cycle cooling would be more challenging from an engineering standpoint, and thus more costly, than was estimated in the 2007 Report.

4. Conclusions Regarding Dry Cooling

While PSNH agrees that dry cooling is not an available technology for Merrimack Station, EPA uses the following logic to rule it out as a possible BAT for Merrimack Station [Ref. 2]:

...Given the undisputed availability of other cooling tower technologies likely to have substantially lower cost, and nearly the same effectiveness at reducing thermal discharges to the Merrimack River, even if EPA was able to determine that dry cooling is an available technology for Merrimack Station, the Agency would presently be unable to determine it to be the BAT. [Page 143]

In the quote above, EPA rules out dry cooling because another technology (wet cooling towers) is available that has a substantially lower cost and comparable environmental impacts. In relation to closed-cycle cooling towers, there are other technologies (CWW screens) that would have appreciably lower cost with comparable environmental impacts. Both of these compromises represent small sacrifices in environmental impact for significant reductions in costs. For whatever reason, EPA has determined that the first compromise (from dry to wet cooling) was justified, but the second (from wet cooling to CWW screens) was not.

5. Available Technologies

In justifying the technological availability of cooling towers, EPA states the following [Ref. 2]:

Mechanical draft wet and hybrid wet-dry cooling tower technologies are widely used at steam-electric power plants. These technologies are often used in closed-cycle configurations and have been retrofitted in closed-cycle configurations at a number of plants... PSNH agrees that either technology could be retrofitted at Merrimack Station in closed-cycle configuration and has provided estimates of the costs and performance consequences of doing so. EPA concludes that retrofitting mechanical draft wet and hybrid wet-dry cooling tower technologies in a closed-cycle configuration for both Units I and II (or for either unit alone) are available technologies for Merrimack Station. [Page 147]

Firstly, as part of its justification for the availability of mechanical draft wet or hybrid cooling towers, EPA states that these technologies are widely used at steam-electric power plants. CWW screens have been installed at over 2,000 locations worldwide with at least 487 locations in the United States [Ref. 4]. This clearly represents a substantial number of successful installations.

Secondly, as part of its justification for the availability of mechanical draft wet or hybrid cooling towers, EPA states that these technologies have been retrofitted at a number of plants. CWW screens have been retrofitted for approximately 55 open-cycle generating facilities within the United States [Ref. 4].

Thirdly, as part of its justification for the availability of mechanical draft wet or hybrid cooling towers, EPA states that PSNH agrees the technologies in question could be retrofitted. In the 2009 Report, PSNH agreed that CWW screens could be retrofitted once the optimum slot size was determined [Ref. 5].

And finally, as part of its justification for the availability of mechanical draft wet or hybrid cooling towers, EPA states that PSNH has provided estimates of the costs and performance consequences of retrofitting with closed-cycle cooling towers. In the 2009 Report, PSNH also provided estimates of the costs and performance consequences of retrofitting the Station with CWW screens [Ref. 5].

With all of these conditions being satisfied by both mechanical draft cooling towers and CWW screens, and since EPA cites the "undisputed availability" of closed-cycle cooling towers, it then follows that CWW screens should also be an available technology.

However, later in the permit, EPA makes the following statement [Ref. 2]:

At Merrimack Station, the only effective available technology to reduce entrainment mortality is to convert the facility to closed-cycle cooling ("CCC"). [Page 318]

Given that CWW screens are an available technology (per the same criteria used to deem closed-cycle cooling available), and that seasonal operation of CWW screens is estimated to reduce entrainment mortality by 79%, the above statement is not supported.

6. Capacity Factor

Despite the many aforementioned reasons why the total cost estimates are conservatively low, EPA claims PSNH's estimate of lost profits during the outage may be biased high [Ref. 2]:

EPA notes two reasons why PSNH's estimate of lost profits may err to the high-side: first, PSNH has used the units' nameplate ratings rather than the lower production capability ratings that PSNH currently claims in its reports to the regional system operator; and second, PSNH has assumed that the units would have been operating at 100 percent capacity rather than a lower figure reflecting the facility's recent actual capacity factors. As shown in the Table 7-3 below, Merrimack Station's actual capacity factor has been closer to about 80 percent over the last ten years. [Page 150]

In estimating potential lost profits due to an outage, it is a given that the actual capacity factor during any period of operation is inherently unknown. There are too many factors that would have to be accurately predicted to estimate exactly what the capacity factor would be on any given day. That being said, the potential loss in profit represents the profit that could have been made if the plant were in operation. When evaluating such an opportunity cost, it seems most prudent to use a 100% capacity factor. There are certainly periods when Merrimack Station operates at full capacity, hence this number represents the potential realizable profit that Merrimack Station can make.

7. Estimated Outage Time

In the draft permit, EPA implies that PSNH's outage time estimate may be biased high [Ref. 2]:

EPA further notes that PSNH has provided little information to support its assertion that converting to closed-cycle cooling would require three weeks of otherwise unnecessary outage. [Page 150]

Given the very large scope of work required to tie-in a closed-cycle system to an existing open-cycle system, three weeks of additional outage represents a conservatively low estimate. A project of this magnitude and complexity, considering the many unknowns associated with implementation and the intrusive nature of the modification, may understandably require a lengthy outage. Again, numerous large-scale changes have occurred at Merrimack Station since the outage estimate in the 2007 Report; hence the forced outage time is likely underestimated.

8. Impact of Outages on Cost Estimate

As previously stated, EPA charges PSNH's cost estimates as being biased high. One contention that EPA makes is with the usage of fans and pumps [Ref. 2]:

EPA notes that the largest of PSNH's estimated costs – the cost of electricity required to run the booster pumps and tower fans – appears to be somewhat overstated because PSNH has assumed that the fans and pumps would run and consume electricity in all hours of each year, which overstates the electricity requirements. Neither the fans nor the pumps would operate at times when the respective generating units experience outages; and required fan usage would likely be reduced during cooler months of the year. [Page 152]

and

The incremental demand would be less when either unit experiences a planned or unscheduled outage and in cooler weather conditions when tower fan operation could be reduced. [Page 157, Ref. 2]

Information concerning Merrimack Station's outage schedule was provided in Section 6.2.4 of the 2007 Report [Ref. 7]. Regular maintenance outages account for less than 10% of a calendar year and would not significantly impact the cost estimates provided by PSNH. As explained in Section 3.2 of this response, there are many reasons why the estimates provided in 2007 likely underestimate the costs of implementing closed-cycle cooling at Merrimack Station.

9. Cost of Seasonal Closed-Cycle Cooling

In its justification for stating that seasonal closed-cycle cooling is economically achievable, it cites the fact that it is "obviously" less expensive than year-round closed-cycle cooling [Ref. 2]:

Obviously, if year-round closed-cycle cooling for both units is economically achievable, then lower cost options, such as the options for seasonal closed-cycle cooling or closed-cycle for only one unit, are also economically achievable. [Page 156]

Merrimack Station requires a cooling water system year-round to operate. Installation of a typical closed-cycle cooling system will not allow Merrimack Station to operate in any other manner besides closed-cycle cooling. The only method by which Merrimack Station could operate a seasonal closed-cycle cooling system would be to install a hybrid cooling system that could function in both open and closed-cycle configurations. The previous report did not include consideration of such a cooling system that could provide seasonal operation in either a closed-cycle or open-cycle configuration. Such a system would be much more complex to design and to operate, and would be largely unprecedented in the industry as a retrofit. As such, higher engineering design, implementation, and material costs would be expected. In stating that seasonal closed-cycle cooling is less expensive, EPA is assuming that the potential increased cost of installing a hybrid system will not offset the potential savings gained by only seasonally operating the closed-cycle system. Given that there is not a detailed design in place for either of these options, it is premature to state that seasonal operation of closed-cycle cooling is "obviously" less expensive than permanent closed-cycle cooling.

10. Cap-and-Trade and the CWA

EPA agrees that installing closed-cycle cooling towers at Merrimack Station will result in increased air emissions, both indirectly and directly. However, EPA states in the permit that the long-term impacts of air pollutant emissions will be close to zero, and cites cap-and-trade regulations as justification for this statement [Ref. 2]:

Further, EPA believes that the long-term impact on air pollutant emissions from installing this cooling system option at Merrimack Station is likely to be less than the near-term impact and may be close to zero. The reason is that cap-and-trade regulations in place for SO_2, NO_x, and, in New England, CO_2 as well, limit cumulative emissions over time because the total number of emission permits issued is fixed. These regulations therefore have the general effect of requiring any temporary near-term increase in air emissions to be offset by a subsequent reduction in emissions. While it is not possible to be certain that the offsetting future reductions would take place specifically in New England for types of pollutants whose permits are traded over a region broader than New England, even if the reductions took place in other regions of the United States, New England would likely be a downwind beneficiary. [Pages 158-159]

EPA has justified the increase in air emissions by stating that there would be a subsequent reduction somewhere else to offset this increase. However, EPA does not give any basis for this statement, and does not provide an example of a subsequent reduction that will take place in the long-term to offset this increase in emissions. If closed-cycle cooling tower retrofits were to become the BTA standard, it would likely result in increased emissions, similar to those at Merrimack Station. The only way to achieve the CWA's goal of eliminating discharge of all pollutants, including heat, will be to transfer the heat into the air. If closed-cycle cooling towers are used to accomplish this, air emissions will increase across the board. Additionally, not all air pollutants are covered under cap-and-trade regulations. Cooling towers will primarily emit Particulate Matter (PM10 and PM2.5), which are not part of cap-and-trade regulations. Hence, cap-and-trade does not constitute a valid justification for stating that long-term emissions from the cooling tower will be close to zero.

11. Tree Removal

In the 2007 Report, PSNH stated that an area around the cooling tower site would have to be cleared to maximize airflow to the towers [Ref. 7]. This would increase the visual impact of the facility [Ref. 7]:

...The addition of the tower would make the entire facility more visible as the clear-cutting of the trees on the discharge canal island that would be required for construction of the tower and to allow maximum airflow to the tower would remove a visual buffer from vantage points both up and down river. [Page 54]

EPA discounts this position, implying that PSNH may be overstating the need to remove trees in the area [Ref. 2]:

While it remains to be seen whether all of this tree removal is necessary... [Page 161]

There would be some aesthetic impact as required to ensure adequate airflow to the air inlets of the cooling towers. Unobstructed airflow is essential to the successful operation of an induced draft cooling tower. Any restrictions or obstructions close to the towers can lead to low pressure areas near air intakes, which may result in unwanted interference or recirculation. For the cooling towers specified by SPX in the 2007 Report, it is recommended that all obstructions to airflow within 100 ft. of the base of the cooling towers be removed [Ref. 7, 8]. This will require removal of all trees, shrubs, and other objects that may obstruct the flow of air into the tower.

12. Volume Reduction

As justification for selecting closed-cycle cooling as the BTA for Merrimack Station, EPA cites the following quote from *Central Hudson*, a court case decided in 1978 [Ref. 2]:

...The only way that massive entrainment damage can be minimized in many circumstances is by restricting the volume of water withdrawn or by relocating the intake structure away from the endangered larvae. The latter approach is often not feasible. [Page 228]

The following, more recent statement is from a report to the Department of Energy in 2010 [Ref. 3]:

...Technology alternatives to closed cycle cooling have advanced significantly since the 1970s and 1980s, when the much lower intake structure flow rates associated with closed cycle cooling were generally viewed as the best means of protecting aquatic species. Since then, most of the technologies listed in the following table have been improved through research, demonstration projects, and a limited number of operational deployments. These demonstrations, although limited in number, have shown promising species protection results – sometimes roughly equivalent to the performance of cooling towers. These alternatives, or combinations of these alternatives, are effectively "catching up" with cooling towers in terms of environmental performance (as "BTAs,") with major cost and reliability benefits compared to cooling towers, and without the downside problems associated with towers. [Page 2-11]

This statement implies that reducing the CWIS flow rate is no longer the only way to gain environmental benefits, as there are other technologies that can provide comparable reductions in environmental impact. It should be noted that the table of alternative technologies mentioned in the above quotation includes CWW screens [Ref. 3].

13. Intake Velocities

In evaluating Merrimack Station's existing CWIS, EPA states the following [Ref. 2]:

According to the PSNH Nov. 2007 CWA § 308 Response (Normandeau 2007d), the through-screen velocities of the plant's two units are 1.5 feet per second (ft/sec) (Unit 1) and 1.82 ft/sec (Unit 2). These velocities range from three to over three-and-a-half (3.64) times greater than a rate of 0.5 ft/sec, the intake velocity identified by EPA as being effective for minimizing the impingement of a broad range of fish species. [Pages 265-266]

There are a variety of technologies that would reduce the intake velocity of Merrimack Station to 0.5 fps or less. The 2009 Report states that intake velocities of less than 0.5 fps can be achieved through use of the Gunderboom MLES [Ref. 5]. Also, as previously stated, CWW screens have been installed with through-slot velocities as low as 0.25 fps [Ref. 4].

14. Entrainment Reductions

In determining the best performing technology, EPA reaches the following conclusion regarding the entrainment reduction provided by closed-cycle cooling [Ref. 2]:

Converting to closed-cycle cooling using wet cooling towers can reduce intake flow – and attendant entrainment and impingement – by 70 to 98%, depending on factors such as any restrictions on cooling tower cycles of concentration due to limits on chloride discharges. No other technology is broadly capable of reducing the mortality of eggs and larvae entrained by open-cycle cooling systems to a similar level. [Pages 310-311]

In the 2009 Report, it was stated that seasonal use of 1.5 mm CWW screens would reduce entrainment mortality by approximately 79% [Ref. 5]. Additionally, it was stated that impingement mortality would be reduced by approximately 84% [Ref. 5]. Both of these reductions fall within the broad limits described above. Therefore, the statement of there being no other technology (besides cooling towers) capable of providing these reductions is not supported.

References – Attachment 2

1. PSNH with Enercon Services, Inc. and Normandeau Services, Inc. Response to Environmental Protection Agency's Information Request for NPDES Permit Re-Issuance PSNH Merrimack Station Units 1 & 2 Bow, New Hampshire. July 2010, Revised June 2011.

2. United States Environmental Protection Agency (USEPA) Draft NPDES Permit NH 0001465. Draft NPDES Permit for PSNH Merrimack Station. 2011.

3. Longenecker & Associates. Cooling Water Issues and Opportunities at U.S. Nuclear Power Plants, A Report to the U.S. Department of Energy Office of Nuclear Energy. December 2010.

4. Johnson Screens Water Process Master Installation List, as of November 21, 2006

5. PSNH with Enercon Services, Inc. and Normandeau Services, Inc. Supplemental Alternative Technology Evaluation. October 2009.

6. SPX Cooling Technologies (SPX). Cooling Tower Fundamentals. 2nd Edition. Overland Park, KS. 2006.

7. PSNH with Enercon Services, Inc. and Normandeau Services, Inc. Response to United States Environmental Protection Agency CWA § 308 Letter, PSNH Merrimack Station Units 1 & 2. November 2007.

8. Marley / SPX Cooling Technologies. Technical Report H-004: External Influences on Cooling Tower Performance. SPX Corporation, 2012.