NORMANDEAU ASSOCIATES, INC. COMMENTS ON EPA'S DRAFT PERMIT FOR MERRIMACK STATION

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

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EXECUTIVE SUMMARY

On behalf of Public Service Company of New Hampshire ("PSNH"), Normandeau Associates, Inc. ("Normandeau") has prepared this report to identify and, where possible, correct the erroneous factual findings presented by the United States Environmental Protection Agency ("USEPA") in *EPA - New England Clean Water Act NPDES Permitting Determinations for the Thermal Discharge and Cooling Water Intake Structures at Merrimack Station in Bow, New Hampshire, NPDES Permit No. NH 0001465* (the "§316 Determination Document"). USEPA issued the §316 Determination Document in support the draft National Pollutant Discharge Elimination System ("NPDES") permit proposed under the federal Clean Water Act, 33 U.S.C. §§ 1251 et seq. (CWA"), for PSNH's Merrimack Station in Bow, New Hampshire, and in particular in support of the Draft NPDES Permit's new thermal discharge and cooling water intake requirements. However, the §316 Determination Document contains countless substantive misinterpretations and misrepresentations of the scientific data collected and analyzed by Normandeau during more than 40 years of ecological studies in the Merrimack River in the vicinity of Merrimack Station. As a result, the §316 Determination Document provides a flawed, inaccurate and thus improper basis for the Draft NPDES Permit's proposed thermal discharge and cooling water intake requirements.

CWA §316(a)

Merrimack Station is seeking a renewal of its existing thermal discharge variance under CWA §316(a), 33 U.S.C. §1326(a), as part of USEPA's renewal of the Permit. CWA §316(a) provides that a permit applicant may demonstrate that any effluent limitation proposed for the thermal component of a discharge is more stringent than necessary to assure the protection and propagation of the balanced, indigenous population ("BIP") of shellfish, fish, and wildlife in and on the body of water into which the discharge is made. Applicants with an existing thermal discharge, such as the Station, may demonstrate that the existing discharge is protective of the BIP by evaluating the BIP over a series of years during which the discharge occurred, and showing an absence of appreciable harm (40 C.F.R. §125.73(c); USEPA 1977). Contrary to USEPA's unfounded assertions, the data and analyses presented in the many reports prepared by Normandeau since 1969 and submitted to USEPA, the New Hampshire Department of Environmental Services and, after 1992, the other members of the Merrimack Station Technical Advisory Committee demonstrate that Merrimack Station's thermal discharge has not resulted in appreciable harm to the BIP in Hooksett Pool, and that the thermal discharge limits in the existing Permit adequately assure the protection and propagation of that BIP.

Nonetheless, in the §316(a) Determination Document, USEPA among other things:

- Incorrectly and without adequate justification ignored the significantly impaired water quality of the Merrimack River in the late 1960s, and selected the 1967-1969 Hooksett Pool fish community as the Hooksett Pool BIP for the purpose of the Draft NPDES Permit.

- Improperly calculated Catch per Unit Effort "(CPUE") values obtained for trap net and electrofish collections from the 1960s.

- Improperly compared Merrimack River temperatures that were clearly documented as having occurred once in 21 years – not annually – to well-established and accepted literature values for critical ambient water temperatures for fish.

- Improperly claimed that the trap net data for Hooksett Pool over time is more reliable than the electrofish data. This is not only clear error because of the inherent weaknesses of sampling a riverine environment using trap nets, but it is also a clear and unexplained contradiction of USEPA's own technical framework document for the development and implementation of large river bioassessment programs, "Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers" (Flotemersch et al. 2006), which identifies boat electrofishing as the most comprehensive and effective single method for the collection of fish from streams and rivers.

- Improperly criticized Normandeau's analysis of electrofish CPUE data due to its inclusion of juvenile fish, on the purported ground that doing so does not provide a good indicator of fishery status, and then included juvenile fish in its own analyses of trap net data.

- Improperly identified Merrimack Station thermal releases as the sole reason for a decline in pumpkinseed and yellow perch abundance, even though the data show that the significant improvements in the water quality in the Merrimack River following the 1972 enactment of the CWA has played a major role in the changes observed in the pool's fish community over time.

Merrimack Station is entitled to a §316(a) variance from both technology-based and water quality-based thermal limits because PSNH has shown that there has been no appreciable harm to the BIP in Hooksett Pool, even when taking into account other stresses upon the BIP. USEPA's finding of appreciable harm is incorrect because the data show that:

- There have not been appreciable decreases in all coolwater fish species in Hooksett Pool over time.

- There have not been appreciable increases in warmwater species in Hooksett Pool over time.

- There have not been appreciable decreases in the diversity of species in Hooksett Pool over time. In fact, the Shannon Diversity Index value shows that the current fish population in Hooksett Pool is more diverse now than it was forty years ago.

- There have not been appreciable increases in the abundance of generalist feeders or pollution-tolerant species in Hooksett Pool over time.

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

1.0 INTRODUCTION

Public Service Company of New Hampshire ("PSNH") owns and operates two separate steam electric power generating units, Unit 1 and Unit 2, known together as Merrimack Station, in Bow, New Hampshire. Merrimack Station is located on the west bank of the Merrimack River, approximately 2.9 miles upstream from the Hooksett Dam and Hydroelectric Station and about 2.9 miles downstream from the Garvins Falls Dam and Hydroelectric Station. The Station withdraws and discharges non-contact cooling water from the Merrimack River subject to and with the benefits of National Pollutant Discharge Elimination System ("NPDES") Permit NH0001465 (the "Permit"). The United States Environmental Protection Agency ("USEPA") last renewed the Permit in 1992. PSNH submitted a timely NPDES permit renewal application to EPA in 1997. On September 30, 2011, USEPA issued a new draft NPDES permit (the "Draft NPDES Permit") for the continued operation of the Station.

1.1 Organization of this Report

This report seeks to identify and, where possible, correct the numerous erroneous factual findings presented in USEPA's §316 Determination Document for Merrimack Station, which USEPA issued in support of the Draft NPDES Permit. In so doing, this report highlights the key findings of forty years of ecological monitoring and analysis of the potential impacts of the Station's thermal discharge on the balanced, indigenous population ("BIP") of shellfish, fish, and wildlife in and on the Hooksett Pool reach of the Merrimack River.

Normandeau Associates, Inc. ("Normandeau") and others, including the New Hampshire Fish and Game Department ("NHFGD"), have performed extensive and comprehensive monitoring in the river in the vicinity of Merrimack Station since the late 1960s (see Section 1.4 below). These studies have covered a wide range of Merrimack River temperature and flow conditions representative of thermal discharge conditions, and have included all major aquatic community components, including phytoplankton, zooplankton, benthic macroinvertebrates and resident and migratory fish. The results of these studies have been subject to the continued scrutiny and direction of USEPA, the New Hampshire Department of Environmental Services ("NHDES") and, after 1992, the other members of the Merrimack Station Technical Advisory Committee ("TAC"). (The TAC was established pursuant to the Permit to "make recommendations … to ensure protection of the aquatic community," and consists of senior biologists from USEPA, NHDES, the United States Fish and Wildlife Service, and NHFGD.)

1.2 Merrimack Station Operations

Merrimack Station withdraws non-contact cooling water from, and discharges it back into, a reach of the Merrimack River known as Hooksett Pool, an approximately 5.8-mile long segment of the river bounded to the north by the Garvins Falls Dam and Hydroelectric Station ("Garvins Falls Dam") and to the south by the Hooksett Dam and Hydroelectric Station ("Hooksett Dam") (Figure 1-1). The Station has two separate generating units, Unit 1 and Unit 2. Unit 1, which was built in 1960, produces electricity at a rated capacity of 120 megawatts electric ("mWe"). Unit 2, built in 1968, produces electricity at 320 mWe. PSNH's normal operating mode, except for annual maintenance outages of one or the other unit, is to operate both units at or near full power. Both units are needed online to meet peak demand in the State of New Hampshire during the summer and winter months;

thus, unit maintenance is typically planned for early spring or late fall so that both units are available to meet that peak demand and ensure electric system reliability.

Units 1 and 2 each withdraw non-contact cooling water from separate cooling water intake structures ("CWISs") on the west bank of the Merrimack River adjacent to Merrimack Station. The CWIS for Unit 1 is located approximately 120 feet upstream from the Unit 2 CWIS (Figure 1-1). When both units are operating, total cooling water intake volume is approximately 397 cubic feet per second ("cfs"), which achieves a design Station maximum ΔT of 25°F. After passing through the Station, cooling water from each unit is discharged from a common bulkhead into the upper end of a 3/4-mile long (3,900 ft) cooling canal. The cooling water is thoroughly mixed between the units in the upper portion of the cooling canal, and then flows downstream past 54 banks of four power spray modules ("PSMs") (216 total) in the lower end of the cooling canal. The downstream end of the cooling canal where the cooling water discharges into the Merrimack River is located on the west bank of Hooksett Pool about 0.5 miles downstream from Merrimack Station (Figure 1-1).

The PSMs provide approximately 2-4°F of cooling when operated, prior to cooling water discharge into the Merrimack River. The Permit requires operation of the PSMs to maintain water temperatures at Merrimack River monitoring station S-4 of 69˚F or less, or to limit temperature increases to 1˚F when the ambient river temperature exceeds 68˚F. Whenever both of these conditions are exceeded at Station S-4, the Permit requires operation of all available PSMs. The typical range in temperature of the heated effluent during the warmer summer months is approximately 80 to 95ºF, with a very infrequent worst-case maximum of about 100ºF. Discharge volume is typically close to or at the maximum once-through cooling water pumping capacity of 397 cfs.

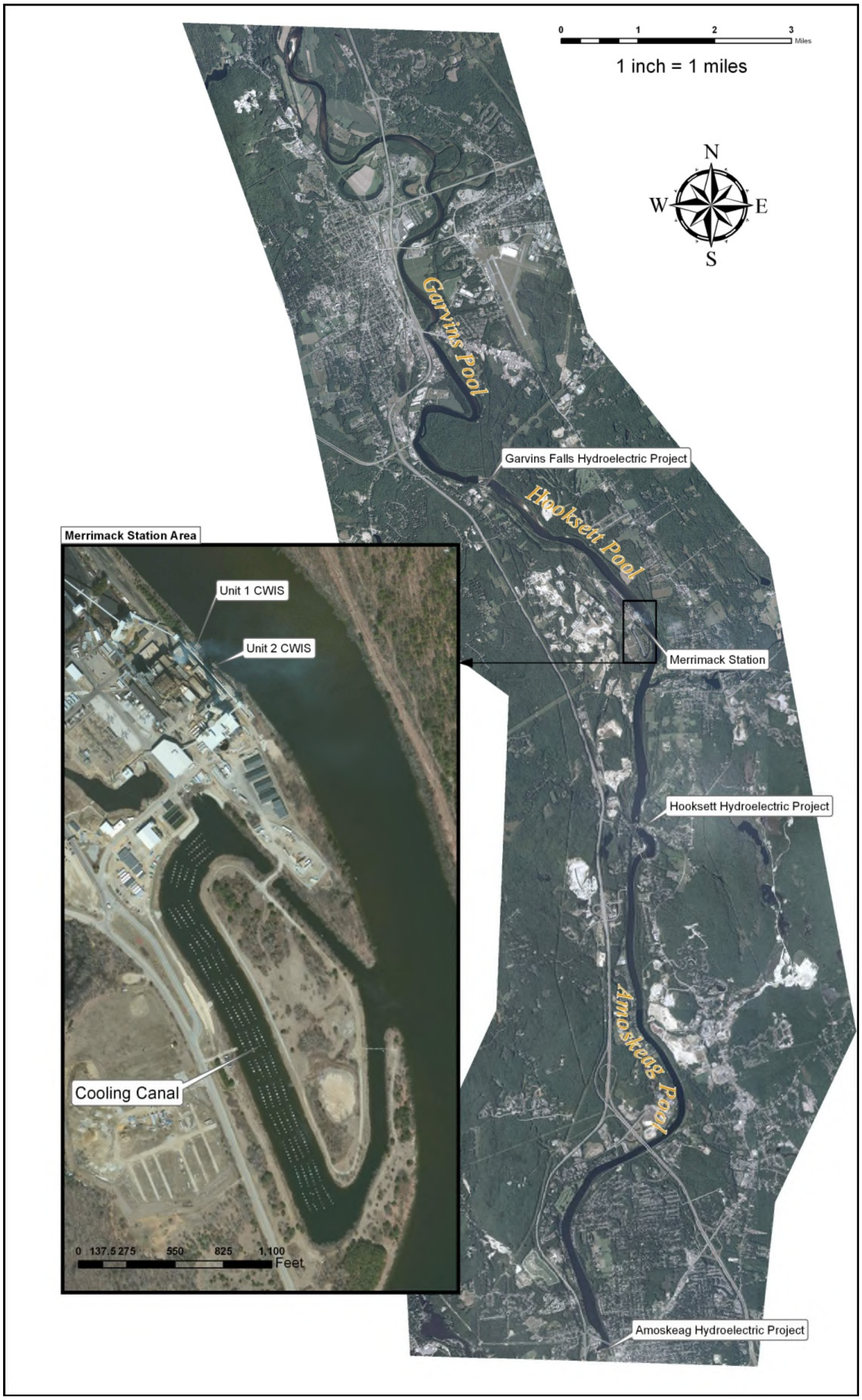

Figure 1-1. Location of Merrimack Station relative to Garvins, Hooksett and Amoskeag Pools of the Merrimack River.

1.3 Merrimack River in the Vicinity of Merrimack Station

As noted above, Merrimack Station withdraws non-contact cooling water from, and discharges it back into, a reach of the Merrimack River known as Hooksett Pool (Figure 1-1). Garvins Falls Dam forms the upstream boundary of Hooksett Pool, and Hooksett Dam forms the downstream boundary (Figure 1-1). Garvins Falls Dam and Hooksett Dam, along with the Amoskeag Dam and Hydroelectric Station, are part of the Merrimack River Project (FERC Project No. 1893), a federally licensed 29.9-mWe hydroelectric project owned and operated by PSNH (Figure 1-1). Garvins Falls Dam is at the southern end of Garvins Pool, the thermally uninfluenced impoundment immediately upstream from Hooksett Pool. The tailwaters of Hooksett Dam, at the southern end of Hooksett Pool, discharge into the upper reach of Amoskeag Pool, the impoundment immediately downstream from Hooksett Pool.

Hooksett Pool averages between 6 and 10 feet in depth under most flow conditions. It has a surface area of 350 acres and a storage volume of 130 million cubic feet retained at a full pond elevation of 189 ft behind Hooksett Dam (USGS Datum). Headpond elevation in Hooksett Pool is maintained within one foot of the full pond elevation, as required in the Merrimack River Project's Federal Energy Regulatory Commission operating license.

1.3.1 Hydrology

The watershed area for the Merrimack River at Merrimack Station is approximately 2,535 square miles ("sq. mi."). The estimated mean annual flow ("MAF") for the Merrimack River at Merrimack Station based on a 100-year period of record from 1903 through 2004 is 4,551 cfs ±455 cfs, or 4,096 to 5,006 cfs (Normandeau 2005). The hydraulic retention time of Hooksett Pool is approximately eight hours under MAF conditions, and about five days under 7Q10 flow conditions. The estimated Merrimack River flow under 7Q10 conditions at Merrimack Station, as calculated for this same 100-year period of record, is 650 cfs (Normandeau 2005).

The Merrimack Project hydroelectric facilities presently store and release Merrimack River water on an hourly basis under certain lower flow conditions, and none of the dams has sufficient storage capacity to modify flows significantly on a daily or longer basis. Consequently, the daily historical flow record that forms the basis of the 100-year MAF and 7Q10 flow estimates are representative of expected future flow conditions, irrespective of any flow modifications that the Federal Energy Regulatory Commission ("FERC") may require (Normandeau 2007c).

1.3.2 Water Quality

The Merrimack River was substantially polluted by anthropomorphic input from the early 1800s through the 1970s. Both the river's water quality and the diversity and abundance of the organisms that could live in and on the river during this time frame reflected this substantially polluted state (Normandeau 2011b). Improvements in water quality began with the passage of New Hampshire's first water pollution control act in 1947. This statute established the New Hampshire Water Pollution Commission "to investigate pollution of surface waters, to recommend classification of surface waters, and to enforce such classification," and required towns and cities to take steps to protect water quality (NH Laws 1947, ch. 183). Efforts at improving Merrimack River water quality were dramatically strengthened in 1974 when, following the 1972 enactment of the federal CWA, New Hampshire mandated secondary treatment for all wastewater discharges in the state (NEIWPCC 2011).

With implementation of secondary treatment, water quality and biological conditions in the Merrimack River, have improved to the point that water quality no longer restricts the river's aquatic community to pollutant-tolerant species. Even so, nutrient levels are still elevated when compared to rivers that do not receive wastewater discharges, and these elevated nutrient levels likely enhance biological productivity in the Merrimack River. Nutrient pollution has long been recognized as a major problem in streams and rivers (USEPA 2000), because in freshwater systems, it can cause eutrophication, a process whereby waterbodies receive excess inorganic nutrients that stimulate excessive growth of plants and algae. As stricter wastewater treatment controls are implemented, especially with respect to nutrient discharges, it is expected that the Merrimack River aquatic community will continue to shift back to one that is more representative of clean, nutrient-poor, northern New England rivers.

At present, water quality in Hooksett Pool is influenced by discharges from upstream wastewater treatment plants, stormwater discharges, and runoff from adjacent and upstream land uses. Interstate 93 ("I-93"), NH Route 3 and NH Route 3-A all run parallel to and in close proximity to the river near the Station. Most of the land use to the west of Hooksett Pool between I-93/NH Route 3-A and the river is industrial and commercial. The area between the river and NH Route 3 to the east is primarily residential and commercial. In addition, Hooksett Pool is heavily used by anglers and recreational boaters, most of whom use the PSNH boat trailer ramp just south of the Station.

Water quality in Hooksett Pool is also influenced by the water quality of the Suncook and Soucook Rivers and Bow Bog Brook, all tributaries to the Merrimack River in Hooksett Pool. The 36-mile-long Suncook River drainage area includes portions of 13 communities. There are numerous dams, and many lakes and ponds created by them within this watershed. The Suncook River is highly prone to flooding and erosion problems, as evidenced by a 2006 event when the river changed its course and created a new one-mile long channel in Epsom. Among the mills and hydroelectric facilities in Suncook Village, and just before reaching the Merrimack River, the Suncook River drops 70 feet in only one-half mile. The 29-mile Soucook River flows through Loudon, Concord and Pembroke. It runs through and along the New Hampshire International Speedway property, a large racetrack facility hosting NASCAR and other motor vehicle racing events. NH Route 106, which crosses the Soucook River four times, provides access to the Steeplegate Mall in Concord and many commercial, warehouse and industrial uses. In addition, there also are many sand and gravel operations in close proximity to the Soucook River.

1.3.3 Temperature Monitoring

Merrimack Station has monitored upstream ambient (Monitoring Station N-10), cooling water intake (Monitoring Station N-5), cooling canal discharge (Monitoring Station S-0) and downstream from the cooling canal discharge (Monitoring Station S-4) water temperatures, as well as other water quality parameters, in Hooksett Pool since Merrimack Station became fully operational in 1968. Monitoring Stations N-5 and S-0 are operated year-round, while Monitoring Stations N-10 and S-4 are removed in the fall when upstream ambient water temperature at Monitoring Station N-10 falls below 40°F, and re-installed in the spring when ambient temperature at Monitoring Station N-5 rises above 50°F. Winter and spring ice conditions in the river make it technically infeasible to maintain monitoring equipment at these two in-river monitoring stations on a year-round basis.

In addition, Normandeau has used predictive modeling of water temperatures in the Merrimack River to evaluate potential water temperatures in lower Hooksett Pool at Monitoring Stations S-0 (at the cooling canal discharge), S-4 (downstream from the cooling canal discharge) and in upper Amoskeag Pool (Monitoring Station A-0, representing the mixed in-river water temperature conditions found in the Hooksett Dam tailwaters) under a variety of flow conditions with a relatively high degree of confidence during 1 April to 1 November of each year. At normal to low river flows, when the Station is operating at or near full power, the temperature at Monitoring Station S-4 would typically exceed that at background Monitoring Station N-10 by 7 to 8 °F during the May 1 to September 1 period (Normandeau 2007c). At Monitoring Station A-0, where complete-mix conditions exist due to hydroelectric operations at Hooksett Dam, the temperature would typically exceed that at Monitoring Station N-10 by 5 to 6°F under normal to low flow conditions, with the Station operating at or near full power. During high flow events, the Station has little influence on Merrimack River temperatures (Normandeau 2007c).

1.4 Merrimack Station Ecological Studies

PSNH has provided EPA with more than 40 years of comprehensive studies of the Merrimack River ecosystem, including:

- The Effects of Thermal Releases on the Ecology of the Merrimack River (Normandeau 1969);
- The Effects of Thermal Releases on the Ecology of the Merrimack River - Supplemental Report No. 1 (Normandeau 1970);
- Merrimack River Monitoring Program: A Report for the Study Period 1971 (Normandeau 1972);
- Merrimack River Monitoring Program: A Report for the Study Period 1972 (Normandeau 1973a);
- Merrimack River: Temperature and Dissolved Oxygen Studies 1972 (Normandeau 1973b);
- Merrimack River Monitoring Program: A Report for the Study Period 1973 (Normandeau 1974);
- Merrimack River Monitoring Program 1974 (Normandeau 1975a);
- Merrimack River Ecological Studies: Impacts Noted to Date; Current Status and Future Goals of Anadromous Fish Restoration Efforts; and Possible Interactions Between Merrimack Station and Anadromous Fishes (Normandeau 1975b);
- Merrimack River Monitoring Program 1975 (Normandeau 1976a);
- Merrimack River Anadromous Fisheries Investigations: Annual Report for 1975 (Normandeau 1976b);
- Further Assessment of the Effectiveness of an Oil Containment Boom in Confining the Merrimack Generating Station Discharge to the West Bank of the River (Normandeau 1976c);
- Merrimack River Monitoring Program 1976 (Normandeau 1977a);

- Final Report: Merrimack River Anadromous Fisheries Investigations 1975-1976 (Normandeau 1977b);
- Merrimack River Thermal Dilution Study 1978 (Normandeau 1978);
- Merrimack River Monitoring Program 1978 (Normandeau 1979a);
- Merrimack River Monitoring Program: Summary Report (Normandeau 1979b);
- Merrimack River Anadromous Fisheries Investigations: 1978 (Normandeau 1979c);
- Phase I Preliminary Report – Information Available Related to Effects of Thermal Discharge at Merrimack Station on Anadromous and Indigenous Fish of the Merrimack River (Stetson-Harza 1993);
- Merrimack Station: Thermal Discharge Modeling Study (Normandeau 1996);
- Merrimack Station (Bow) Fisheries Study (Normandeau 1997);
- Merrimack Station Thermal Discharge Effects on Downstream Salmon Smolt Migration (Normandeau 2006a);
- DRAFT - An Examination of Fish Catch Between Trap Nets with 0.75-in and 2.00-in Mesh Sizes Deployed in Hooksett Pool of the Merrimack River (Bow, NH) (Normandeau 2006b);
- Merrimack Station Fisheries Survey Analysis of 1967 through 2005 Catch and Habitat Data (Normandeau 2007a);
- Entrainment and Impingement Studies Performed at Merrimack Generating Station from June 2005 through June 2007 (Normandeau 2007b);
- A Probabilistic Thermal Model of the Merrimack River Downstream of Merrimack Station (Normandeau 2007c);
- Biocharacteristics of Yellow Perch and White Sucker Populations in Hooksett Pool of the Merrimack River (Normandeau 2009a);
- Biological Performance of Intake Screen Alternatives to Reduce Annual Impingement Mortality and Entrainment at Merrimack Station (Normandeau 2009b);
- Modeling the Thermal Plume in the Merrimack River from the Merrimack Station Discharge (ASA 2010).

In addition, PSNH is submitting the following five reports as part of its response to and comments on the Draft NPDES Permit:

- Merrimack Station Fisheries Survey Analysis of the 1972-2011 Catch Data (Normandeau 2011a);
- Historic Water Quality and Selected Biological Conditions of the Upper Merrimack River, New Hampshire (Normandeau 2011b);

- Changes in the Composition of the Fish Aggregation in Black Rock Pool in the Vicinity of Cromby Generating Station from 1970 to 2007 (Normandeau 2011c);

- Quantification of the Physical Habitat within Garvins, Hooksett and Amoskeag Pools of the Merrimack River (Normandeau 2011d);

- Comparison of Benthic Macroinvertebrate Data Collected from the Merrimack River near Merrimack Station (Normandeau 2012a).

These five reports provide new and substantive supplemental information and analysis regarding the fish community, macroinvertebrate community and water quality of Hooksett Pool, and three of them – *Merrimack Station Fisheries Survey Analysis of the 1972-2011 Catch Data* (Normandeau 2011a), *Quantification of the Physical Habitat within Garvins, Hooksett and Amoskeag Pools of the Merrimack River* (Normandeau 2011d), and *Comparison of Benthic Macroinvertebrate Data Collected from the Merrimack River near Merrimack Station* (Normandeau 2012a) – are based on the additional sampling efforts conducted by Normandeau in Garvins, Hooksett and Amoskeag Pools during the 2008-2011 time period. Full citations are found in Section 7.0 of this document.

2.0 §316(A) VARIANCE

Merrimack Station is seeking a renewal of its existing thermal discharge variance under CWA §316(a) as part of USEPA's renewal of the Permit. CWA §316(a) provides that a permit applicant may demonstrate that any effluent limitation proposed for the thermal component of a discharge is more stringent than necessary to assure the protection and propagation of the BIP in and on the body of water into which the discharge is made. Applicants with an existing thermal discharge, such as the Station, may demonstrate that the existing discharge is protective of the BIP by evaluating the BIP over a series of years during which the discharge occurred, and showing an absence of appreciable harm (40 C.F.R. §125.73(c); USEPA 1977). Contrary to USEPA's unfounded assertions, the data and analyses presented in the many reports prepared by Normandeau since 1969 and submitted to USEPA, NHDES and, after 1992, the other members of the TAC demonstrate that Merrimack Station's thermal discharge has not resulted in appreciable harm to the BIP in Hooksett Pool, and that the thermal discharge limits in the existing Permit adequately assure the protection and propagation of that BIP.

The most significant and pervasive flaws in USEPA's §316(a) analysis are the Agency's selection of the 1967-1969 fish community as the Hooksett Pool BIP, and its failure, in making this selection, to account in any way for the severe, non-thermal discharge-related water quality impairments that adversely affected the Merrimack River during the 1960s. In its desire to link *all* of the changes that have occurred in Hooksett Pool since the 1960s to Merrimack Station's thermal discharge after May 1968 (when Unit 2 came on-line), USEPA has overlooked both these severe water quality impairments and how pollution of that magnitude negatively impacts and alters biological communities. Evidence of the Merrimack River's poor water quality during the 1960s is well-documented in the ecological reports produced during the 1960s and 1970s (see Section 1.4 above). Moreover, USEPA, PSNH and Normandeau specifically discussed the potential impacts of the Merrimack River's non-thermal discharge-related water quality impairments during the late 1960s on the biological community in Hooksett Pool during those years at a 2006 meeting. Nonetheless, despite these facts, USEPA does not raise this issue once in the Draft NPDES Permit or the §316(a)

Determination Document. This is puzzling, given that the improvement of Merrimack River water quality is likely the greatest ecological change to have occurred in the river over the past forty years.

The fish community in Hooksett Pool has changed dramatically when compared between 1967-1969 and the present day (Table 2-1). However, by not providing an accurate picture of the current fish community in Hooksett Pool in the Draft NPDES Permit, USEPA obscures the obvious differences. Many of the fish species in the current Hooksett Pool fish community could not have survived the conditions found in the Hooksett Pool of 1967-1969. The high numbers of yellow perch, pumpkinseed, white sucker, brown bullhead and golden shiners captured in 1967-1969 will not be seen again in Hooksett Pool, because that fish community was shaped by the severely impaired water quality that existed in the Merrimack River at the time. Even so, USEPA inappropriately bases the bulk of its §316(a) analysis on those fish species in an attempt to demonstrate that the drop in abundance for these species was caused solely by the Station's thermal discharge into Hooksett Pool. Omitting any discussion about the dramatic improvements in Merrimack River water quality in the Draft NPDES Permit or the §316(a) Determination Document allows USEPA to advance the false argument that all of the changes to the Hooksett Pool BIP since the 1960s are solely attributable to Merrimack Station's thermal discharge. Indeed, the changes to the Hooksett Pool fish community that have occurred over the decades as water quality has so significantly improved should not be characterized as a negative outcome. Rather, because of these water quality improvements, the aquatic community that exists in Hooksett Pool today is healthy and more diverse than the community that existed during the 1960s.

The other most significant flaw in USEPA's §316(a) analysis – which flows directly from the Agency's disregard of the impaired water quality in the Merrimack River during the 1960s and improved river water quality since the 1960s – is the Agency's inaccurate, inadequately supported finding that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool. USEPA's finding of appreciable harm is clearly incorrect because properly interpreted, the data show that over time, there have not been (1) appreciable decreases in all coolwater fish species in Hooksett Pool, (2) appreciable increases in warmwater species in Hooksett Pool, (3) appreciable decreases in the diversity of species in Hooksett Pool (as discussed in detail below, the Shannon Diversity Index value shows that the current fish population in Hooksett Pool is more diverse now than it was forty years ago), or (4) appreciable increases in the abundance of generalist feeders or pollution-tolerant species in Hooksett Pool. In fact, when compared to Garvins Pool – the thermally uninfluenced impoundment immediately upstream from Hooksett Pool, and the proper reference to compare to Hooksett Pool – the biocharacteristics of the fish population in Hooksett Pool in general, and of the individual species in Hooksett Pool in particular, indicate no appreciable harm to the BIP.

Table 2-1. Common name and percent composition for fish captured in Hooksett Pool during 1967-1968 (trapnet and electrofishing), and 2004-2005 (trapnet and electrofishing) / 2010-2011 (electrofishing).

Hooksett Pool Fish Community 1967-1968		Hooksett Pool Fish Community 2004-2011	
Common Name	**Percent Comp.[1]**	**Common Name**	**Percent Comp.[2]**
Pumpkinseed	31.70%	Spottail shiner	31.80%
Yellow perch	22.90%	Largemouth bass	16.10%
Brown bullhead	15.40%	Smallmouth bass	11.80%
White sucker	12.50%	Bluegill	10.60%
Golden shiner	7.30%	Fallfish	7.00%
Redbreast sunfish	4.70%	Redbreast sunfish	5.20%
Smallmouth bass	2.10%	White sucker	4.20%
Yellow bullhead	1.50%	Yellow perch	3.50%
Chain pickerel	1.20%	Pumpkinseed	1.80%
American eel	0.40%	Common shiner	1.40%
White perch	<0.1%	Rock bass	1.10%
Walleye	<0.1%	Golden shiner	0.90%
Largemouth bass	<0.1%	Alewife	0.90%
Fallfish	<0.1%	Black crappie	0.80%
Madtom sp.	<0.1%	American eel	0.60%
Common shiner	<0.1%	Tessellated darter	0.60%
		American shad	0.60%
		Chain pickerel	0.50%
		Eastern silvery minnow	0.20%
		Margined madtom	0.10%
		Yellow bullhead	0.10%
		Brown bullhead	0.10%
		Atlantic salmon	<0.1%
		Brown trout	<0.1%
		Common carp	<0.1%
		Eastern blacknose dace	<0.1%
		White perch	<0.1%

1 - Based on electrofish and trapnet data from 1967 and 1968

2 – Based on electrofish and trapnet data from 2004-2005 and electrofish data from 2010-2011

2.1 Hooksett Pool BIP

As defined in 40 C.F.R. § 125.71(c), the term "balanced, indigenous community" is synonymous with the term "balanced, indigenous population" in the CWA and means a biotic community typically characterized by (1) diversity, (2) the capacity to sustain itself through cyclic seasonal changes, (3) the presence of necessary food chain species and (4) a lack of domination by pollution-tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management, as well as species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with CWA §301(b)(2), and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to CWA §316(a).

On Page 31 (Section 5.3) of the §316(a) Determination Document, USEPA states:

> *In order to evaluate Merrimack Station's conclusion that the plant's thermal discharge has not resulted in appreciable harm to the balanced, indigenous population of fish and other aquatic organisms, EPA reviewed data collected in Hooksett Pool over a period of 38 years, from 1967 to 2005. For the purpose of evaluating Merrimack Station's thermal impacts, EPA and NHFGD conclude that the relevant balanced, indigenous community is comprised of all species that existed in Hooksett Pool immediately prior to the start-up of Unit 1, in 1960. Unfortunately, no comprehensive biological sampling was conducted until 1967, after Unit 1 had already been operation for approximately seven years. Sampling by NHFGD took place prior to the May 1968 start-up of Unit 2, however, and continued for a year thereafter. Absent any earlier studies for Hooksett Pool, EPA considers the resident biotic community identified during sampling conducted from 1967 to 1969 to best represent the balanced, indigenous community for this assessment (Table 5-1). This is a reasonable approach in light of the best, reasonably available data because the 1967-1969 data is the earliest data available, and because the volume of heated cooling water discharged into Hooksett Pool more than tripled in 1968 after Unit 2 came on line, increasing from approximately 86.4 MGD to 286.6 MGD (design flow) (footnote omitted).*

The USEPA's selection of the 1967-1969 Hooksett Pool fish community as the BIP for Hooksett Pool is flawed and does not provide an appropriate basis for USEPA's determinations presented in the §316(a) Determination Document, because the available data show that aquatic community in Hooksett Pool during those years was not "balanced," but rather was dominated by fish and macroinvertebrate species able to tolerate the severe pollution present in the Merrimack River prior to the improvements in water quality that followed the 1972 enactment of the CWA. USEPA does not mention, let alone consider in any reasoned, technically sound manner, either the significant system-wide pollution that existed in the Merrimack River during the 1960s or the fact that improvements in water quality can dramatically alter aquatic communities. Instead, the Agency focuses solely on the potential impacts of the thermal releases into Hooksett Pool after Unit 2 came on-line in May 1968. However, unbiased, accurate analysis of the 40 years of ecological monitoring in and on the Merrimack River in the vicinity of Merrimack Station demonstrates that the changes in abundance of the resident biota of Hooksett Pool that occurred from the 1960s to the present was not caused by the Station's thermal discharge, but by the dramatic improvements to Merrimack River water quality that began in earnest in 1972.

The following sections (1) summarize the historic water quality conditions found in the Merrimack River, (2) explain why, based on the fisheries and macroinvertebrate sampling data from 1967-1969, USEPA's selection of the 1967-1969 Hooksett Pool aquatic community as the Hooksett Pool BIP for the purpose of the Draft NPDES Permit is inappropriate, misleading and technically indefensible, and (3) explain why, based on the fisheries and macroinvertebrate sampling data from 1972-2011, either the current Hooksett Pool aquatic community or the current Garvin Pool aquatic community represents the proper BIP for Hooksett Pool for the purpose of the Draft NPDES Permit.

2.1.1 Historic Water Quality of the Merrimack River

The Normandeau report *Historic Water Quality and Selected Biological Conditions of the Upper Merrimack River, New Hampshire* (Normandeau 2011b), which PSNH is submitting as part of its response to and comments on the Draft NPDES Permit, documents the nature and substantial extent of the water pollution that had already impaired the Merrimack River as of May 1968: the month when Merrimack Station's Unit 2 commenced operation, and when, according to USEPA, Merrimack Station's thermal discharge began to cause appreciable harm to the aquatic community in Hooksett Pool (Normandeau 2011b). This pollution significantly altered the river's water quality, especially with respect to nutrients, and had a corresponding impact on resident biota. As noted by Wolf (1965):

> *Historic observations of this contamination give a picture of a river contaminated beyond our current comprehension: sewage so dense that a single drop contains "dangerous" levels of bacteria; coliform bacterial counts exceeding 1 million per 100 ml for several cities; toxic metals and wastes including phenol and cyanide found in the river; suspended solids covering the river bottom and decomposing, causing gas to bubble up "as if the river were cooking"; and a predominant smell of rotten egg from hydrogen sulfide, which can ruin painting on boats and houses (Wolf 1965).*

The sources of contamination were many and included waste from wood and paper processing mills and textile mills (wool and cotton fiber mills) that were situated along the river. However, one of the major sources of significant pollution came from the constant release of untreated sewage wastes into the river (Normandeau 2011b). In 1964, no town in New Hampshire on the mainstem of the Merrimack River treated its wastes (Wolf 1965). As late as the mid-1960s, more than 120 million gallons per day of untreated or minimally treated wastewater were discharged into the Merrimack River (USGS 2003). The effects of this waste effluent impacted all the aquatic biota in the river, including in Hooksett Pool. The effects of this type of sustained nutrient enrichment, and the resulting enhancement of primary producers, ultimately enhances secondary and tertiary productivity (deBruyn et al. 2003).

The United States Department of the Interior ("USDI") measured nutrient levels (nitrogen and phosphate), total and fecal coliform, dissolved oxygen ("DO") and biological oxygen demand ("BOD") levels in the Merrimack River during 1965 (USDI 1966). Levels of ammonia and nitrate were substantially elevated (approaching and exceeding 1 mg/L) in the Concord to Manchester reach of the river, and total phosphorous levels in excess of 0.1 mg/L to near 1 mg/L were recorded. These values indicate a high level of nutrient loading in the Merrimack River during that time period. In addition to the USDI data collected during 1965, sampling in Hooksett Pool during 1969 also demonstrated elevated nutrient levels, with both total phosphorous and total nitrogen levels significantly greater than what would be expected for uncontaminated waters in northeast rivers

(Normandeau 2011b). Figure 3-1 (originally presented in Normandeau 1979b) presents the seasonal mean nitrate and phosphate concentrations recorded in Hooksett Pool for the period 1967-1978, when the river was at its most polluted state. In addition to the elevated nutrient levels, total and fecal coliform levels were also elevated (USDI 1966). High BOD readings, indicative of a high level of organic material in the river, were present when measured during the January-April period, with lower levels measured during the summer months (USDI 1966). Lower summer BOD combined with low DO is indicative of significant organic pollution in the river (Normandeau 2011b).

The reduction in oxygen available to Merrimack River biota that was caused by the nutrient loading to the river was the most important effect on the system as a whole. USDI (1966) notes the sources of pollution to the river were mainly sewage and industrial waste that contain a variety of "obnoxious components", including oxygen "demanding" materials that limited fish and aquatic life by removing DO from the water. Other "greasy substances" in the water form surface scums, settleable solids and sludge deposits, and other suspended materials can make the water turbid, limiting light penetration. Industrial wastes can contain chemical or toxic substances that can kill fish and aquatic organisms or promote slime growth.

USEPA and most states consider DO levels below 5 mg/L as detrimental to most temperate freshwater ecosystems (Normandeau 2011b). The DO levels measured during 1965 in the upper Merrimack River were often below 5.0 mg/L during the June through September period throughout the river reach between East Concord and Manchester, NH (USDI 1966). Minimum DO values of 2.8 mg/ L were measured during September at Garvins Falls Dam, just upstream from Hooksett Pool. Low levels of DO were also recorded during studies conducted in Hooksett Pool during the late 1960s, and it was reported in 1969 that rhythmic, daily oxygen pulses, resulting from photosynthetic and respiratory activity of aquatic organisms, ranged up to 80% during days with low flows (Normandeau 1970). Concentrations of DO during the daytime were usually well above 5 mg/L and at times as high as 10 mg/L or higher, but during the evening would fall to as low as <1 mg/L, depending on conditions (Normandeau 1969). Large diurnal changes in DO levels are indicative of a eutrophic condition, caused by high levels of nutrients such as nitrates and phosphorous being discharged into a waterbody (Normandeau 2011b). High nutrient levels result in enhanced primary productivity, which causes large phytoplankton blooms. These phytoplankton blooms were primarily responsible for the large diurnal changes in DO levels recorded in Hooksett Pool during the 1960s, which ranged from supersaturated conditions recorded during the day (due to photosynthesis) to values approaching zero during pre-dawn hours. Eutrophication can decrease biodiversity and change species composition and dominance for all aquatic biota. It can increase growth of gelatinous zooplankton, decrease epiphytic algae and change macrophyte biomass and composition (Smith et al. 1999). It is evident from these data that the pollution levels present in the Merrimack River, and in particular in Hooksett Pool, during the late 1960s were harmful to the resident aquatic biota.

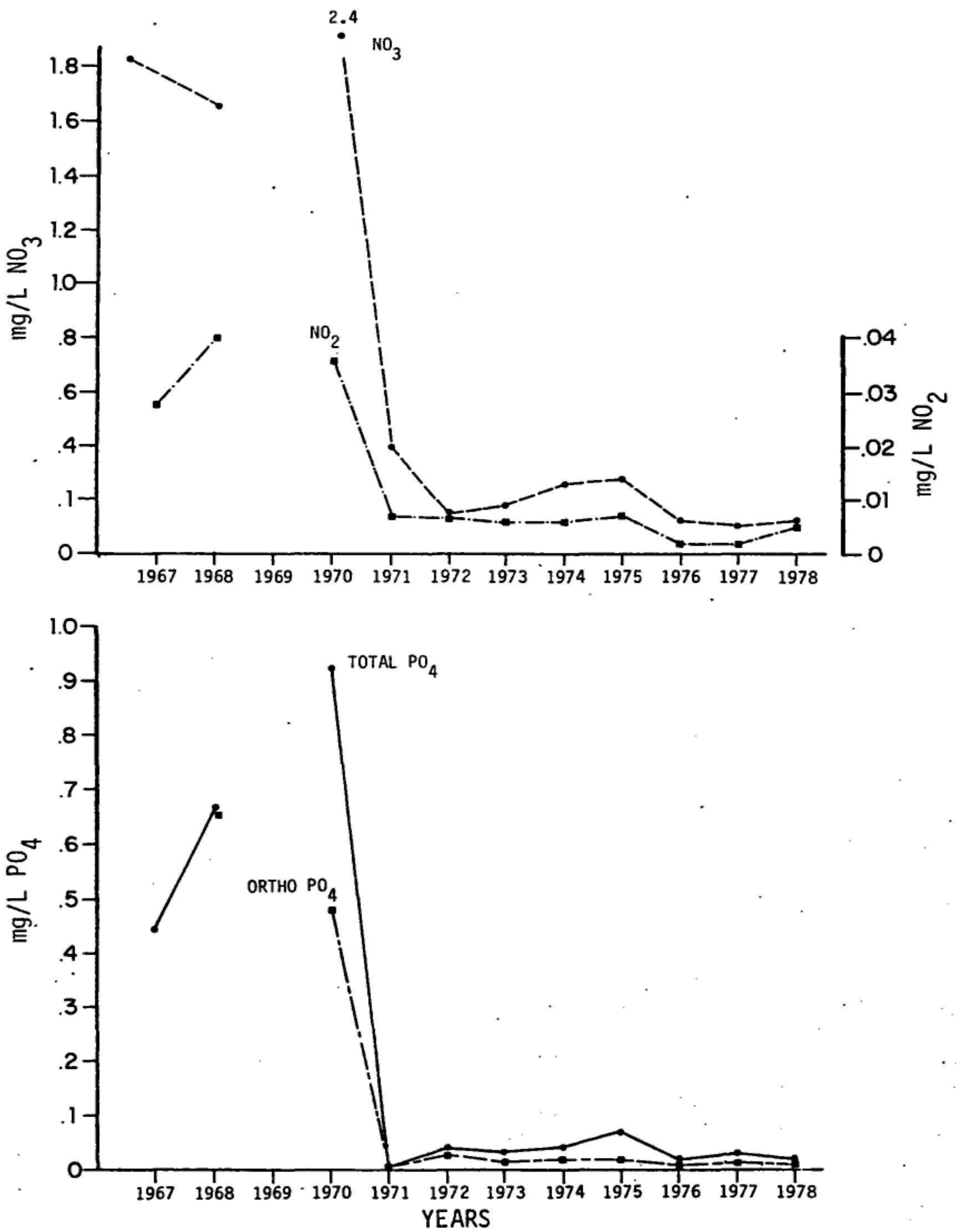

Figure 2-1. Seasonal Mean Concentrations of PO4, NO3 and NO2 (mg/L) in Hooksett Pool 1967-1978 (Merrimack Summary Report, Normandeau 1979).

In the 1960s, New Hampshire Water Use Classification and Quality Standards included Classes A through D for rivers, based primarily on dissolved oxygen, coliform bacteria and pH, among other parameters. When the USDI issued its report in 1966, New Hampshire had not yet classified the Merrimack River, but it was expected to do so by June 1967 (according to the Federal Water Pollution Control Act). Had the river been classified as of June 1967, the USDI data would have supported a Class D rating – a level of water pollution unheard of today.

An annual monitoring program conducted in Hooksett Pool between 1971 and 1978 observed that DO levels were higher than those measured during 1965, 1967 and 1968. During the mid-1960s, DO levels had averaged in the mid-3 mg/L range during low flow conditions at the Garvins Falls Dam. By 1972, DO values remained above 6.4 mg/L at Hooksett Pool Monitoring Station N-10. Hooksett Pool water quality was beginning to improve during the 1970s, with the reduction in nutrient loading (Figure 2-1) acting as a major driving force behind those improvements (Normandeau 2011b).

As stated in Normandeau (1979b), "[n]itrite, nitrate, orthophosphate and total phosphate concentrations decreased by an order of magnitude from 1971 to 1972. Municipal and industrial pollution abatement activity in the upper Merrimack River basin prior to 1971 was most likely responsible for this decrease in Hooksett Pond nutrient concentration."

2.1.2 1960s Aquatic Community in Hooksett Pool

Despite the foregoing, USEPA determined that the fish community observed in Hooksett Pool during 1967-1969 should serve as the BIP to which the current Hooksett Pool fish community should be compared to assess the potential impacts of Merrimack Station's thermal discharge. In so doing, USEPA either ignored or overlooked the fact that the abundance of pollution-tolerant fish species in Hooksett Pool was higher in 1967-1969 than under to current conditions because of the ability of those species to survive in an aquatic habitat impaired by conventional and toxic pollutants.

The Hooksett Pool fish community and relative abundance as sampled by boat electrofishing and trap nets during 1967-1968 and described by Wightman (1971) is presented in Table 2-2. (The 1969 fish data was not included in Table 2-2 because the trap net data did not present the number of fish captured that year, but instead calculated population catch indices. However, no additional species were captured in 1969.) For reference, Table 2-3 presents the Hooksett Pool fish community and relative abundance as sampled by boat electrofishing and trap nets during the 2000s and described by Normandeau (2007a, 2011a). USEPA did not provide such a current species list in the §316(a) Determination Document.

Table 2-2. Percent composition, USEPA trophic guild and tolerance classifications for fish captured in Hooksett Pool during 1967-1968 (trapnet and electrofishing).

	Hooksett Pool Fish Community 1967-1968		
Common Name	**Percent Comp.[1]**	**Trophic Guild[2]**	**Tolerance[2]**
Pumpkinseed	31.70%	Generalist	Intermediate
Yellow perch	22.90%	Piscivore	Intermediate
Brown bullhead	15.40%	Generalist	Tolerant
White sucker	12.50%	Generalist	Tolerant
Golden shiner	7.30%	Generalist	Tolerant
Redbreast sunfish	4.70%	Generalist	Intermediate
Smallmouth bass	2.10%	Generalist	Intermediate
Yellow bullhead	1.50%	Generalist	Tolerant
Chain pickerel	1.20%	Piscivore	Intermediate
American eel	0.40%	Piscivore	Tolerant
White perch	<0.1%	Piscivore	Intermediate
Walleye	<0.1%	Piscivore	Intermediate
Largemouth bass	<0.1%	Piscivore	Intermediate
Fallfish	<0.1%	Generalist	Intermediate
Madtom sp.	<0.1%	Insectivore	Intermediate
Common shiner	<0.1%	Generalist	Intermediate
Total	**16 Species**	**3 Guilds**	**2 Tolerance Levels**

Table 2-3. Percent composition, USEPA trophic guild and tolerance classifications for fish captured in Hooksett Pool during 2004-2005 (trapnet and electrofishing) / 2010-2011 (electrofishing).

	Hooksett Pool Fish Community 2004-2011		
Common Name	**Percent Comp.[3]**	**Trophic Guild[2]**	**Tolerance[2]**
Spottail shiner	31.80%	Insectivore	Intermediate
Largemouth bass	16.10%	Piscivore	Intermediate
Smallmouth bass	11.80%	Piscivore	Intermediate
Bluegill	10.60%	Generalist	Tolerant
Fallfish	7.00%	Generalist	Intermediate
Redbreast sunfish	5.20%	Generalist	Intermediate
White sucker	4.20%	Generalist	Tolerant
Yellow perch	3.50%	Piscivore	Intermediate
Pumpkinseed	1.80%	Generalist	Intermediate
Common shiner	1.40%	Generalist	Intermediate
Rock bass	1.10%	Piscivore	Intermediate
Golden shiner	0.90%	Generalist	Tolerant
Alewife	0.90%	Filter feeder	Intermediate
Black crappie	0.80%	Piscivore	Intermediate
American eel	0.60%	Piscivore	Tolerant
Tessellated darter	0.60%	Insectivore	Intermediate
American shad	0.60%	Filter feeder	Intermediate
Chain pickerel	0.50%	Piscivore	Intermediate
Eastern silvery minnow	0.20%	Herbivore	Intolerant
Margined madtom	0.10%	Insectivore	Intermediate
Yellow bullhead	0.10%	Generalist	Tolerant
Brown bullhead	0.10%	Generalist	Tolerant
Atlantic salmon	<0.1%	Piscivore	Intolerant
Brown trout	<0.1%	Piscivore	Intolerant
Common carp	<0.1%	Generalist	Tolerant
Eastern blacknose dace	<0.1%	Generalist	Tolerant
White perch	<0.1%	Piscivore	Intermediate
Total	**27 Species**	**5 Guilds**	**3 Tolerance Levels**

1 - Based on electrofish and trapnet data from 1967 and 1968

2 - Barbour et al. 1999

3 - Based on electrofish and trapnet data from 2004-2005 and electrofish data from 2010-2011.

A review of species-specific tolerance to environmental perturbations (Barbour et al. 1999) for the fish species observed in Hooksett Pool during 1967-1968 reveals that the Hooksett Pool fish community during those years consisted only of fish species listed as tolerant or intermediate in tolerance to pollution (Table 2-2). USEPA's own definition of "balanced, indigenous community" (i.e., BIP) provides that a BIP does not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with CWA §301(b)(2) (40 C.F.R. §125.71(c)). Of the sixteen fish species collected during 1967-1968, five are considered tolerant to pollution, including brown bullhead, white sucker, golden shiner, yellow bullhead and American eel (Table 2-2; Barbour et al. 1999). Those five tolerant species accounted for 37% of the total fish catch from Hooksett Pool collected during 1967-1968. In addition, the 1967-1969 Hooksett Pool fish community was composed solely of species considered to be members of the generalist, insectivore and piscivore trophic guilds. The lack of any fish species considered to be intolerant to pollution, and the lack of any fish species representing the filter feeder or herbivore trophic guilds, in the 1967-1969 Hooksett Pool fish community reflects the high degree to which Hooksett Pool water quality was impaired by pollutants other than heat in the late 1960s.

The five most abundant fish species collected in Hooksett Pool during the 1967-1968 fish sampling – pumpkinseed, yellow perch, brown bullhead, white sucker and golden shiner – represented 89.8% of the total catch. All of these fish are known for their capability to withstand low DO conditions (Holtan 1990, Fox 1994, Trial et al. 1982, Scarola 1987, Twomey et al. 1984, Becker 1983). Three of those species – white sucker, brown bullhead and golden shiner – are also classified as tolerant to pollution (Barbour et al. 1999). It stands to reason that the increased abundance of these five fish in Hooksett Pool during the 1960s is attributable to their ability to withstand pollutants that were greatly reduced following the 1972 enactment and subsequent enforcement of the CWA and parallel state clean water regulations.

Further evidence of the polluted nature of Hooksett Pool during the 1960s is evidenced by macroinvertebrate sampling conducted during that time period. Macroinvertebrate communities are useful indicators of anthropomorphic perturbation due to their limited mobility. They are unable to avoid adverse environmental conditions and are often eliminated from areas where stresses exceed tolerance levels. In response to stressed conditions, the macroinvertebrate community often shifts towards high numbers of a few tolerant taxa. Data from USDI (1966) clearly indicates that pollution in the Merrimack River was adversely affecting the river's macroinvertebrate community. Less than 15 miles of the Merrimack River, from a total of 115 miles studied, contained benthic organisms.

A review of shoreline kick net samples collected at Hooksett Pool Monitoring Stations N-10, S-0, S-4 and S-16 during 1972 revealed low values for Ephemeroptera/Plecoptera/Trichoptera (EPT) richness, taxa richness and EPT/Chironomid ratio, all of which can be attributed to the low water quality conditions in Hooksett Pool prior to the Clean Water Act. Kick net data collected in October 2011 at these same monitoring stations (N-10, S-0, S-4 and S-16) showed that EPT richness had increased by 150-300% from 1972, and taxa richness had increased from 7-10 species in 1972 to 21-23 species in 2011. The 2001 EPT/chironomid ratios were also higher than their 1970s counterparts, as would be expected from samples collected in a river with improved water quality and habitat tolerated by more pollution-sensitive species (Normandeau 2012a). Benthic samples collected by ponar during 1972, 1973 and 2011 at Monitoring Stations N-10, S-0, S-4 and S-16 also show indications of improved riverine conditions over time, although these are not as dramatic as the shoreline samples, likely due to the sand substrate typically inhabited by tolerant organisms even in pristine conditions (Normandeau 2012a).

In short, the substantial improvements in water quality in the Merrimack River since the enactment of the CWA in 1972 (Normandeau 2011b) have appreciably influenced the fish community in the river, including in Hooksett and Garvins Pools, during the operation of Merrimack Station. When the "natural variability inherent in aquatic communities" (USEPA 1990) is considered along with such significant changes in water quality, it is clear that there was not an unaffected, unchanging fish community in Hooksett Pool during the 1960s and 1970s that can now be used as a baseline for comparison to the pool's current fish community. As a result, USEPA's use of the Hooksett Pool resident biotic community as sampled during 1967-1969 as the BIP by which the current species assemblage in Hooksett Pool is to be compared when assessing potential impacts related to Merrimack Station's thermal discharge is misguided, inappropriate and unsupportable using the available sampling data.

2.1.3 Current Aquatic Communities in Hooksett Pool and Garvins Pool

Rather than designate the compromised fish community that survived in the conventional and toxic pollutant-impaired Hooksett Pool of the 1960s as the Hooksett Pool BIP, USEPA should have adopted one of the following two approaches. It should have found, based on the fisheries and macroinvertebrate sampling data from 1972-2011, that the current fish community in Hooksett Pool is the proper BIP for the purpose of considering PSNH's request for renewal of Merrimack Station's §316(a) variance. The current fish community in Hooksett Pool meets USEPA's definition of "balanced indigenous population," because it is a community characterized by (1) diversity at all trophic levels, (2) the capacity to sustain itself through cyclic seasonal changes, (3) the presence of necessary food chain species, and (4) non-domination by pollution-tolerant species (40 C.F.R. §125.71(c)).

In the alternative, USEPA should have found that the current fish community in Garvins Pool provides a more appropriate point of comparison that may allow the identification of trends in Hooksett Pool that are potentially due to Merrimack Station's thermal discharge. Immediately upstream of Hooksett Pool, Garvins Pool is uninfluenced by the Station's thermal discharge but has similarly benefited from the significant water quality improvements that have occurred in the Merrimack River since 1972. The pool is contained within the natural banks of the Merrimack River and extends approximately eight miles upstream of the Garvins Falls Dam to near Sewalls Falls (PSNH 2003). As in most ecological studies involving comparisons, Garvins Pool is not the ideal reference area, because of certain differences from Hooksett Pool in habitat and physical area. The Garvins Pool impoundment has a surface area of approximately 640 acres at full pond versus 350 acres at full pond for Hooksett Pool (PSNH 2003). Additionally, abundance of submerged aquatic macrophytes is greater in Garvins Pool than in Hooksett Pool, and fish in Garvins Pool have access to productive oxbow and backwater habitats that are not available in Hooksett Pool. Backwater habitat in riverine systems serve as important nursery and spawning areas for resident fish species. Nonetheless, sand/silt/clay is the dominant substrate type within both pools, followed by boulder and woody debris (Normandeau 2011d), and both pools have undergone similar environmental changes over the last four decades due to improved water quality and the introduction of non-native species. Merrimack River fisheries sampling was undertaken during 2008 and 2009 to examine and compare biological characteristics of two fish species, yellow perch and white sucker, among Garvins, Hooksett and Amoskeag Pools (Normandeau 2009a). Additional sampling was undertaken during

2010 and 2011 to provide a current assessment of the whole fish community in Garvins, Hooksett and Amoskeag Pools (Normandeau 2011a). As discussed in detail below, the biocharacteristics data collected during this 2008-2011 sampling confirms that when compared to the fish community in Garvins Pool, the fish community in Hooksett Pool in general, and individual species in Hooksett Pool in particular, is diverse, healthy and productive.

2.2 No appreciable harm to the Hooksett Pool BIP

2.2.1 No Appreciable Harm to the Hooksett Pool Fish Community

CWA §316(a) provides that a permit applicant may demonstrate that any effluent limitation proposed for the thermal component of any discharge is more stringent than necessary to assure the protection and propagation of the BIP in and on the body of water into which the discharge is made. Applicants with an existing thermal discharge may demonstrate that the existing discharge is protective of the BIP by evaluating the BIP over a series of years during which the discharge occurred, and showing an absence of appreciable harm (40 C.F.R. §125.73(c); USEPA 1977). Here, support for a finding of "no appreciable harm" to the fish community in Hooksett Pool from Merrimack Station's thermal discharge is provided through assessment of trends in abundance and an examination of the health and condition of fish species relative to those collected from an appropriate reference BIP, the current fish community in Garvins Pool.

USEPA's finding of appreciable harm is clearly incorrect because properly interpreted, the data show that over time, there have not been (1) appreciable decreases in all coolwater fish species in Hooksett Pool, (2) appreciable increases in warmwater species in Hooksett Pool, (3) appreciable decreases in the diversity of species in Hooksett Pool (as discussed in detail below, the Shannon Diversity Index value shows that the current fish population in Hooksett Pool is more diverse now than it was forty years ago), or (4) appreciable increases in the abundance of generalist feeders or pollution-tolerant species in Hooksett Pool (Normandeau 2011a). In fact, when compared to Garvins Pool – the thermally uninfluenced impoundment immediately upstream from Hooksett Pool, and the proper reference to compare to Hooksett Pool – the biocharacteristics of the fish population in Hooksett Pool in general, and of the individual species in Hooksett Pool in particular, indicate no appreciable harm to the BIP (Normandeau 2011a).

- There has been no appreciable harm to the BIP in Hooksett Pool based on decreases in all coolwater species. Aquatic habitat that has been adversely impacted by a thermal discharge characteristically contains a higher abundance of fish species that are tolerant of warmer water, and a lower abundance of fish species that prefer cooler water. Merrimack Station's thermal discharge has not adversely impacted the abundance and distribution of fish in Hooksett Pool (the area of the Merrimack River from which Merrimack Station withdraws cooling water and into which it discharges heated effluent). Specifically, the abundance of all resident coolwater species in the pool (as estimated by standardized electrofish sampling efforts conducted between 1972 and 2011) has not significantly decreased for three out of the five coolwater fish species resident in Hooksett Pool. The abundance of chain pickerel and yellow perched has decreased, but there were no significant trends for fallfish and white sucker. The abundance of the remaining coolwater species, black crappie, increased in Hooksett Pool over the 1972-2011 period of time. These findings support the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

- There has been no appreciable harm to the BIP in Hooksett Pool based on increases in warmwater species. As estimated by the same standardized electrofish sampling efforts, there have not been increases in abundance for any of the warmwater fish species resident in Hooksett Pool from 1972-2011. Specifically, there were no significant trends for seven out of ten warmwater species (bluegill, golden shiner, largemouth bass, rock bass, smallmouth bass, spottail shiner and yellow bullhead), and abundance of the remaining three warmwater species (brown bullhead, pumpkinseed and redbreast sunfish) decreased, suggesting causes unrelated to the Station's thermal discharge. These findings support the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

- There has been no appreciable harm to the BIP in Hooksett Pool based on a decrease in diversity of the fish community. Based on the 1972-2011 electrofish sampling efforts, the highest Shannon diversity index value for the Hooksett Pool fish community observed was in 2011. Moreover, all of the per year diversity index values from the sampling years in the 2000s were higher than the values from the sampling years in the 1970s, indicating that the diversity of the fish community in Hooksett Pool – and therefore the biological health of that community – has generally increased, not decreased, over the past forty years. These findings support the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool (Normandeau 2011a).

- There has been no appreciable harm to the BIP in Hooksett Pool based on an increase in generalist feeders or increase in pollution-tolerant species. Aquatic habitat that has been adversely impacted by a thermal discharge characteristically contains a higher percentage of both generalist feeders (which can capitalize on a variety of different food sources and often increase dramatically with habitat degradation) and pollution-tolerant individuals. However, neither of these findings was observed in Hooksett Pool for fish collected during the standardized electrofish sampling efforts that PSNH conducted between 1972 and 2011. These findings support the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool (Normandeau 2011a).

- A review of warmwater and coolwater species compared between Hooksett Pool and Garvins Pool indicates that there has been no appreciable harm to the BIP in the Hooksett Pool. As noted above, aquatic habitat that has been adversely impacted by a thermal discharge characteristically contains a higher abundance of fish species that are tolerant of warmer water, and a lower abundance of fish species that prefer cooler water. However, a comparison of the 2010 and 2011 fish communities in Hooksett Pool and Garvins Pool (the thermally uninfluenced impoundment immediately upstream from Hooksett Pool) shows no clear pattern consistent with the hypothesis that Merrimack Station's thermal discharge has caused an increase in the abundance of warmwater species or a decrease in the abundance of all coolwater species in the pool. This comparison, therefore, supports the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool (Normandeau 2011a).

- A review of generalist feeders and pollution tolerant species compared between Hooksett Pool and Garvins Pool indicates that there has been no appreciable harm to the BIP in the Hooksett Pool. As noted above, aquatic habitat that has been adversely impacted by a thermal discharge characteristically contains a higher percentage of both generalist feeders and pollution-tolerant individuals. Although the percentage of generalist and tolerant species were higher in Hooksett Pool than Garvins Pool during both 2010 and 2011, these differences were the result of increased relative abundance of both coolwater and warmwater species in Hooksett Pool. If Merrimack Station's thermal discharge has adversely impacted the BIP in Hooksett Pool by increasing the percentage of generalist feeders or pollution-tolerant individuals, it would not be expected that coolwater species would have significantly contributed to these increases, as documented (Normandeau 2011a).

- A review of length-weight-curve sampling data of fish compared between Hooksett Pool and Garvins Pool indicates that there has been no appreciable harm to the BIP in Hooksett Pool. Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data tend to show a decreasing slope to the length-weight curve – signifying progressively lower weight for a given length – for a resident fish species over time or in comparison to the same species residing in thermally uninfluenced habitat. Such a decreasing slope indicates a reduction in quality of body condition due to the thermal impact. Here, the observations of similar or increased growth among coolwater species residing in Hooksett Pool compared to the same species residing in thermally uninfluenced Garvins Pool during years of comparable sampling (2008-2011) indicated that there has been no appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).
- Changes in the mean length at age for resident species in Hooksett Pool does not mean that the thermal discharges from Merrimack Station has caused appreciable harm to the BIP in the Hooksett Pool. Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show lower mean length at age for a resident fish species compared to the same species in a thermally uninfluenced area, due to a reduction in growth rates associated with thermal stress. Here, the observation of reduced mean length at age for two coolwater fish species (white sucker and yellow perch) in Hooksett Pool suggests that growth (as estimated by mean length at age) may be reduced for some age classes in Hooksett Pool as compared to the same age classes of the same species in Garvins Pool. However, the inverse relationship between density and growth (i.e., the larger the fish population in a given water body, the slower the growth of individual fish in that population, due to competition for resources) has been well-studied and documented in other systems for both white sucker and yellow perch. Here, abundance of white sucker was greater in Hooksett Pool than Garvins Pool during the sampling period, suggesting that the causes for such lower mean length at age for one of the coolwater fish species in question are unrelated to the Station's thermal discharge (Normandeau 2011a).
- Decreases in mortality levels for resident species in Hooksett Pool as compared to Garvins Pool indicates that the thermal discharges from Merrimack Station have not caused appreciable harm to the BIP. Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a greater total mortality (Z) for a resident fish species compared to the same species in a thermally uninfluenced area, due to increased stress associated with thermal impacts. Here, the mortality levels observed in Hooksett Pool are lower than or equal to those observed in Garvins Pool for five of the seven species examined, including yellow perch and pumpkinseed, two fish species that have decreased in abundance in Hooksett Pool between 1972 and 2011. These findings support the hypothesis

that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool (Normandeau 2011a).

- Length-fecundity relations were significant for white suckers in both Hooksett and Garvins Pools, indicating that fecundity (i.e., the number of eggs per female) increases with length in both locations. The estimated range of number of eggs per female white sucker as well as the range of observed body lengths overlapped for individuals collected within Hooksett and Garvins Pools in 2008 and 2009, suggesting that the BIP in Hooksett Pool has not experienced appreciable harm from reduced reproductive success as a result of Merrimack Station's thermal discharge (Normandeau 2011a).
- A comparison of external and internal parasites on the same resident species in both Hooksett Pool and Garvins Pool indicates that there has been no appreciable harm to the BIP in Hooksett Pool. Resident fish species in aquatic habitat that has been adversely impacted by a thermal discharge characteristically manifest more frequent infestation of internal and external parasites compared to the same species resident in a thermally uninfluenced area, indicating a reduction in the overall health and conditions of the fish due to thermal impacts. Parasitism levels in Hooksett Pool were less than or equal to those observed in Garvins Pool for seven of the thirteen species examined for external parasites (2008 to 2011) and both species examined for internal parasites (2008 to 2009). These observations support the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool (Normandeau 2011a).

In sum, observations on the 1972-2011 time series of abundance data for both coolwater and warmwater fish in Hooksett Pool do not show a consistent pattern of increase or decrease in abundance to support the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the fish community in the pool (Normandeau 2011a). Moreover, comparison of the results of the standardized fish sampling conducted in Hooksett Pool and Garvins Pool in 2008-2011 shows that CPUE data collected for 24 fish species did not exhibit a clear pattern that would be consistent with the hypothesis that Merrimack Station's thermal discharge has caused an increase in the abundance of warmwater species or a decrease in the abundance all of coolwater water species in Hooksett Pool (Normandeau 2011a). Finally, while, where aquatic habitat has been adversely impacted by a thermal discharge, fish sampling data typically show a reduction in quality of body condition, lower mean length at age, higher total instantaneous mortality rate, decreased reproductive potential and more frequent infestation of parasites when compared to an appropriate BIP, here a review of biocharacteristics for thirteen fish species resident in both Hooksett Pool and Garvins Pool did not indicate a consistent pattern of impaired health and condition for either warmwater or coolwater individuals residing in Hooksett Pool (Normandeau 2011a) which is supportive of a finding of "no prior appreciable harm" due to Merrimack Station operations.

2.2.1.1 No Appreciable Harm to the Hooksett Pool Representative Important Species of Fish

Representative Important Species ("RIS") of fish were evaluated to assess the potential effects of Merrimack Station's thermal discharge on the resident and migratory species found in or passing through Hooksett Pool. In a meeting on August 31, 1992, the Advisory Committee unanimously selected and approved seven fish species from the Hooksett Pool fish community as RIS for Merrimack Station: (1) alewife, (2) American shad, (3) Atlantic salmon, (4) smallmouth bass, (5) largemouth bass, (6) pumpkinseed, and (7) yellow perch (Advisory Committee, 1992). Fallfish, and white sucker, were suggested but not formally recommended or approved by the Advisory Committee for inclusion as RIS for Merrimack Station, but nonetheless were added by PSNH. Solely for ease of reference, this report will refer to these two supplemental species as RIS.

2.2.1.1.1 Alewife

Alewife (*Alosa pseudoharengus*) is a native anadromous species that inhabits the lower Merrimack River. No adult alewives that ascend the fish ladder at the Amoskeag Dam (located downstream from Hooksett Dam) during the spring spawning migration pass upstream into Hooksett Pool, because there are presently no upstream fish passage facilities at Hooksett Dam. Similarly, there are no upstream passage facilities at the Garvins Falls Dam, which forms the upstream boundary of Hooksett Pool.

Periodically over the past two decades, resource agencies have stocked adult alewives into ponds and tributaries that enter the Merrimack River at or upstream from Hooksett Pool, and these adult stockings have successfully spawned and produced juvenile alewives that emigrate downstream in the fall through Hooksett Pool. For example, juvenile alewives produced in Northwood Lake move downstream and pass through Hooksett Pool via the Suncook River during their autumn emigration. A downstream fish bypass operates at Hooksett Dam during the fall to aid in passing these emigrating juvenile alewives downstream. Alewife juveniles were captured in Hooksett Pool at the standardized electrofishing stations during August and September in 2004 and 2010. In addition, in 2010, several hundred alewives were captured in Hooksett Pool at standardized electrofish stations and moved to tanks at Garvins Falls for use in a downstream fish passage study. These alewives captured in Hooksett Pool were much larger than the alewives captured in Northwood Lake that year, demonstrating excellent growth in the pool.

PSNH's FERC license for the Merrimack Project requires the construction of upstream fish passage facilities at Hooksett Dam, in the form of a fish ladder or fish lift, when sufficient numbers of river herring (alewife and blueback herring) and American shad are consistently passing upstream at the Amoskeag Dam fish ladder. Based on recent fish passage counts at the Amoskeag Dam Fishway, it is unlikely that a fish passage facility will be built at Hooksett Dam within the next five years. Nonetheless, as noted above, alewives (juveniles and adults from stockings) are utilizing habitat in Hooksett Pool during summer and fall periods.

2.2.1.1.2 American shad

American shad (*Alosa sapidissima*) is a native anadromous species similar to alewife (in the same genus) that inhabits the lower Merrimack River. American shad that ascend the fish ladder at the Amoskeag Dam (located downstream from Hooksett Dam) cannot presently migrate upstream into Hooksett Pool during their spring spawning run because no upstream fish passage facilities exist at Hooksett Dam. Similarly, there are no upstream passage facilities at the Garvins Falls Dam, which forms the upstream boundary of Hooksett Pool.

Agencies are currently stocking larval shad upstream of Hooksett Pool, and in some instances they also stock adult shad upstream of Hooksett Pool. In 1978 and 2002, resource agencies stocked adult American shad directly into Hooksett Pool, and these adult stockings successfully spawned and produced juvenile fish that subsequently emigrated downstream in the fall through Hooksett Pool. (A downstream fish bypass operates at Hooksett Dam during the fall to aid in passing these emigrating juvenile American shad downstream.) In 1978, agencies stocked 624 adult American shad in Hooksett Pool following their capture and successful trucking from the Connecticut

River. A 1978 Normandeau study documented that stocked shad did spawn in Hooksett Pool, as indicated by eggs captured throughout June in drift net collections. The capture of juvenile shad in Hooksett Pool began on July 25 and continued into the fall (Normandeau 1979c). A total of 313 juvenile shad were captured by seining, and out of these, all but 13 were captured between discharge station 0-W and S-4-E, in the thermal plume. Even with Unit 2 offline, the surface water temperatures during the capture of shad juveniles ranged from 23.9 C to 28.2 C during July and August. These shad exhibited excellent growth in Hooksett Pool and were larger than those collected that year in Amoskeag Pool. New Hampshire Fish and Game stocked 1,861 adult shad in Hooksett Pool during 2002 and these fish successfully spawned. Normandeau captured 750 juvenile shad for use during a fall downstream bypass study from a pool below Amoskeag Dam, documenting successful spawning. In 2010, shad juveniles were collected at the standardized electrofish stations in Hooksett Pool during August and September sampling and in 2011; one juvenile shad was captured in August. These collections demonstrate that juvenile clupeids (shad, alewife) are able to use the habitat in Hooksett Pool during the spring, summer and fall months, and the adults have been documented successfully spawning in the pool.

PSNH's FERC license for the Merrimack Project requires the construction of upstream fish passage facilities at Hooksett Dam, in the form of a fish ladder or fish lift when sufficient numbers of river herring (alewife and blueback herring) and American shad are consistently passing upstream at the Amoskeag Dam fish ladder. Based on recent fish passage counts at the Amoskeag Dam Fishway, it is unlikely that a fish passage facility will be built at Hooksett Dam within the next five years.

2.2.1.1.3 Atlantic salmon

Atlantic salmon, an anadromous fish, is native to Merrimack River and is presently the subject of restoration efforts. As a result, the current population in Merrimack River watershed is essentially entirely maintained by hatchery rearing and stocking of fry and smolts, with no natural reproduction. The Atlantic salmon restoration program in Merrimack River that began in 1976 is ongoing, and agencies continue to capture adult sea-run Atlantic salmon at Essex Dam in Lawrence, Massachusetts, which is the first man-made mainstem barrier encountered by salmon migrating upstream from the sea. These adult salmon are transferred to a hatchery for egg production. The salmon eggs are hatched and the fry used to stock tributaries to the Merrimack River, including the Pemigewasset River and its East Branch, Souheagan River, Piscataquaog River, Smith River, Baker River and Mad River. Adult brood stock that are no longer useful for fry production are also stocked into the upper Merrimack River each year to support a popular fishery for this species, and hundreds of these adult fish have been seen each spring passing the Garvins Falls Dam and entering upper Hooksett Pool. In August and September of all years with consistent sampling effort (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010 and 2011), the period of comparable and documented electrofish sampling in Hooksett Pool, neither juvenile nor adult Atlantic salmon were observed within Hooksett Pool (Normandeau 2011a).

Other than the salmon smolts' transient use of Hooksett Pool during the spring downstream migration, and the adult broodstock salmon documented passing through the pool, there is no habitat suitable for completion of life history requirements of Atlantic salmon within Hooksett Pool. This is primarily because ambient water temperature conditions upstream from the influence of Merrimack Station's thermal discharge naturally exceed their life history requirements (Normandeau 2007a). Thus, the relevant potential interaction between Merrimack Station's thermal discharge and Atlantic salmon will occur primarily during the transient upstream migration of adults and downstream migration of smolts. The effects of the thermal discharge on the downstream migration of Atlantic salmon smolts has been assessed in a separate study, the results of which demonstrate that Merrimack Station's thermal discharge has neither delayed nor created a barrier to the downstream migration of Atlantic salmon smolts (Normandeau 2006). Therefore, analysis of migratory behavior supports a finding of no appreciable harm to Atlantic salmon in Hooksett Pool due to Merrimack Station's existing thermal discharge.

2.2.1.1.4 Smallmouth bass

Smallmouth bass (*Micropterus dolomieu*) is a non-native resident (non-migratory) fish species that was introduced into New Hampshire waters, including Merrimack River, during the 1860s (Scarola 1987). Smallmouth bass represents the piscivore trophic guild of fish species that are reported to be intermediate in their tolerance to pollution (Halliwell et al. 1999).

Smallmouth bass CPUE collected via boat electrofish sampling in August and September of 2010 and 2011 was compared between Hooksett Pool and Garvins Pool (Normandeau 2011a). Although CPUE for young of year and immature smallmouth bass was higher in Hooksett Pool during 2010, there was no significant difference in CPUE for mature smallmouth bass. During 2011, CPUE for smallmouth bass (all lifestages pooled) was greater in Hooksett Pool than Garvins Pool. Similar within-year abundance (as measured by CPUE) of smallmouth bass in Hooksett Pool relative to Garvins Pool supports a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool.

In August and September of all years during which electrofishing data was collected in Hooksett Pool using consistent and well-documented procedures (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010 and 2011) (these months and years of standardized, documented sampling are hereinafter referred to collectively as the "1972-2011 time period," for ease of reference) (Normandeau 2007a, 2011a), juvenile and adult smallmouth bass have been numerically important components of the Merrimack River fish community. They are found throughout Hooksett Pool, including within Merrimack Station's cooling canal at water temperatures approaching or exceeding the literature reported values for upper incipient lethal temperature ("UILT") and avoidance temperatures, and in natural habitats exposed to the Station's thermal discharge (Normandeau 2007a). The thermally influenced habitat has no unique characteristics and is not critical or necessary for completion of any life history functions for smallmouth bass in Hooksett Pool or elsewhere in Merrimack River. No statistically significant decreasing trends were observed in smallmouth bass annual mean CPUE in Hooksett Pool during the 1972-2011 time period, supporting a finding that the Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

Biocharacteristics data were collected for smallmouth bass captured during 2008-2011 within Garvins and Hooksett Pools (Normandeau 2011a). An examination of smallmouth bass condition during 2010 and 2011 showed no significant difference in weight at length among fish captured in Hooksett and Garvins Pools. A comparison of condition among smallmouth bass collected in 1972-1978 and 2004-2005 in Hooksett Pool showed similar incremental weight gain with increasing length. However, there was evidence that smallmouth bass at a given length during 2004-2005 weighed significantly more (i.e., was in better condition) than those at the same length during 1972-1978. A similar range of ages were observed for smallmouth bass collected in Hooksett and Garvins Pools. Mean length at age did not differ for age-0 smallmouth bass within Garvins and Hooksett Pools during 2010. Total instantaneous mortality was higher for smallmouth bass in Hooksett Pool, and the prevalence of external parasites was higher for smallmouth bass within Garvins Pool. Degraded habitat conditions that might be caused by continued exposure to Merrimack Station's thermal discharge should result in a consistent pattern of impaired health and condition for the Hooksett Pool smallmouth bass population when compared to a thermally uninfluenced but otherwise comparable population, that is, the smallmouth bass population in Garvins Pool. That hypothesis is not supported by the 2008-2011 biocharacteristics data from Hooksett and Garvins Pools,

Analysis of Hooksett Pool smallmouth bass abundance relative to that of the thermally uninfluenced but otherwise comparable Garvins Pool, historical trends in smallmouth bass abundance within Hooksett Pool, and comparative biocharacteristics findings for smallmouth bass between Hooksett Pool and Garvins Pool all support a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

2.2.1.1.5 Largemouth bass

Largemouth bass (*Micropterus salmoides*) is a non-native resident (non-migratory) fish species found in Merrimack River, including Hooksett Pool and Amoskeag Pool. Like smallmouth bass, they were introduced into New Hampshire waters during the 1860s (Scarola 1987). Largemouth bass represent the piscivore trophic guild of fish species that are reported to be intermediate in their tolerance to pollution (Halliwell et al. 1999).

Largemouth bass CPUE collected via boat electrofish sampling in August and September of 2010 and 2011 was compared between Hooksett Pool and Garvins Pool (Normandeau 2011a). CPUE for mature and immature largemouth bass was higher in Hooksett Pool during 2010, and the CPUE for young of year largemouth bass was higher in Garvins Pool. During 2011, CPUE for largemouth bass (all lifestages pooled) was greater in Hooksett Pool than Garvins Pool. Similar within-year abundance (as measured by CPUE) of largemouth bass in Hooksett Pool relative to Garvins Pool supports a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool.

During the 1972-2011 time period, juvenile and adult largemouth bass have been numerically important components of the Merrimack River fish community. They are found throughout Hooksett Pool, including within Merrimack Station's cooling canal at water temperatures approaching or exceeding the literature reported values for UILT and avoidance temperatures, and in natural habitats exposed to the thermal discharge (Normandeau 2007a). The thermally influenced habitat has no unique characteristics and is not critical or necessary for completion of any life history functions for largemouth bass in Hooksett Pool or elsewhere in Merrimack River. No statistically significant decreasing trends were observed in largemouth bass annual mean CPUE in Hooksett Pool during the 1972-2011 time period, supporting a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

Biocharacteristics data were collected for largemouth bass captured during 2008-2011 within Garvins and Hooksett Pools (Normandeau 2011a). An examination of largemouth bass condition during 2010 and 2011 showed largemouth bass in Hooksett Pool grew significantly more rotund (or "fatter") with increasing length than in Garvins Pool. A similar range of ages were observed for largemouth bass collected in Hooksett and Garvins Pools. Mean length at age did not differ for age-1 and age-2 largemouth bass but for age-0 largemouth bass was greater in Hooksett Pool during 2010. There was no significant difference in largemouth bass total instantaneous mortality rate or prevalence of external parasites between pools. Degraded habitat conditions that might be caused by continued exposure to Merrimack Station's thermal discharge should result in a consistent pattern of impaired health and condition for the Hooksett Pool largemouth bass population when compared to a thermally uninfluenced but otherwise comparable population, that is, the largemouth bass population in Garvins Pool. That hypothesis is not supported by the 2008-2011 biocharacteristics data from Hooksett and Garvins Pools.

Analysis of Hooksett Pool largemouth bass abundance relative to that of the thermally uninfluenced but otherwise comparable Garvins Pool, historical trends in largemouth bass abundance within Hooksett Pool, and comparative biocharacteristics findings for largemouth bass between Hooksett Pool and Garvins Pool all support a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

2.2.1.1.6 Pumpkinseed

Pumpkinseed (*Lepomis gibbosus*) is a native, resident fish species found throughout Merrimack River watershed, including Hooksett Pool. Similar in habitat preference to the bluegill, pumpkinseed prefer quiet or slow-moving water and are particularly abundant in areas of dense aquatic vegetation. Pumpkinseed represent the generalist trophic guild of fish species that are reported to be intermediate in their tolerance to pollution (Halliwell et al. 1999). Pumpkinseed feed on microcrustaceans and small aquatic insects.

Pumpkinseed CPUE collected via boat electrofish sampling in August and September of 2010 and 2011 was compared between Hooksett Pool and Garvins Pool (Normandeau 2011a). Although CPUE for young of year and immature pumpkinseed was higher in Garvins Pool during 2010, there was no significant difference in CPUE for mature pumpkinseed. During 2011, CPUE for pumpkinseed (all lifestages pooled) was greater in Garvins Pool than Hooksett Pool. The lack of a significant difference in the CPUE of adult pumpkinseed between Hooksett and Garvins Pools is not consistent with the hypothesis that the operation of Merrimack Station has caused appreciable harm to pumpkinseed in Hooksett Pool. The greater abundance of young of year and immature pumpkinseed in Garvins Pool could be attributed to the higher abundance of submerged aquatic vegetation mapped along Garvins Pool electrofish transects than was available on Hooksett Pool electrofish transects. The young of year and immature lifestages of pumpkinseed show a high affinity of submerged aquatic vegetation (Normandeau 2011a).

Pumpkinseed have been present in Hooksett Pool during all years of the 1972-2011 time period. A statistically significant decreasing trend was observed in pumpkinseed annual mean CPUE in Hooksett Pool during this time period (Normandeau 2011a). Notably, both improvements to Merrimack River water quality since pumpkinseed abundance peaked during the late 1960s and early 1970s and direct competition with bluegill have coincided with the decline in pumpkinseed abundance within Hooksett Pool over this time period.

Biocharacteristics data were collected for pumpkinseed captured during 2008-2011 within Garvins and Hooksett Pools (Normandeau 2011a). An examination of pumpkinseed condition showed no significant difference in weight at length between fish captured in Hooksett and Garvins Pools during 2010 and 2011. A similar range of ages were observed for pumpkinseed collected in Hooksett and Garvins Pools. There was no significant difference in pumpkinseed total instantaneous mortality rate or prevalence of external parasites between pools. Degraded habitat conditions that might be caused by continued exposure to Merrimack Station's thermal discharge should result in a consistent pattern of impaired health and condition for the Hooksett Pool pumpkinseed population when compared to a thermally uninfluenced but otherwise comparable population, that is, the pumpkinseed population in Garvins Pool. That hypothesis is not supported by the 2008-2011 biocharacteristics data from Hooksett and Garvins Pools.

Although abundance of pumpkinseed has decreased in Hooksett Pool, the abundance of mature pumpkinseed in Hooksett Pool was comparable to the abundance of mature pumpkinseed in Garvins Pool for the year with available data. Pumpkinseed are a warmwater fish species and are capable of existing in high water temperatures, suggesting that their decline in abundance is more likely related to a lower ability to successfully compete with other resident fish species. In addition, the lack of a consistent pattern of impaired health and condition of Hooksett Pool pumpkinseed supports a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool. In addition trends in the abundance of individual fish species should not be used to represent ecological changes; rather, the changes in abundance of entire species groups should be considered. Here, pumpkinseed are one of three warmwater fish species that serve as Merrimack Station RIS. Abundance trends and biocharacteristics data for the other two species, smallmouth bass and largemouth bass, support a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool.

2.2.1.1.7 Yellow perch

Yellow perch (*Perca flavescens*) is a native, resident fish species found throughout Merrimack River watershed, including Hooksett Pool. Yellow perch are widespread, very adaptable, and found in a variety of warmwater to coolwater habitats. They are common in clear open water habitats with moderate vegetation, typically less than 30 feet deep. Yellow perch represents the piscivore trophic guild of fish species that are reported to be intermediate in their tolerance to pollution (Halliwell et al. 1999). Some researchers consider yellow perch to be insectivorous or a generalist forager; however, these alternate trophic guilds undoubtedly apply to different age classes, with general foraging occurring in the earlier life stages, a predominance of piscivory in the older and larger individuals, and insectivory occurring throughout their life.

Yellow perch CPUE collected via boat electrofish sampling in August and September of 2010 and 2011 was compared between Hooksett Pool and Garvins Pool (Normandeau 2011a). The 2010 CPUE for young of year, immature and mature yellow perch and the 2011 CPUE (all lifestages combined) was higher in Garvins Pool than was observed in Hooksett Pool.

During the 1972-2011 time period, juvenile and adult yellow perch have been numerically important components of the Merrimack River fish community as sampled by electrofishing. They are found throughout Hooksett Pool, including downstream of Merrimack Station's cooling water discharge canal. A statistically significant decreasing trend was observed in yellow perch annual mean CPUE in Hooksett Pool during this time period (Normandeau 2011a).

Biocharacteristics data were collected for yellow perch captured during 2008-2011 within Garvins and Hooksett Pools (Normandeau 2011a). An examination of yellow perch condition showed no significant difference in weight at length among perch captured in Hooksett and Garvins Pools during 2009, that yellow perch in Hooksett Pool grew significantly more rotund with increasing length during 2008, and that yellow perch in Garvins Pool grew significantly more rotund with increasing length during 2011. A comparison of condition among yellow perch collected in 1972-1978 and 2004-2005 in Hooksett Pool showed that at larger lengths, yellow perch may have weighed more during 2004-2005 than during 1972-1978 but may have weighed less at smaller lengths during 2004-2005 than during 1972-1978.

A similar range of ages were observed for yellow perch collected in Hooksett and Garvins Pools. Mean length at age did not differ for age-0 yellow perch but for age-1, age-2, and age-3 yellow perch mean length was greater in Garvins Pool than Hooksett Pool during 2009. There was no significant difference in the total instantaneous mortality rate between pools. The prevalence of external parasites was significantly greater in Garvins Pool, and there was no significant difference in the prevalence of internal parasites between pools. The ranges of fecundity estimates for female yellow perch were similar between pools. Degraded habitat conditions that might be caused by continued exposure to Merrimack Station's thermal discharge should result in a consistent pattern of impaired health and condition for the Hooksett Pool yellow perch population when compared to a thermally uninfluenced but otherwise comparable population, that is, the yellow perch population in Garvins Pool. That hypothesis is not supported by the 2008-2011 biocharacteristics data from Hooksett and Garvins Pools.

Abundance of yellow perch has decreased in Hooksett Pool and is lower than that observed in Garvins Pool. Although abundance is reduced, the lack of a consistent pattern of impaired health and condition does not support a finding that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool. As noted above, trends in the abundance of individual fish species should not be used to represent ecological changes; rather, the changes in abundance of entire species groups should be considered. Yellow perch are one of three coolwater fish species that serve as Merrimack Station RIS. Abundance trends and biocharacteristics data for the other two species, white sucker and fallfish, support a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool.

2.2.1.1.8 White sucker

White sucker (*Catostomus commersoni*) is New Hampshire's most common native, resident fish species. Normandeau (1979b) states "The white sucker is the least heat tolerant species that resides in Hooksett Pool." White sucker, considered a non-game fish, has generalized habitat requirements. It populates a wide range of gradients and substrates in waters that range from clear to turbid in both lentic and lotic habitats. White sucker represents the generalist trophic guild of fish species that are reported to be tolerant (Halliwell et al. 1999). White sucker is also considered to be an insectivore or an omnivore forager by some researchers. This species often feeds on midge larvae, small crustaceans, clams, other invertebrates, fish eggs, algae and other plants. There is a shift in the type of food consumed with increasing size. Fry begin feeding near the surface on plankton and other small invertebrates until they reach 16- 18 mm in size. At that point, the mouth moves from terminal to ventral and there is a shift to bottom feeding.

White sucker CPUE collected via boat electrofish sampling in August and September of 2010 and 2011 was compared between Hooksett Pool and Garvins Pool (Normandeau 2011a). Although there was no significant difference in the CPUE for young of year white sucker between Garvins and Hooksett Pools during 2010, CPUE of immature and mature white sucker was higher in Hooksett Pool during that year. During 2011, CPUE for white sucker (all lifestages pooled) was greater in Hooksett Pool than Garvins Pool. Similar or significantly higher within-year abundance (as measured by CPUE) of white sucker in Hooksett Pool relative to Garvins Pool supports a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool..

During the 1972-2011 time period, white sucker have been important components of the Merrimack River fish community sampled by electrofishing. They are found throughout Hooksett Pool, including downstream of Merrimack Station's cooling canal. No statistically significant negative (decreasing) trends were observed in white sucker annual mean CPUE in Hooksett Pool during this time period, supporting a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

Biocharacteristics data were collected for white sucker captured during 2008-2011 within Garvins and Hooksett Pools (Normandeau 2011a). An examination of white sucker condition showed no significant difference in weight at length among sucker captured in Hooksett and Garvins Pools during 2009, and that white sucker in Hooksett Pool grew significantly more rotund (or "fatter") with increasing length than in Garvins Pool during 2011. A similar range of ages were observed for white sucker collected in Hooksett and Garvins Pools. Mean length at age for age-2, age-3, and age-4 white sucker was greater in Garvins Pool than Hooksett Pool during a single year. There was no significant difference in the total instantaneous mortality rate between pools. Although the prevalence of external parasites was significantly greater in Hooksett Pool than in Garvins Pool, there was no significant difference in the prevalence of internal parasites. The ranges of fecundity estimates for female white sucker were similar between pools. Degraded habitat conditions that might be caused by continued exposure to Merrimack Station's thermal discharge should result in a consistent pattern of impaired health and condition for the Hooksett Pool white sucker population when compared to a thermally uninfluenced but otherwise comparable population, that is, the white sucker population in Garvins Pool. That hypothesis is not supported by the 2008-2011 biocharacteristics data from Hooksett and Garvins Pools.

Analysis of Hooksett Pool white sucker abundance relative to that of the thermally uninfluenced but otherwise comparable Garvins Pool, historical trends in white sucker abundance within Hooksett Pool, and comparative biocharacteristics findings for white sucker between Hooksett Pool and Garvins Pool all support a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

2.2.1.1.9 Fallfish

Fallfish (*Semotilus corporalis*) is a native, resident fish species in Merrimack River that is reported to inhabit clear flowing, gravel-bottomed streams and lakes. Larger adults have been noted to inhabit large pools and deeper runs in rivers, while the young prefer more rapid water upstream. Fallfish represents the generalist trophic guild of fish species that are reported to be intermediate in their tolerance to pollution (Halliwell et al. 1999). Fallfish are opportunistic feeders, eating aquatic insect larvae, terrestrial insects, crustaceans, and fish.

Fallfish CPUE collected via boat electrofish sampling in August and September of 2010 and 2011 was compared between Hooksett Pool and Garvins Pool (Normandeau 2011a). Although there was no significant difference in the CPUE for young of year and immature fallfish between Garvins and Hooksett Pools during 2010, CPUE of mature fallfish was higher in Hooksett Pool during that year. During 2011, CPUE for fallfish (all lifestages pooled) was greater in Hooksett Pool than Garvins Pool. Similar or significantly higher within-year abundance (as measured by CPUE) of fallfish in Hooksett Pool relative to Garvins Pool supports a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool.

During the 1972-2011 time period, fallfish were present in relatively low abundance during eight of the nine years sampled (Normandeau 2011a). No statistically significant decreasing trends were observed in fallfish annual mean CPUE in Hooksett Pool during the 1972-2011 time period, supporting a finding that the Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

Biocharacteristics data were collected for fallfish captured during 2008-2011 within Garvins and Hooksett Pools (Normandeau 2011a). An examination of fallfish condition during 2011 showed fallfish in Hooksett Pool grew significantly more rotund (or "fatter") with increasing length than in Garvins Pool. A similar range of ages were observed for fallfish collected in Hooksett and Garvins Pools. Fallfish within Hooksett Pool had a significantly higher total instantaneous mortality rate than was observed in Garvins Pool. The prevalence of external parasites was significantly greater in Hooksett Pool than was observed in Garvins Pool. Degraded habitat conditions that might be caused by continued exposure to Merrimack Station's thermal discharge should result in a consistent pattern of impaired health and condition for the Hooksett Pool fallfish population when compared to a thermally uninfluenced but otherwise comparable population, that is, the fallfish population in Garvins Pool. That hypothesis is not supported by the 2008-2011 biocharacteristics data from Hooksett and Garvins Pools.

Analysis of Hooksett Pool fallfish abundance relative to that of the thermally uninfluenced but otherwise comparable Garvins Pool, historical trends in fallfish abundance within Hooksett Pool, and comparative biocharacteristics findings for fallfish between Hooksett Pool and Garvins Pool all support a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool (Normandeau 2011a).

2.2.1.2 Adequate Fish Passage as Evidence of No Appreciable Harm

Hooksett Pool is used by both resident and anadromous fish species. For the purposes of assessing the potential impact of Merrimack Station's thermal discharge on the BIP in Hooksett Pool, the entire length of Hooksett Pool should be considered a single water body, because fish residing in the pool are not limited in their ability to move about. The absence of any fish passage structure at Hooksett Dam prevents adult anadromous species from accessing Hooksett Pool unless directly stocked in or above Hooksett Pool. While several species of anadromous fish are occasionally present in Hooksett Pool due to stocking, the pool is not annually used as spawning or juvenile rearing habitat. With regards to anadromous species, the major role of Hooksett Pool is to serve as a downstream passage route and, once fish passage is installed, an upstream passage route. Concerns related to the interaction of migrating anadromous fish species and Merrimack Station's thermal discharge have been examined. Telemetry studies using Atlantic salmon smolts (Normandeau 2006) and adult American shad (Normandeau 1979c) indicated that the thermal plume did not act as a barrier to migration.

A joint probability was developed using Hooksett Pool river flow and water temperature for each of four one-week biological periods of interest using a 21-year data set (ASA 2012). These biological periods were defined as early-spring (May 7-14), late-spring (June 1-7), summer (August 7-13) and fall (September 24-30). For each biological period, a single year representative of average (approximately 50th percentile of temperature-flow occurrence) and extreme (approximately 90th percentile of temperature-flow occurrence) conditions was selected for modeling (ASA 2012). The previously calibrated and validated hydrothermal model was run for both maximum plant and no plant conditions to estimate the temperature rise in the river from the plant. Figures of the results showing surface temperatures and cross sections at previously established stations S0 (located just downstream of the confluence of the plant discharge canal and the River) and S4 (located approximately 2,000 ft. downstream from S0) were provided by ASA to Normandeau at times reflecting the median environmental condition for the biological period. The median environmental condition was characterized as the time at which the upstream temperatures were at the 50th percentile for that period.

- Visual representations of the modeled temperature rise above ambient conditions (ΔT) at an instance that reflects the median environmental condition from the seven day simulated period during the early-spring and late-spring biological periods at Monitoring Stations S-0 and S-4 are presented in Figures 2-2, 2-3, 2-6 and 2-7 for an average year (approximately 50th percentile of temperature-flow occurrence) and Figures 2-4, 2-5, 2-8 and 2-9 for an extreme year (approximately 90th percentile of temperature-flow occurrence). As evidenced by these figures, an adequate zone of passage exists for both resident and transient anadromous fish species moving between the portions of Hooksett Pool upstream and downstream of Merrimack Station's cooling canal.

- Visual representations of the modeled temperature rise above ambient conditions (ΔT) at an instance that reflects the median environmental condition from the seven day simulated period during the summer (August 7-13) biological period at Monitoring Stations S-0 and S-4 is presented in Figures 2-10 and 2-11 for an average year (approximately 50th percentile of temperature-flow occurrence) and Figures 2-12 and 2-13 for an extreme year (approximately 90th percentile of temperature-flow occurrence). As evidenced by these figures, a zone of passage within 6^{o}C to 10^{o}C of ambient exists for resident fish species moving between the portions of Hooksett Pool upstream and downstream of the thermal discharge.

- Visual representations of the modeled temperature rise above ambient conditions (ΔT) at an instance that reflects the median environmental condition from the seven day simulated period during the fall (September 24-30) biological period at Monitoring Stations S-0 and S-4 is presented in Figures 2-14 and 2-15 for an average year (approximately 50th percentile of temperature-flow occurrence) and Figures 2-16 and 2-17 for an extreme year (approximately 90th percentile of temperature-flow occurrence). As evidenced by these figures, an adequate zone of passage exists for resident fish species moving between the portions of Hooksett Pool upstream and downstream of the thermal discharge. During the average year (approximately 50th percentile of temperature-flow occurrence), an adequate zone of passage is evident from the ambient or near ambient water temperatures throughout much of the river cross sections at S-0 and S-4. In an extreme year (approximately 90th percentile of temperature-flow occurrence), temperatures at S-0 and S-4 ranged from approximately 6^{o}C to 10^{o}C above the ambient water temperature.

In sum, evidence for the ability of fish species to move around and past the thermal plume associated with the Merrimack Station discharge is supported by radio-telemetry studies as well as thermal modeling data, both of which indicate that an adequate zone of passage exists for resident and migratory fish under the majority of conditions present in Hooksett Pool.

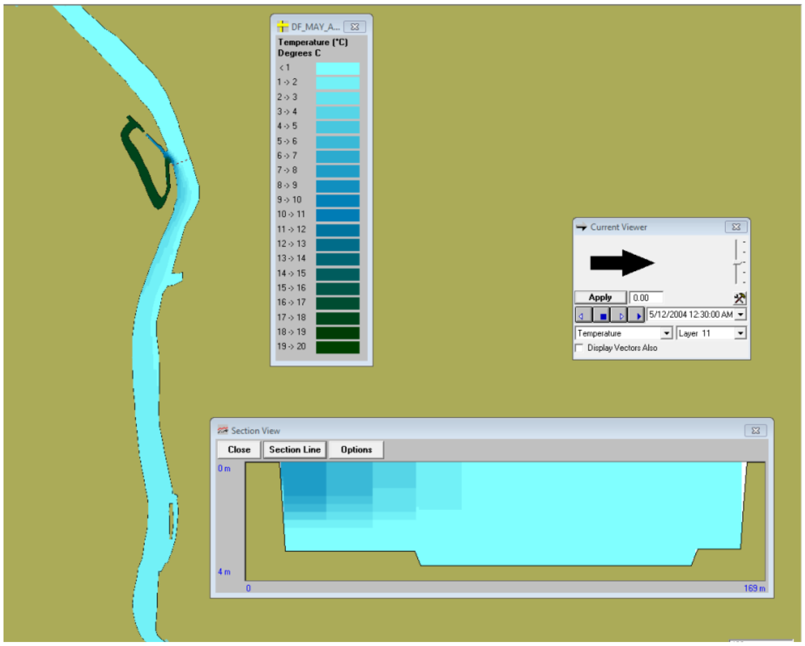

Figure 2-2. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the early spring biological period for an average year: 7-14 May 2004. Surface temperatures and cross section at S0 shown.

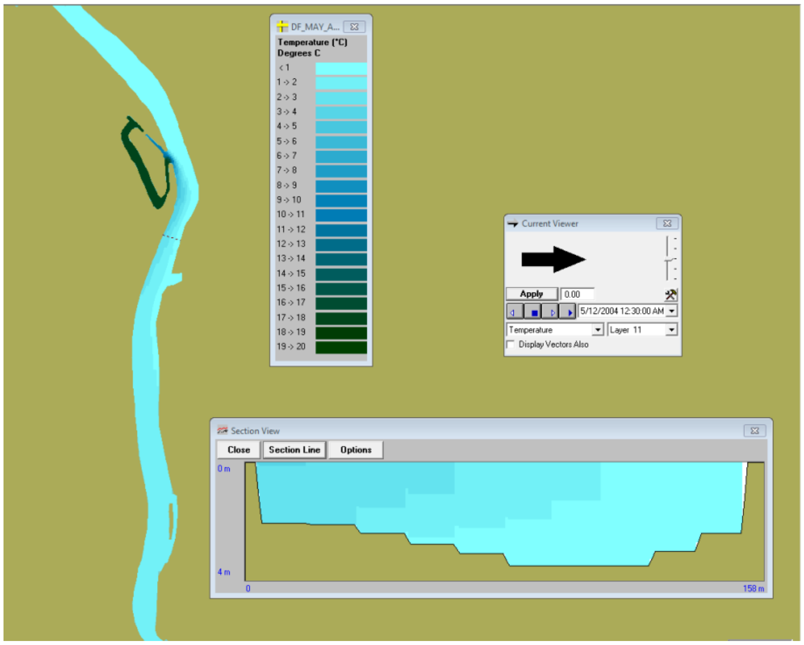

Figure 2-3. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the early spring biological period for an average year: 7-14 May 2004. Surface temperatures and cross section at S4 shown.

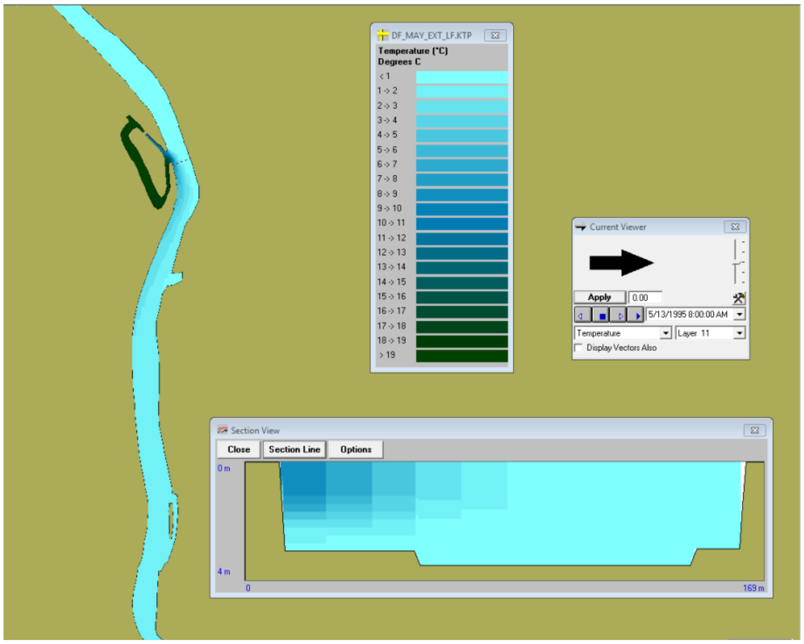

Figure 2-4. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the early spring biological period for an extreme year: 7-14 May 1995. Surface temperatures and cross section at S0 shown.

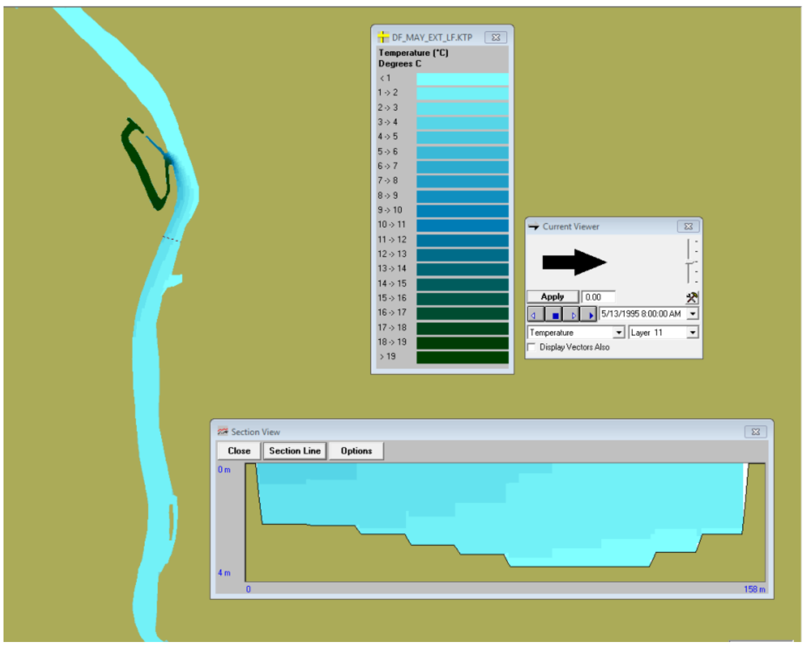

Figure 2-5. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the early spring biological period for an extreme year: 7-14 May 1995. Surface temperatures and cross section at S4 shown.

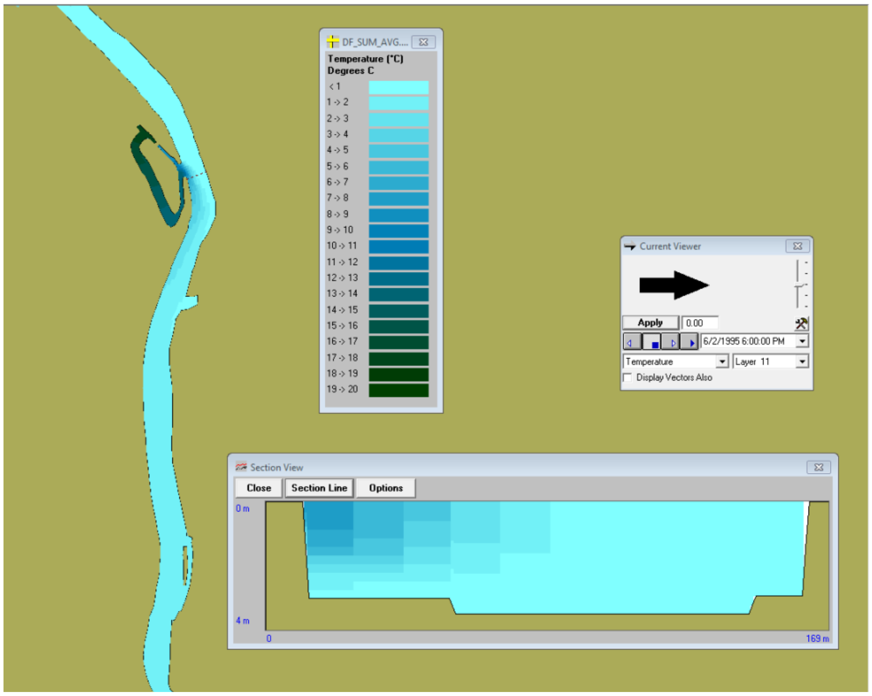

Figure 2-6. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the late spring biological period for an average year: 7-14 June 1995. Surface temperatures and cross section at S0 shown.

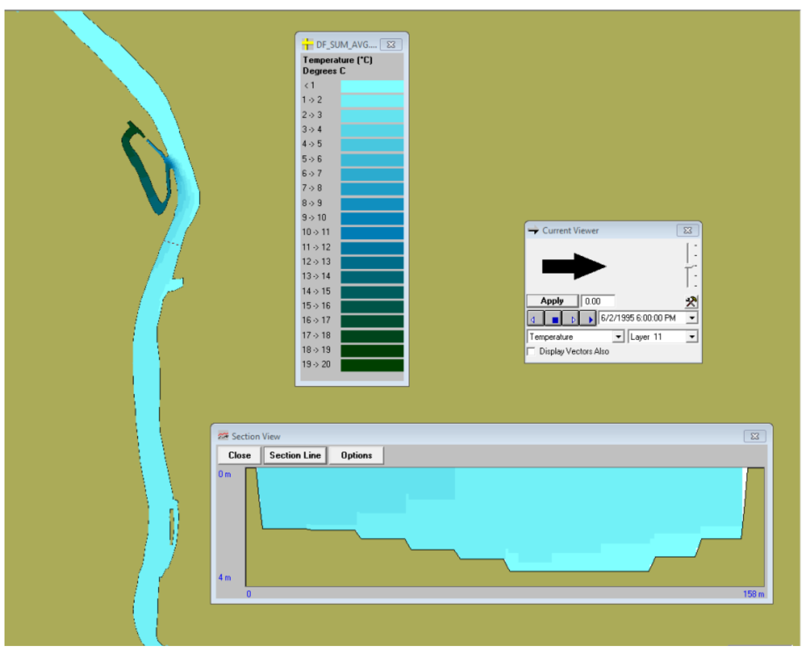

Figure 2-7. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the late spring biological period for an average year: 7-14 June 1995. Surface temperatures and cross section at S4 shown.

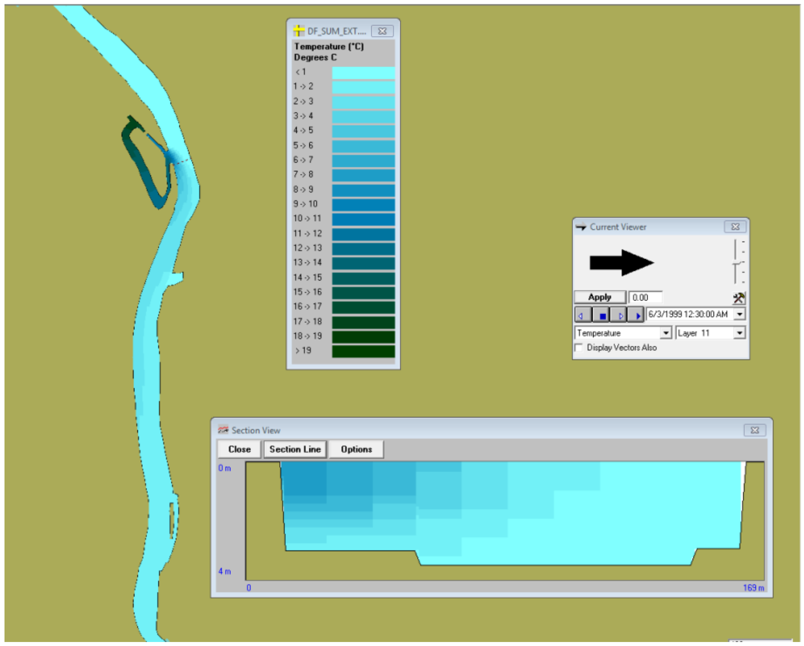

Figure 2-8. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the late spring biological period for an extreme year: 7-14 June 1999. Surface temperatures and cross section at S0 shown.

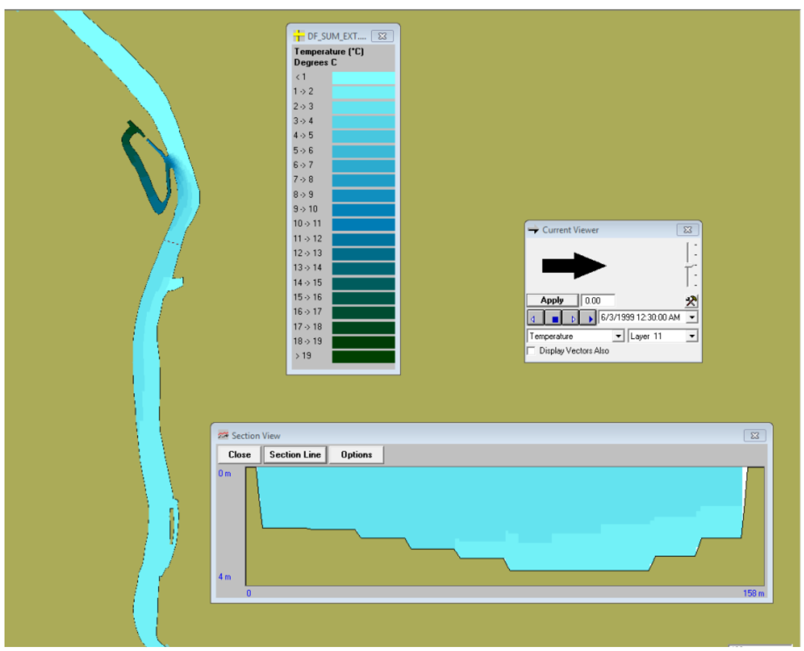

Figure 2-9. Model predicted delta temperature contours at 50th percentile upstream ambient condition during the late spring biological period for an extreme year: 7-14 June 1999. Surface temperatures and cross section at S4 shown.

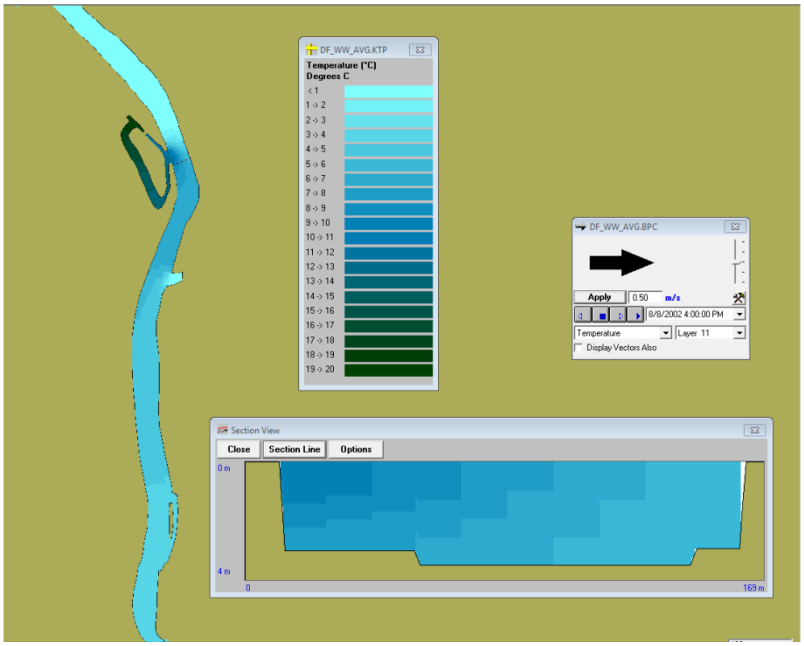

Figure 2-10. Model predicted delta temperature contours at 50th percentile upstream ambient condition during summer biological period for an average year: 13-20 August 2002. Surface temperatures and cross section at S0 shown.

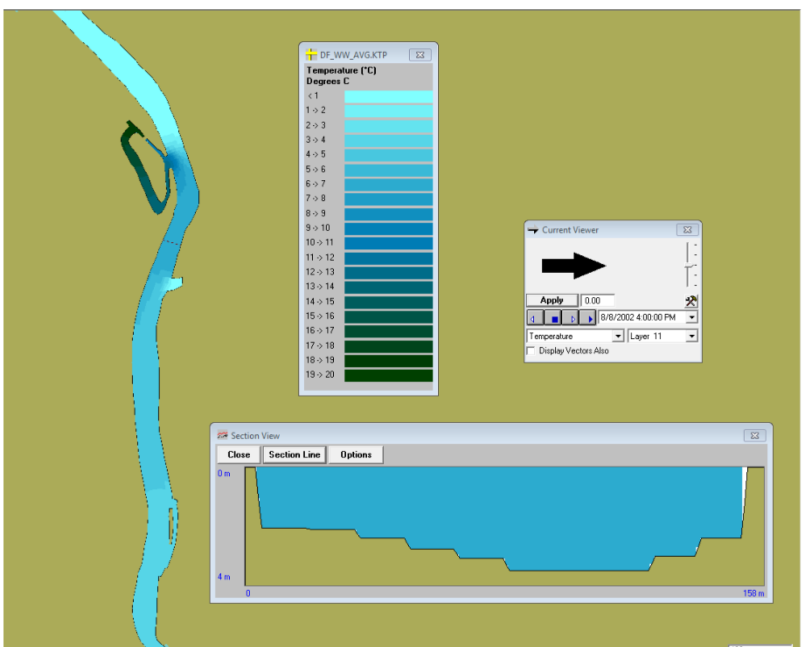

Figure 2-11. Model predicted delta temperature contours at 50th percentile upstream ambient condition during summer biological period for an average year: 13-20 August 2002. Surface temperatures and cross section at S4 shown.

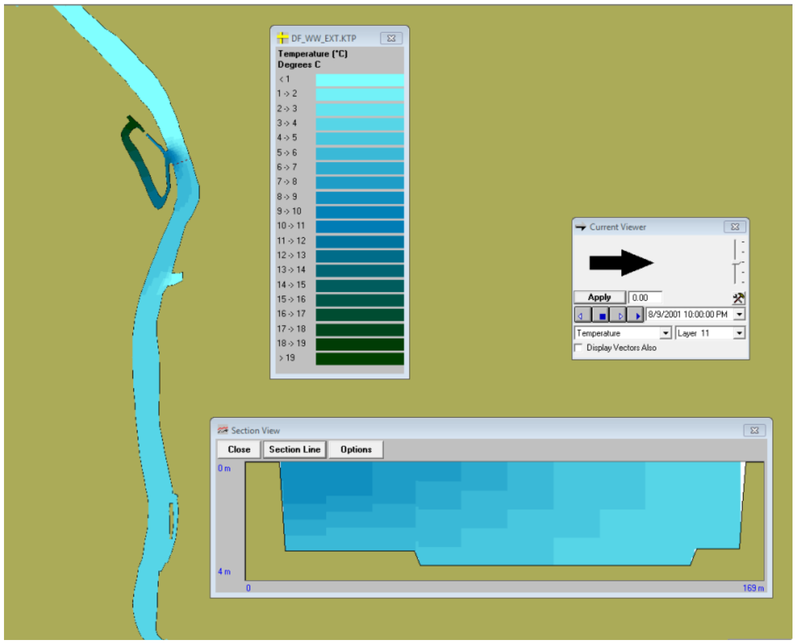

Figure 2-12. Model predicted delta temperature contours at 50th percentile upstream ambient condition during summer period for an extreme year: 13-20 August 2001. Surface temperatures and cross section at S0 shown.

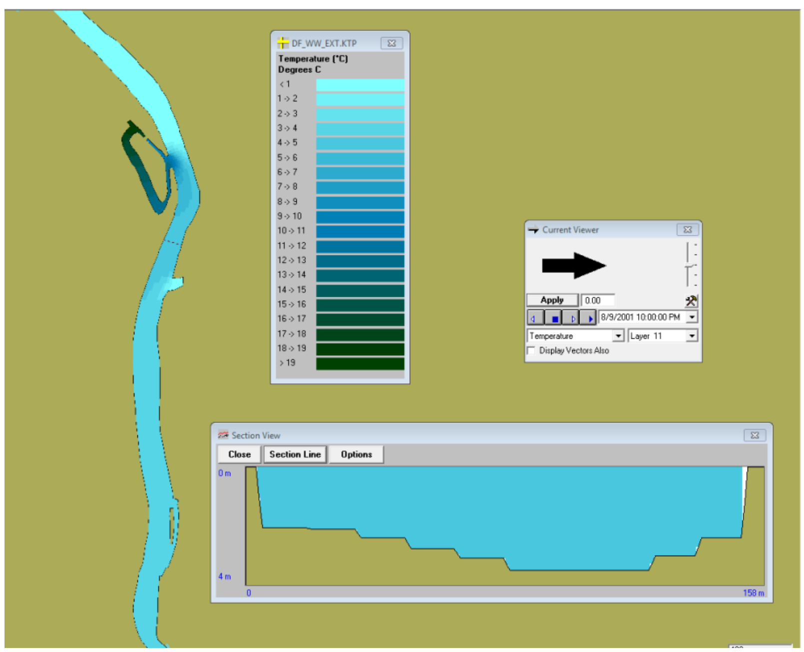

Figure 2-13. Model predicted delta temperature contours at 50th percentile upstream ambient condition during summer biological period for an extreme year: 13-20 August 2001. Surface temperatures and cross section at S4 shown.

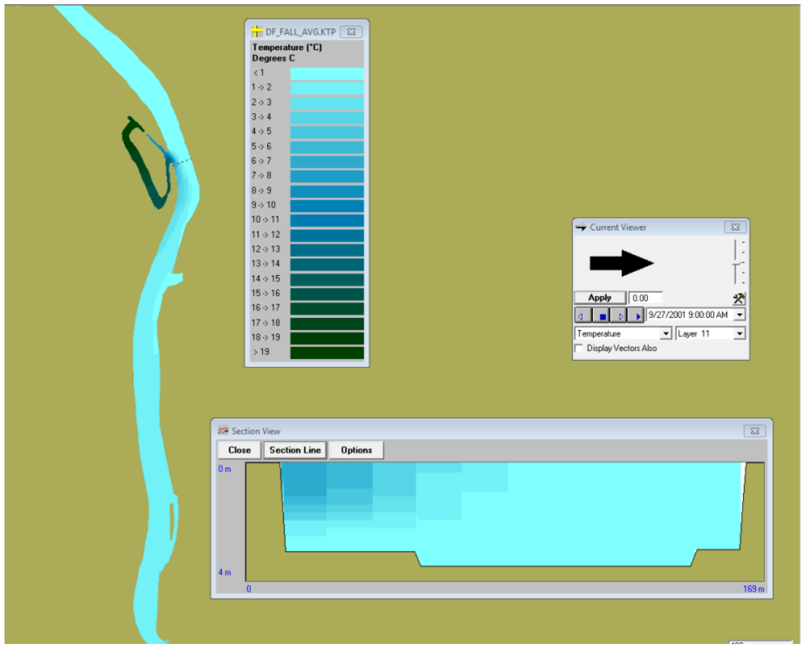

Figure 2-14. Model predicted delta temperature contours at 50th percentile upstream ambient condition during fall biological period for an average year: 24-30 September 2001. Surface temperatures and cross section at S0 shown.

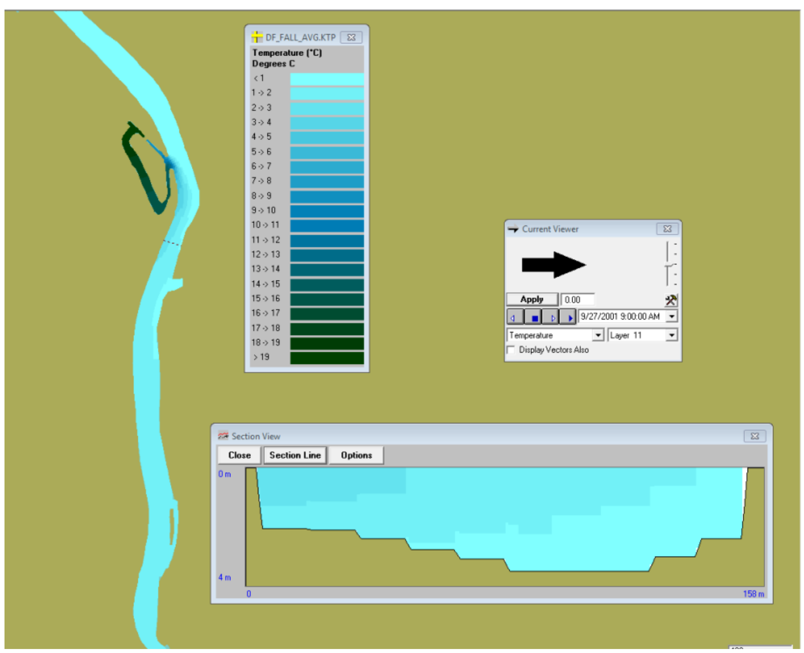

Figure 2-15. Model predicted delta temperature contours at 50th percentile upstream ambient condition during fall biological period for an average year: 24-30 September 2001. Surface temperatures and cross section at S4 shown.

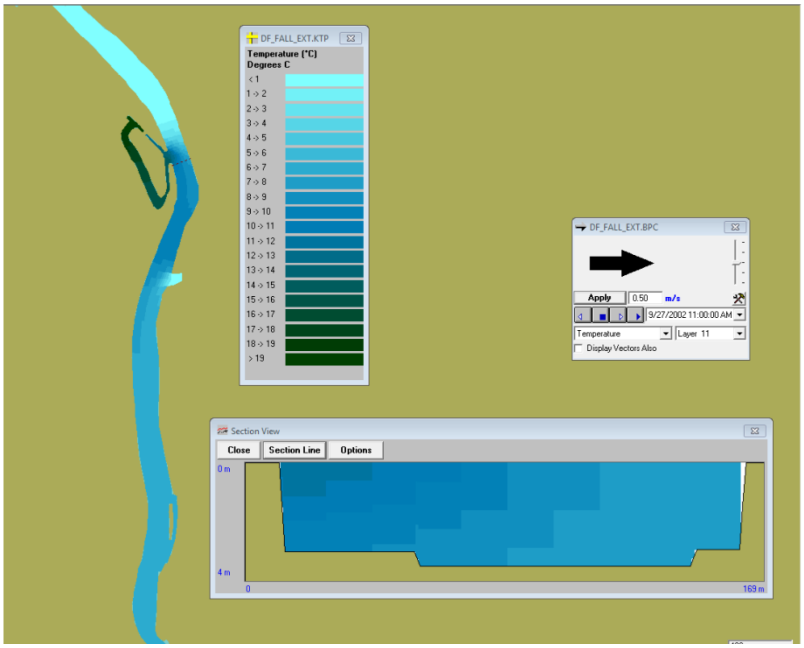

Figure 2-16. Model predicted delta temperature contours at 50th percentile upstream ambient condition during fall biological period for an extreme year: 24-30 September 2002. Surface temperatures and cross section at S0 shown.

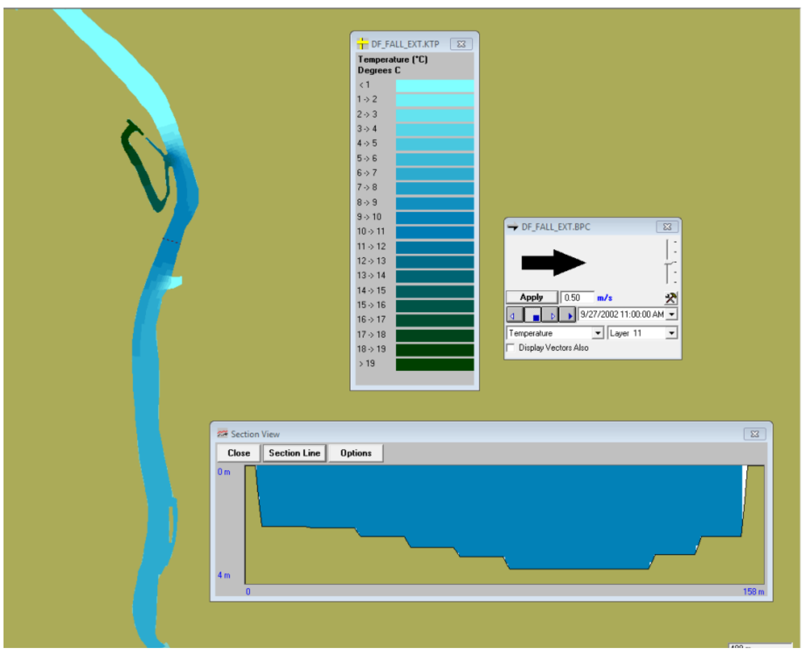

Figure 2-17. Model predicted delta temperature contours at 50th percentile upstream ambient condition during fall biological period for an extreme year: 24-30 September 2002. Surface temperatures and cross section at S4 shown.

2.2.2 No Appreciable Harm to the Hooksett Pool Phytoplankton Community

Lower Hooksett Pool is a segment of the Merrimack River that is considered a low potential impact area for phytoplankton (USEPA 1977), because it is in a portion of the Merrimack River continuum where the annual carbon cycle is typically dominated by heterotrophic activities in a detrital food chain (Hynes 1970). Annual studies of the community composition and standing crop of phytoplankton and periphyton from 1975 through 1978 in the portion of Hooksett Pool upstream and downstream of Merrimack Station confirm the designation of the study area as a low potential impact area for the phytoplankton community (Normandeau 1979a). Over the four-year study period (1975-1978), no endangered or threatened species were found, no shift towards nuisance species was observed in either the upstream or downstream portions of Hooksett Pool, and there were no long-term reductions or increases in autotrophic production of the periphyton or phytoplankton components of the algal community that could be attributed to Merrimack Station's thermal discharge (Normandeau 1979a). Continuation of autotrophic production at low levels insures maintenance of the detrital food chain in Hooksett Pool. Occasional short-term reductions in abundance of primary producers were observed in the thermally influenced portion of lower Hooksett Pool during low flow periods in the autumn of some years (Normandeau 1979a). However, these transient episodes of low productivity resolved quickly due to the short generation time (up to two cell divisions per day) of the diatoms which were dominate in the algal community and replenished rapidly during the fall season.

2.2.3 No Appreciable Harm to the Hooksett Pool Zooplankton and Meroplankton Communities

Lower Hooksett Pool is a segment of the Merrimack River that is considered low potential impact areas for net zooplankton and meroplankton (USEPA 1977), because no endangered or threatened species were found, and no reduction or adverse change was observed in exhaustive annual studies performed from 1975 through 1978 in the portion of Hooksett Pool upstream and downstream of Merrimack Station (Normandeau 1979a). The results of the source water body studies were corroborated by a finding of minimal entrainment mortality of net zooplankton and meroplankton due to passage through the condenser cooling system and cooling canal of Merrimack Station (Normandeau 1979a), indicating that the heated discharge did not alter the standing crop, relative abundance, natural population fluctuations or free drift of these components of the BIP.

2.2.4 No Appreciable Harm to Hooksett Pool Aquatic Vegetation

Aquatic vascular plants (i.e., "macrophytes") are the primary habitat formers in the impounded freshwater riverine ecosystem found in lower Hooksett Pool. This segment of the Merrimack River is considered a low potential impact area (USEPA 1977) for aquatic macrophytes, because no endangered or threatened species were found, and because within-year comparison of similar habitats upstream and downstream from the cooling canal discharge revealed that Merrimack Station's thermal discharge has generally had no adverse effect on the distribution and abundance of aquatic macrophytes in Hooksett Pool (Normandeau 1979a). A total of 14 species of aquatic vascular plants were observed during surveys conducted from 1970 to 1974; these aquatic plants were generally most abundant during August and September of each year (Normandeau 1979a). Merrimack River currents, substrate, water chemistry and depth are all factors influencing the distribution of macrophytes in impounded freshwater riverine ecosystems. Within-year variability among stations sampled from 1970 through 1974 in both the upstream ambient and thermally influenced portions of the study area was lower in magnitude than inter-annual variation at each station, supporting classifying the study area as one of low potential impact for habitat formers.

Trends in the abundance of submerged aquatic vegetation can be linked to changes in nutrient loading associated with impaired water quality in the system prior to the 1972 enactment of the CWA (Normandeau 2011b). Increases in system production due to algal growth have been linked to the addition of sewage to a receiving water (Mackenthun 1965). Semi-quantitative submerged aquatic vegetation data were collected in Hooksett Pool by Normandeau in 2002 and 2010. Looking at presence-absence only, a decline in overall extent of submerged aquatic vegetation in Hooksett Pool is implied between the 1970s data and the 2002 and 2010 data. This apparent decrease in submerged aquatic vegetation is likely attributable to the reduction in nutrients in the Merrimack River. Such improvement has likely resulted in corresponding changes to the river's indigenous aquatic populations.

2.2.5 No Appreciable Harm to Hooksett Pool Shellfish and Macroinvertebrate Communities

Water velocity and substrate conditions were found to determine the distribution, standing crop and species composition of the benthic macroinvertebrate community (including shellfish) observed in exhaustive annual studies performed from 1975 through 1978 in Hooksett Pool both upstream and downstream of Merrimack Station (Normandeau 1979a). Lentic taxa inhabited the slow-flowing or ponded areas of the study area near Hooksett Dam with fine sediments and organic debris in the substrate, while lotic taxa inhabited rapid-flowing and turbulent areas of moderate currents with a cobble or boulder substrate found primarily in the Garvin's Falls Dam tailwaters at the upstream end of Hooksett Pool and in the Hooksett Dam tailwaters at the downstream end. No endangered or threatened species of shellfish or benthic macroinvertebrates were found. The preference for lentic or lotic habitats overrides any influence of Merrimack Station's thermal discharge, because the standing crop and structure of benthic macroinvertebrate communities sampled by Ponar grabs and by artificial multiplates were similar within the same habitat types found both upstream and downstream from the cooling canal discharge (Normandeau 1979a). The relatively high thermal tolerance of organisms found in the benthic macroinvertebrate community and the surface-orientation of the thermal plume were two factors ameliorating any discharge effects, including those on drifting invertebrates sampled by artificial multiplate samplers (Normandeau 1979a).

Kick net and Ponar macroinvertebrate sampling was conducted within Garvins Pool and at Monitoring Station N-10 in Hooksett Pool during late 2011 to validate the use of N-10 as a control site for the assessment of potential impacts to the macroinvertebrate community due to Merrimack Station's thermal discharge. Due to the limited mobility of benthic organisms in Hooksett Pool and the presence of ambient water temperatures at Station N-10, its use as such a control site is appropriate. Among the metrics examined for kick net data, no consistent pattern was detected to suggest that a significant difference in the macroinvertebrate communities within Garvins Pool and Hooksett Pool at Station N-10 exists. In contrast, data collected by Ponar revealed increased richness and diversity within Garvins Pool relative to Hooksett Pool Station N-10. However, kick net sampling provides the best representation of macroinvertebrate species available as a food source to fish residing within shallow water littoral habitats (Flotemersch et al. 2006). Even though the wadeable shore zone only accounts for a small proportion of the entire river channel, it may be the most productive and diverse zone for benthic macroinvertebrates (Wetzel 2001).

Macroinvertebrate sampling was conducted during October 2011 using the same sampling techniques and sampling locations as was performed during 1972. When compared to samples collected during 1972, kick net data collected in 2011 at Monitoring Stations N-10, S-0, S-4 and S-17 showed an increase in EPT richness of 150-300%. Taxa richness increased from 7-10 in 1972 to 21-23 in 2011. The 2011 EPT/chironomid abundance ratio was higher than that recorded during the 1970s, as would be expected from samples collected in a river with improved water quality and habitat tolerable for more pollution sensitive species (Normandeau 2012a). Benthic samples, collected by Ponar grab during 1972, 1973 and 2011 at Monitoring Stations N-10, S-0, S-4 and S-17, also show indications of improved riverine conditions over time, although these are not as dramatic as the shoreline samples, likely due to the sand substrate that is typically inhabited by tolerant organisms even in pristine conditions (Normandeau 2012a). A direct comparison of kick net and Ponar sampling data collected in Garvins Pool and Hooksett Pool downstream of Merrimack Station was not conducted due to concerns over the effect of varied seasonal timing of the sampling.

Degraded habitat conditions that might be caused by continued exposure to Merrimack Station's thermal discharge should result in a consistent pattern of reduced diversity and increased abundance of pollution-tolerant species for the Hooksett Pool macroinvertebrate population located downstream of Merrimack Station over time (1970s to present). That hypothesis is not supported by the data collected during 2011.

2.3 §316(A) SUMMARY

USEPA has erroneously rejected PSNH's request for renewal of Merrimack Station's §316(a) variance because it has selected the compromised fish community that survived in the conventional and toxic pollutant-impaired Hooksett Pool of the 1960s as the Hooksett Pool BIP. If USEPA had taken into consideration and appropriately evaluated *all* of the fisheries, macroinvertebrate and other aquatic sampling data from the 1972-2011 time period, it necessarily would have concluded that the current fish community in Hooksett Pool is the proper BIP for the purpose of considering PSNH's variance renewal request. The current fish community in Hooksett Pool meets USEPA's definition of "balanced indigenous population," because it is a community characterized by (1) diversity at all trophic levels, (2) the capacity to sustain itself through cyclic seasonal changes, (3) the presence of necessary food chain species, and (4) non-domination by pollution-tolerant species (40 C.F.R. §125.71(c)).

2.3.1 Diversity

Support for diversity at all trophic levels is provided in the numerous reports detailing the ecology of Hooksett Pool over the last four decades. Detailed studies of phytoplankton, zooplankton and meroplankton were last conducted during the late 1970s and no reduction or adverse changes were detected that could be attributed to Merrimack Station's thermal discharge (Normandeau 1979b). Submerged aquatic vegetation species that dominated during the 1970s were still the dominant species during a 2003 survey (Normandeau 2011b). Diversity in the number of macroinvertebrate species as sampled by kick net has increased in Hooksett Pool, and additional metrics indicate that the observed increase is due to an increase in pollution-sensitive species, which require improved water quality to survive (Normandeau 2012a).

Similarly, diversity in the fish community has also been observed in Hooksett Pool. During the 1972-2011 time period, species diversity has increased as indicated by taxa richness and Shannon Diversity Index values (Normandeau 2011a). Moreover, when Hooksett Pool fisheries sampling during comparable periods within 2010 and 2011 is compared to sampling in the thermally uninfluenced but otherwise comparable Garvins Pool, taxa richness is similar (22 and 19 fish species, respectively) (Normandeau 2011a).

2.3.2 Sustainability Through Cyclic Seasonal Changes

Support for the ability of the Hooksett Pool BIP to sustain itself through cyclic seasonal changes is provided by the intensive age and growth analyses conducted for multiple species of fish in Hooksett and Garvins Pools during 2008-2011. A similar range of ages for each of the Merrimack Station RIS was detected within Hooksett Pool when compared to fish resident to Garvins Pool (Normandeau 2011a). Pumpkinseed and yellow perch, both species that have decreased in abundance since initial electrofish sampling in 1972, are still represented by a range of age classes within Hooksett Pool. In addition, the age data-dependent catch curve analysis conducted for those two species showed no significant difference in the total instantaneous mortality rates for either species when compared to an appropriate reference BIP (i.e., in Garvins Pool). In addition, evidence of successful spawning for resident fish was supported through the entrainment of eggs and larvae during entrainment studies at the Station (Normandeau 2007b).

2.3.3 Presence of Necessary Food Chain Species

Support for the continued presence of necessary food chain species is provided through an examination of recent macroinvertebrate and fisheries data within Hooksett Pool. Benthic macroinvertebrate data collected from littoral areas of Hooksett Pool, where numerous young of year and juvenile fish reside and forage, showed that total abundance, taxonomic richness, EPT richness, and the abundance of EPT taxa to chironomid taxa were all much higher in 2011 compared to 1972. A review of recent fisheries sampling indicates that forage species such as spottail shiner, fallfish, common shiner and golden shiner are important components of the Hooksett Pool fish community as they were during the 1970s (Normandeau 2011a). Abundance of these forage species are comparable to levels observed during sampling conducted during the same years in Garvins Pool.

2.3.4 Non-Domination by Pollution-Tolerant Fish Species

Support for non-domination by pollution-tolerant fish species is provided by a review of historic and recent fisheries sampling. During recent fisheries sampling, a comparable number of pollution tolerant species were detected in Hooksett Pool (n=6) and Garvins Pool (n=5). It should be noted that of the six pollution tolerant fish species in Hooksett Pool one (Eastern blacknose dace) is represented by a single specimen and another (American eel) is a diadromous species that is currently under consideration for listing as endangered. The contribution of those tolerant fish species was slightly greater to the overall fish community in Hooksett Pool than in Garvins Pool. However, that increased contribution can be attributed to the greater relative abundance of bluegill (a warmwater fish species) and white sucker (a thermally sensitive species) in Hooksett Pool. Trends in the overall contribution of tolerant fish species to the Hooksett Pool fish community over the 1972-2011 time period reveal an inconsistent pattern. The percentage of pollution-tolerant species in Hooksett Pool was highest during 1995 and lowest during 1973. The increased abundance of bluegill in Hooksett Pool during 1995 is the principal factor in the elevated percentage of pollution tolerant species in Hooksett Pool observed during that year. The percentage of pollution tolerant species observed during more recent sampling years (2004, 2010) are comparable to the range of percentages observed during the 1970s.

2.3.5 No Appreciable Harm from Merrimack Station's Thermal Discharge

2.3.5.1 Hooksett Pool Historical Trends Analysis (1972-2011)

Aquatic habitat that has been adversely impacted by a thermal discharge characteristically contains a higher abundance of fish species that are tolerant of warmer water, and a lower abundance of fish species that prefer cooler water. If the Station's thermal discharge had adversely impacted the abundance and distribution of fish in Hooksett Pool over the 1972-2011 time period, the abundance of all resident coolwater species in the pool (as estimated by the standardized electrofish sampling efforts conducted between 1972 and 2011) should have significantly decreased during this time period. However, no such significant decrease in abundance was observed for three out of the five coolwater fish species resident in Hooksett Pool. Specifically, abundance of chain pickerel and yellow perch decreased, but there were no significant trends for fallfish and white sucker, and abundance of the remaining coolwater species, black crappie, increased in Hooksett Pool over the 1972-2011 time period (Normandeau 2011a). None of these findings is consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

Similarly, if Merrimack Station's thermal discharge had adversely impacted the abundance and distribution of fish in Hooksett Pool over the 1972-2011 time period, the abundance of resident warmwater species in the pool (as estimated by the same standardized electrofish sampling efforts) should have significantly increased during this time period. However, no such increase in abundance was observed for any of the warmwater fish species resident in Hooksett Pool during this time period. Specifically, there were no significant trends for seven out of ten warmwater species (bluegill, golden shiner, largemouth bass, rock bass, smallmouth bass, spottail shiner and yellow bullhead), and abundance of the remaining three warmwater species (brown bullhead, pumpkinseed and redbreast sunfish) decreased, suggesting causes unrelated to the Station's thermal discharge (Normandeau 2011a). None of these findings is consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

In addition to investigating trends in abundance of individual species, community attributes were investigated to determine whether Merrimack Station's thermal discharge caused appreciable harm to the BIP in Hooksett Pool over the 1972-2011 time period. Aquatic habitat that has been adversely impacted by a thermal discharge characteristically contains a higher percentage of both generalist feeders and pollution-tolerant individuals. However, abundance of generalist feeders peaked during the 1976 sampling year and was lowest during 2010. Moreover, the percentage of pollution-tolerant species peaked during the 1995 sampling year, and the percentage of pollution-tolerant species in Hooksett Pool during two of the four most recent sampling years (2004 and 2010) were similar to levels observed during the 1970s (Normandeau 2011a). Neither of these findings is consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

A community analysis was conducted by comparing the results of standardized electrofish sampling in Garvins, Hooksett and Amoskeag Pools during the 1972-2011 time period. Five major groups were identified consisting of sample collections primarily from the 1970s (Groups IA and IB), the 2000s (Group IIA), 1995 (Group IIB1) and the 2000s (Group IIB2). As would be expected from these groupings, there were significant differences among each of the decades (1970s, 1995, 2000s), indicating a high degree of temporal variability. Many individual years were also significantly different from each other. If Merrimack Station's thermal discharge had adversely impacted the abundance and distribution of fish in Hooksett Pool over the 1972-2011 time period, there should have been a consistent increase in the abundance of warmwater fish and an accompanying decrease in abundance of coolwater fish in the Hooksett Pool fish community over the 1970-2011 time period. However, the data indicate no such consistent increases and decreases. The groups from the 1970s (Groups IA and IB) were most similar to each other and least similar to the group from 1995 (Group IIB1) and the 2000s (Groups IIA and IIB2). An increase in the abundance of bluegill, a warmwater fish, contributed most to the differences among the 1970s groups and the 1995 group. However, abundance of bluegill decreased between 1995 and the 2000s, and this decrease made the major contribution to the differences between Group IIB1 (1995) and Groups IIA and IIB2 (2000s). The increase in the abundance of bluegill between the 1970s and 1995 was accompanied by a decrease in the abundance of pumpkinseed. The 1970s were distinguished from the 2000s by a general increase in the abundance of spottail shiner, largemouth bass and bluegill, all warmwater fish. However, a decrease in the abundance of pumpkinseed, another warmwater fish, also distinguished the 1970s from the 2000s. Among coolwater fish, an increase in the abundance of fallfish and a decrease in the abundance of yellow perch contributed to the differences between these decades. In sum, a combination of increases and decreases in the abundances of both warmwater and coolwater contributed to the differences in the Hooksett Pool fish community between the 1970s and 1995, and the 1970s and the 2000s. None of these findings is consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

2.3.5.2 Hooksett and Garvins Pool Comparison (2010-2011)

As noted above, aquatic habitat that has been adversely impacted by a thermal discharge characteristically contains a higher abundance of fish species that are tolerant of warmer water, and a lower abundance of fish species that prefer cooler water. However, a comparison of the 2010 and 2011 fish communities in Hooksett Pool and Garvins shows no clear pattern consistent with the hypothesis that Merrimack Station's thermal discharge has caused an increase in the abundance of warmwater species or a decrease in the abundance of coolwater species in the pool (Normandeau 2011a). This finding is not consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

Specifically, in 2010, there were no significant differences in electrofish CPUE between Garvins and Hooksett Pools for 12 out of 22 fish species (Normandeau 2011a). Among the RIS and other resident species belonging to the warmwater guild, Hooksett Pool had higher CPUE for bluegill, redbreast sunfish and smallmouth bass. There were no significant differences in CPUE, or CPUE was higher in Garvins Pool, for the following seven warmwater fish: brown bullhead, golden shiner, largemouth bass, pumpkinseed, rock bass, spottail shiner, and yellow bullhead. For coolwater fish, lower CPUE in Hooksett Pool relative to Garvins Pool could be a reflection of higher water temperatures in Hooksett Pool. However, among the coolwater fish, there were no significant differences in CPUE in 2010 between Garvins and Hooksett Pool for black crappie and fallfish. Furthermore, CPUE of white sucker, a coolwater fish, was significantly higher in Hooksett Pool. While two species among the coolwater fish, yellow perch and chain pickerel, had a significantly lower CPUE in Hooksett Pool during 2010, both of these species make use of habitats with submerged aquatic vegetation (Armbruster 1959; Scarola 1987), which is more common in Garvins Pool than Hooksett Pool.

In 2011, there were no significant differences in CPUE between Garvins and Hooksett Pools for 13 out of 22 species (Normandeau 2011a). Warmwater fish would be expected to be more abundant in

Hooksett Pool if Merrimack Station's thermal discharge were adversely affecting the abundance and distribution of fish. Among the RIS and other resident species belonging to the warmwater guild, in 2011 three species were more abundant in Hooksett Pool: largemouth bass, redbreast sunfish and smallmouth bass. There were no significant differences in CPUE, or CPUE was higher in Garvins Pool, for seven warmwater fish: bluegill, brown bullhead, golden shiner, pumpkinseed, rock bass, spottail shiner and yellow bullhead. If the Station's thermal discharge were adversely affecting fish distribution and abundance, CPUE might be expected to be lower in Hooksett Pool for coolwater species, and this did occur for chain pickerel and yellow perch. However, equally important, CPUE was higher in Hooksett Pool for fallfish and white sucker, both native coolwater species.

Aquatic habitat that has been adversely impacted by a thermal discharge also characteristically contains a higher percentage of both generalist feeders (which can capitalize on a variety of different food sources and often increase dramatically with habitat degradation) and pollution-tolerant individuals. Although the percentage of generalist and tolerant species were higher in Hooksett Pool than Garvins Pool during both 2010 and 2011, these differences were the result of increased relative abundance of both coolwater and warmwater species in Hooksett Pool(Normandeau 2011a). More particularly, while a higher percentage of generalist feeders was observed in Hooksett Pool than in Garvins Pool during both 2010 and 2011, that difference can be attributed to greater relative abundance in Hooksett Pool of a warmwater species (bluegill) during 2010 and a coolwater species (fallfish) during 2011. Similarly, while a higher percentage of tolerant species was observed in Hooksett Pool than in Garvins Pool during both 2010 and 2011, that difference can primarily be attributed to greater relative abundance in Hooksett Pool of a warmwater species (bluegill) and coolwater species (white sucker) during both years. (Eastern silvery minnow, a species intolerant to pollution, was only recorded in Hooksett Pool during 2010.) If Merrimack Station's thermal discharge has adversely impacted the BIP in Hooksett Pool by increasing the percentage of generalist feeders or pollution-tolerant individuals, it would not be expected that coolwater species would have significantly contributed to these increases, as documented. Neither of these findings is consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

In short, while some warmwater species were more abundant in Hooksett Pool in 2010 and 2011, there were no significant differences in abundance between Garvins and Hooksett Pools for others, and some warmwater species were more abundant in Garvins Pool (Normandeau 2011a). Among coolwater species, only the abundance of yellow perch and chain pickerel was higher in Garvins Pool in 2010 and 2011, and, as noted above, this pool contains more of the aquatic vegetated habitat that is preferred by both species. Similarly, although the percentage of generalist and tolerant fish species was higher in Hooksett Pool than in Garvins Pool during 2010 and 2011, this difference stems from the increased relative abundance of both warmwater and coolwater species in Hooksett Pool. If Merrimack Station's thermal discharge had caused appreciable harm to the BIP in Hooksett Pool, it would be expected that the differences observed between Garvins and Hooksett Pools would be directly attributable to only warmwater, generalist and tolerant species. However, it was two coolwater fish species, fallfish and white sucker that contributed to these differences.

A community analysis was conducted by comparing the results of electrofish sampling in Garvins, Hooksett and Amoskeag Pools in August and September of 2010 and 2011. This analysis showed that significant differences existed among the fish communities of each of the three pools, and that there was a clear trend of decreasing similarity among pools moving downriver from Garvins Pool to

Hooksett Pool to Amoskeag Pool (Normandeau 2011a). Differences in community similarity of fish residing in a regulated river have been observed elsewhere for spatially separated segments (Pegg and McClelland 2004; Pegg and Taylor 2007). Five major groups were identified by Bray-Curtis numerical classification. Of these five groups, three – IIA, IIB1 and IIB2 – were the most similar, with dissimilarities ranging from 50.52% to 55.92%. These groups consisted of a combination of samples from Garvins and Hooksett Pools. Group IIA contained 19 samples from Garvins Pool and seven from Hooksett Pool. Group IIB1 contained 22 samples from Hooksett Pool, and Group IIB2 contained 19 samples from Hooksett Pool. Importantly, the samples from Garvins Pool did not form a unique group, but were instead clustered with samples from Hooksett Pool to form Group IIA, indicating that the fish community in Garvins Pool, which is not subject to Merrimack Station's thermal discharge, is not wholly distinct from the fish community in Hooksett Pool. If the Station's thermal discharge has adversely affected the fish community in Hooksett Pool, the differences between these groups could be explained by an increase in the abundance of warmwater species in Hooksett Pool or a decrease in the abundance of coolwater species. However, the two Hooksett Pool groups (IIB1 and IIB2) were distinguished from the majority Garvins Pool group (IIA) by generally lower abundances of fish including both warmwater and coolwater species. This finding is not consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

2.3.5.3 Biocharacteristics Sampling (2008-2011)

Finally, fisheries biocharacteristics data for resident species were collected over a four-year period (2008-2011) from Garvins, Hooksett and Amoskeag Pools of the Merrimack River. USEPA's draft §316(a) guidance identifies five response metrics that may be used to assess whether a thermal discharge has caused appreciable harm to the resident fish community of Hooksett Pool (USEPA 1977). Comparison of biocharacteristics data collected during 2008-2011 within Hooksett Pool and Garvins Pool (the thermally uninfluenced impoundment immediately upstream from Hooksett Pool), allows for assessment of four of those metrics: condition factors (e.g., length and weight), age and growth, reproduction, and disease and parasitism.

With regard to the length-weight relationship in fish, it is well-established that the magnitude of the slope in the regression equation reflects the condition (or robustness) of the fish, with a higher slope indicating a greater weight relative to a constant increase in length (Anderson and Neumann 1996). At the same time, since juvenile fish usually have a lower length-weight slope than older individuals, variation in the length-weight slope can also be the result of changes in the age composition of the samples. Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a decreasing length-weight curve – signifying progressively lower weight for a given length – for a resident fish species over time or in comparison to the same species residing in thermally uninfluenced habitat. Such a decreasing curve indicates a reduction in quality of body condition due to the thermal impact. Here, the observations of similar or increased growth among coolwater species residing in Hooksett Pool compared to the same species residing in thermally uninfluenced Garvins Pool are not consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

Adequate length-weight data was available to compare within-year condition for four coolwater species in Garvins and Hooksett Pools (Normandeau 2011a). Of the seven possible comparisons, there were no significant differences observed in weight growth relative to a constant increase in length in three cases (2011 chain pickerel, 2009 white sucker, 2009 yellow perch). In three instances

(2011 fallfish, 2011 white sucker, 2008 yellow perch), the length-weight curves showed coolwater species in Hooksett Pool grew significantly more rotund (or "fatter") with increasing length than in Garvins Pool. Only yellow perch during 2011 grew significantly more rotund with increasing length in Garvins Pool than was observed in Hooksett Pool.

In addition, adequate length-weight data was available to compare within-year condition for six warmwater species in Garvins and Hooksett Pools (Normandeau 2011a). In ten of the eleven comparisons, the length-weight curves showed warmwater species in Hooksett Pool grew either equal to or significantly more rotund with increasing length than in Garvins Pool. The observations of similar or increased growth of coolwater species residing in Hooksett Pool relative to thermally uninfluenced Garvins Pool are not consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

Similarly, where aquatic habitat has been adversely impacted by a thermal discharge, sampling data tend to show lower mean length at age for a resident fish species compared to the same species in a thermally uninfluenced area, due to a reduction in growth rates associated with thermal stress. Adequate age data for the comparison of mean length at age for individual cohorts between Garvins and Hooksett Pools was collected for two coolwater species during 2009 and four warmwater species during 2010 (Normandeau 2011a). Mean length at age was significantly greater in Garvins Pool for two of the three cohorts of the coolwater white sucker (age-2 and age-3) and three of the four cohorts of the coolwater yellow perch (age-1, age-2, and age-3) collected during 2009. The remaining two cohorts (white sucker, age-4; yellow perch, age-0) did not show a significant difference in mean length at age between Garvins and Hooksett Pools. Mean length at age for four of the six cohorts of warmwater species examined during 2010 did not differ between Garvins and Hooksett Pool. The remaining two cohorts (largemouth bass, age-0; pumpkinseed, age-1) exhibited a significantly higher mean length at age for individuals collected in Hooksett Pool.

The observation of reduced mean length at age for these two coolwater fish species in Hooksett Pool suggests that growth (as estimated by mean length at age) may be reduced in Hooksett Pool for some age classes relative to that in Garvins Pool. The inverse relationship between density and growth of fish has been well-studied and has been documented in other systems for both white sucker and yellow perch (Chen and Harvey 1995, Irwin et al. 2009). Here, abundance of white sucker was greater in Hooksett Pool than Garvins Pool, suggesting that the causes for such lower mean length at age are unrelated to the Station's thermal discharge. Observations for white sucker are not consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in the Merrimack River.

In addition to mean length at age, total instantaneous mortality rates (Z) were compared for fish species common to Garvins and Hooksett Pools (Normandeau 2011a). Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a greater total mortality (Z) for a resident fish species compared to the same species in a thermally uninfluenced area, due to increased stress associated with thermal impacts. Mortality rates were calculated for seven fish species (four warmwater and three coolwater) with adequate sample sizes and common to both Garvins and Hooksett Pools. No significant differences in Z were detected for two of the three coolwater fish species (white sucker and yellow perch) as well as three of the four warmwater fish species (bluegill, largemouth bass and pumpkinseed).

Mortality estimates for both fallfish (a coolwater species) and smallmouth bass (a warmwater species) were significantly higher in Hooksett Pool than in Garvins Pool (Normandeau 2011a). However, elevated mortality estimates observed for smallmouth bass in Hooksett Pool may be impacted by heavy recreational fishing pressure (total instantaneous mortality (Z) represents the sum of natural mortality (M) and fishing mortality (F)). Unfortunately, creel data from the Hooksett Pool bass fishery is not available to estimate the fishing mortality component of Z for smallmouth bass. Overall, the mortality levels observed in Hooksett Pool are less than or equal to those observed in Garvins Pool for five of the seven species examined, including yellow perch and pumpkinseed, two fish species that have decreased in abundance in Hooksett Pool between 1972 and 2011. These observations are not consistent with the hypothesis that the operation of Merrimack Station has caused appreciable harm to the balanced indigenous population in the Merrimack River.

Assessment of the impacts to reproduction were limited to two coolwater fish species (yellow perch and white sucker) collected during spring of 2008 and 2009 (Normandeau 2011a). Due to the sampling design, which targeted the collection of spawning perch and sucker for assessment of fecundity, it is likely that the significant differences observed in the sex ratios within species and among pools were biased. Yellow perch in particular often form large spawning aggregations of one to several females with larger numbers of male individuals. As a result, collections made during that time of the year may not be ideal for assessing sex ratios.

Resident fish species in aquatic habitat that has been adversely impacted by a thermal discharge characteristically manifest more frequent infestation of internal and external compared to the same species resident in a thermally uninfluenced area, indicating a reduction in the overall health and conditions of the fish (USEPA 1977). The prevalence of external parasites was assessed for thirteen fish species (five coolwater species and eight warmwater species) common to both Hooksett and Garvins Pools over the 2008-2011 time period (Normandeau 2011a). Of the five coolwater fish species, the prevalence of external parasites was greater for three species in Hooksett Pool (black crappie, fallfish and white sucker) and a single species in Garvins Pool (chain pickerel). There was no significant difference in the prevalence of external parasites on yellow perch collected within Hooksett and Garvins Pools. Prevalence of external parasites among warmwater fish species was greater for common shiner, rock bass and spottail shiner in Hooksett Pool, and for bluegill, pumpkinseed and smallmouth bass in Garvins Pool. There were no significant difference in the prevalence of external parasites on largemouth bass or redbreast sunfish collected within Hooksett and Garvins Pools. The prevalence of internal parasites was assessed for two coolwater species collected during 2008-2009. Presence of internal parasites in white sucker did not differ between Hooksett and thermally uninfluenced Garvins Pool whereas internal parasites were present in a greater percentage of yellow perch collected in Garvins Pool.

In general, the prevalence of internal and external parasites associated with resident fish species common to both Garvins and Hooksett Pools has been variable. There is no consistent evidence of warm or coolwater fish species residing in Hooksett Pool being subjected to increased parasitism. Parasitism levels are less than or equal to those observed in Garvins Pool for seven of the thirteen species examined for external parasites and both species examined for internal parasites. These observations are not consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

In sum, fisheries surveys in the Merrimack River in the vicinity of Merrimack Station over the course of about 40 years have highlighted the variability in the fish community. When compared to an appropriate BIP such as that found in Garvins Pool, abundance of some coolwater species is greater in Hooksett Pool and for some warmwater species is greater in Garvins Pool. These findings do not support the hypothesis that Merrimack Station's discharge has caused appreciable harm to Hooksett Pool. Similarly, the time series of available and comparable boat electrofish data for the 1972-2011 time period shows an increase in some coolwater fish species and a decrease in some warmwater species. Similar to the comparison with Garvins Pool, the inconsistent nature of the changes in abundance of warm and coolwater fish species do not support the hypothesis that the Station's thermal discharge has caused appreciable harm to Hooksett Pool. The overall health and condition of fish in Hooksett Pool is comparable to that found in Garvins Pool. Although differences do exist, the inconsistent pattern of findings does not support the hypothesis that Merrimack Station has caused appreciable harm to Hooksett Pool. When both community richness and evenness are considered, diversity of the fish assemblage is greater at the present time than was found historically in Hooksett Pool.

3.0 DETAILED COMMENTS ON USEPA'S DRAFT §316(A) DETERMINATION

This section provides detailed comments related to USEPA's §316 Determination as USEPA has presented and explained it in Sections 5, 6 and 8 of the §316 Determination Document. These comments highlight the flaws and incorrect assumptions in USEPA's analysis contained in the §316 Determination Document.

3.1 Detailed Comments on Section 5 of the §316 Determination Document

Page 31, Section 5.3: USEPA states:

> *Absent any earlier studies for Hooksett Pool, EPA considers the resident biotic community identified during sampling conducted from 1967 to 1969 to best represent the balanced, indigenous community for this assessment (Table 5-1).*

While it is true that the fisheries data collected by NHFGD during 1967, 1968 and 1969 (Wightman 1971) is the earliest data available for the fish community of Hooksett Pool, USEPA fails to provide the reader with any indication as to the impaired nature of the water quality of Hooksett Pool during that period due to uncontrolled releases of raw sewage and other phosphates. High levels of nutrients within aquatic systems can lead to eutrophication and an increase in system vegetation. In turn, increased weed beds provide extensive cover and food sources for some littoral zone fish species such as pumpkinseed. A detailed summary of the severe impairment of Hooksett Pool water quality during this time period is provided in the 2011 Normandeau report *Historic Water Quality and Selected Biological Conditions of the Upper Merrimack River, New Hampshire* (Normandeau 2011b). High levels of nutrient input within aquatic systems can lead to eutrophication, characterized by algal blooms, oxygen depletion, loss of water clarity and fish kills (Whittier et al. 2002).

In addition, the balanced indigenous community for Hooksett Pool presented in Table 5-1 of USEPA §316 Determination Document and taken from Wightman (1971) is not specific to just Hooksett Pool but summarizes fish species encountered during the 1967-1969 population studies on the Merrimack River (Hooksett Pool and Amoskeag Pool) and its tributaries (Bow Bog Brook and Soucook River). Of the twenty species listed in Table 5-1, only sixteen were actually documented by sampling (fyke net, gill net or electrofish) within Hooksett Pool. During the 1967-1969 sampling period, blacknose and longnose dace and landlocked Atlantic salmon (a single juvenile individual) were only documented within the Soucook River, and burbot were only documented within Amoskeag Pool. As a result, the total number of taxa observed in Hooksett Pool within NHFGD fyke net, electrofish and gill net catches during the period 1967-1969 was 16 species.

The presence of redfin shiner (*Notropis umbratilis*) on that list is puzzling. Scarola (1987), a NHFGD publication, does not list *N. umbratilis* as occurring in New Hampshire state waters. Scott and Crossman (1973) suggests that the distribution of *N. umbratilis* ranges from the southern portion of the Great Lakes watershed and south in the Mississippi River system, from New York and Pennsylvania west to southern Minnesota, south to Louisiana and Texas. Scarola (1987) considers redfin shiner to be another common name for the common shiner (*Notropis cornutus*). The common shiner (*N. cornutus*) has been identified in Hooksett Pool electrofish catches during the 1970s through the most recent sampling in 2011.

Normandeau questions the classification of brown bullhead as a "cool water" fish species. A review of Eaton and Scheller (1996), which USEPA cites as its rationale for considering brown bullhead as coolwater fish, suggests that in addition to brown bullhead, pumpkinseed, smallmouth bass and common shiner should all also be considered as coolwater fishes. The peer-reviewed scientific literature on thermal tolerance indicates that all four of these fish species (brown bullhead, pumpkinseed, smallmouth bass and common shiner) should be classified as warmwater fish species.

Page 33, Section 5.3.1: USEPA states:

> *Anadromous species that commonly inhabit Hooksett Pool during part of their life cycle are Atlantic salmon, American shad, and alewife. Blueback herring and sea lamprey may occasionally be present, as well. Only one catadromous species, American eel, is at times present in the pool.*

In August and September of all years during which electrofishing data was collected in Hooksett Pool using consistent and well-documented procedures (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010 and 2011) (these months and years of standardized, documented sampling are hereinafter referred to collectively as the "1972-2011 time period," for ease of reference) (Normandeau 2007a, 2011a), juvenile alewife were only recorded during 2004 and 2010 and juvenile shad only during 2010. There are no records of blueback herring or sea lamprey from Hooksett Pool during the 1967-1969 or the 1972-2011 time period. However, contrary to USEPA's assertion, American eel have been recorded during fish sampling in Hooksett Pool during all sampling years between 1967 and 2011.

Page 34, Section 5.3.1: USEPA states:

> *As a result, only juvenile Atlantic salmon, American shad, and alewife, which are regularly stocked upstream of Hooksett Pool, spend time in the pool during their downstream migration to the sea.*

Normandeau disagrees with this statement. In addition to juvenile Atlantic salmon, which have been shown to migrate readily past Merrimack Station's thermal discharge (Normandeau 2006a), adult Atlantic salmon have been captured in Hooksett Pool and are able to move past the thermal discharge without suffering mortality. Following their time in the hatchery system, adult broodstock Atlantic salmon are regularly stocked by NHFGD in portions of the Merrimack River upstream of the Garvins Falls Dam for recreational anglers, and many move downstream following stocking. Normandeau and the fisheries agencies (USFWS and NHFGD) set up an electrofishing array in the downstream fish bypass chute of the Garvins Falls Dam every spring for several years during the 1990s to stun and pass downstream (into Hooksett Pool) numerous adult salmon, because the adult salmon would position themselves in the bypass entrance and eat the young salmon smolts migrating downstream. Similarly, during a 2000 radio-telemetry study of the fish bypass system at Garvins Falls, an electrofish unit was run in the forebay canal to remove broodstock and prevent them from eating the radio-tagged salmon smolts (Normandeau 2001). Page 6 of Normandeau (2001) states "During the 2000 study, an electro-shocker was run before the radio-tagged smolts were released. The Project's canal had 200-300 Atlantic broodstock in it." In addition, underwater video showing 95 adult broodstock Atlantic salmon going upstream and downstream in the Amoskeag fishway between May 19 through June 18, 2003, as well as large numbers of adult broodstock Atlantic salmon in the ladder from 1 June through 2 July, 2002, indicate that these individuals were able to pass downstream by Merrimack Station without suffering mortality (Normandeau 2003a; Normandeau 2003b). It has been previously been documented that some of the adult salmon drop all the way downstream past the Lawrence Dam (50 mi downstream) and then come back upstream. Massachusetts biologists operating the fish lift in Lawrence during the 1990s would trap these broodstock adult salmon thinking they were wild fish coming in from the ocean, and then have to release the fish when they noticed the belly tags. Normandeau captured two of these broodstock in the Hooksett Pool canal, one during the early winter of 2004 and the second during the early winter of 2005, demonstrating that they can live and do in Hooksett Pool (Normandeau 2007a).

Evidence suggests that American shad stocked in the system use of Hooksett Pool for more than just a migratory corridor. NHFGD stocked 1,861 adult shad in Hooksett Pool during 2002, and these fish successfully spawned. Normandeau captured 750 juvenile shad for use during a fall 2002 downstream bypass study from a pool below Amoskeag Dam, documenting successful spawning by the stocked adult shad. This event was witnessed by both a senior USFWS employee and an NHDES employee who were present on-site with Normandeau. USEPA does acknowledge the successfully spawned juvenile shad in the §316 Determination Document (Page 91, Section 5.6.3.3b) but suggests that if spawning did occur in Hooksett Pool, either "the drifting surface-oriented shad larvae may have passed over Hooksett Dam and developed into juveniles in Amoskeag Pool," or "larvae that developed into juveniles in Hooksett Pool could have dropped down into Amoskeag Pool if conditions in Hooksett Pool were unsuitable, and remained there until emigrating in the fall."

However, USEPA also states in the §316 Determination Document that adult shad drop downstream immediately following spawning (Page 90, Section 5.6.3.3b), which occurs during late May/early June. Normandeau captured a group of adult shad on video in the Amoskeag fish ladder moving downstream on July 18, 2002 (Normandeau 2003a). This late departure date suggests that these fish were further upstream than Amoskeag Pool or they would have been observed much sooner than late July.

In addition, Normandeau's 1979 report *Merrimack River Anadromous Fish Investigation* (Normandeau 1979c) details the stocking of 624 adult American shad within Hooksett Pool following their capture and successful trucking from the Connecticut River in 1978. Notably, USEPA did not cite this report once in its analysis of shad in Hooksett Pool. The report documented that stocked shad did spawn in Hooksett Pool as indicated by eggs captured throughout June in drift net collections. The majority of eggs were collected at Stations 0-E (discharge canal) and S-8-E, and based on high capture rates at those locations combined with a paucity of eggs collected upstream, it was determined that the majority of spawning occurred between N-1 and S-8. That area can be characterized as the deeper region south of the discharge canal as well as the shallow water just north of the discharge. The report also documented that the capture of juvenile shad began in Hooksett Pool on July 25, and that juvenile shad catches continued into the fall (Normandeau 1979c, Table 6). A total of 313 juvenile shad were captured seining and out of these, all but 13 were captured between Stations 0-W and S-4-E, in the thermal plume. Even with Unit 2 offline, the water temperatures during the capture of shad juveniles ranged from 23.9 C to 28.2 C during July and August.

Page 41, Section 5.6.2: USEPA presents its interpretation of Normandeau's population trend analysis of RIS abundance in Hooksett Pool during the 1967-2005 time period, as that analysis was originally presented in the 2007 Normandeau report *Merrimack Station Fisheries Survey Analysis of 1967 through 2005 Catch and Habitat Data* (Normandeau 2007a) (the "2007 Fisheries Survey Analysis Report"), in the §316 Determination Document. Use of fisheries catch data collected during the 1960s, 1970s 1995 and 2000s has been misunderstood and misused by USEPA throughout this section of the §316 Determination Document.

Page 41, Section 5.6.2: USEPA states:

> *There are inherent biases or inefficiencies associated with any form of fish sampling which is why multiple methods are often used to develop a comprehensive understanding of the status of multiple fish populations. Electrofishing is typically conducted during daylight hours, and therefore misses fish that may visit sampling areas after dark. Trapnet (also known as fyke net) sampling, on the other hand, utilizes static gear that captures fish moving through the sampling area over the course of one or more days. Trapnets typically capture larger (and older) fish that reside and actively move in deeper water, although trap mesh size may affect sampling effectiveness for certain sizes of fish. As noted in the annual summary of monitoring at Merrimack Station for 1975, "Fyke netting was employed to illustrate the distribution of larger fishes within Hooksett Pond in relation to the Merrimack Station thermal discharge." (Normandeau 1976a). In the 1975 Merrimack River Monitoring Program report, Merrimack Station refers to fyke-netting as "the most quantifiable sampling technique employed in the Merrimack River Program" (Normandeau 1976a). EPA carefully considered the effectiveness of both sampling types in its assessment of the Hooksett Pool fish community.*

Normandeau also considered both gear types (boat electrofish and trap net) in its assessment of the Hooksett Pool fish community over time. Normandeau agrees that trap nets are effective at capturing certain selected fish species. However, passive gears, such as trap nets, can be most effective for specific species, guilds or size classes of fish and, as a result, may only effectively sample a segment of the fish community. The American Fisheries Society states in its book "Standard Methods for Sampling North American Freshwater Fishes" that the use of trap nets is more appropriate for standing waters such as lakes and ponds (Bonar et al. 2009). Effectiveness of trap nets at steep-sided locations is limited. In addition, deployment of trap nets in a riverine system such as Hooksett Pool can be problematic due to varying river flows and debris loading interfering with the ability of the gear to properly sample resident fish. Observations by the experienced field crews conducting fisheries sampling in Hooksett Pool provide support for the high susceptibility of trap nets fished in

Hooksett Pool to impacts from river currents. Twists in the lead and/or net wings lead to severe impairment of the gear to properly sample fish.

USEPA's technical framework document for the development and implementation of large river bioassessment programs, "Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers," identifies electrofishing as the most comprehensive and effective single method for the collection of fish from streams and rivers (Flotemersch et al. 2006). Boat electrofishing is one of several active sampling methods that are recommended for sampling warmwater fish in rivers (Bonar et al. 2009). Flotemersch et al. (2006) details a large river bioassessment protocol (LR-BP) for assessment of fish assemblage metrics. The LR-BP protocol states "at sites with a mean thalweg depth <4 m, a daytime main-channel border design that includes electrofishing 1000 m along a single bank or 500 m on paired banks was sufficient to characterize sites for bioassessment purposes. The thalweg is defined as the deepest portion of the river channel and is almost always the line of fastest flow in the river. At sites with a mean thalweg depth > 4 m, results were more variable. Therefore, at such sites, the LR-BP protocol suggests that a switch from daytime to nighttime electrofishing be considered". If night electrofishing is not conducted, the LR-BP protocol suggests sampling 1000 m along paired banks. The 1967-2005 Hooksett Pool trends analysis relied on daytime electrofish sampling from paired bank transects at locations with a mean thalweg depth of >4m. This LR-BP is designed to collect samples that are as unbiased and as representative as possible and are indicative of the ecological condition of a site when compared to sites of known condition (Flotemersch et al. 2006).

Page 42, Section 5.6.2: USEPA states:

> *However, aggregations of juvenile fish alone are not good indicators of the fishery's status since many juveniles will not survive long enough to reach maturity and spawn. Therefore, combining the adult, breeding population with juveniles without adjusting for age differences tends to <u>overestimate the population</u>. Unfortunately, this appears to be the case for all of the trends analyses conducted by Merrimack Station.*

It is unclear what USEPA is attempting to say here. There were no estimates of population size provided as part of the 1967-2005 Hooksett Pool trends analysis (Normandeau 2007a). The trends analysis focused on comparing the catch of a particular species within a standardized unit of sampling effort (Catch Per Unit of Effort ("CPUE")) over time. The calculation of CPUE for a particular fish species in Hooksett Pool does not provide an estimate of the fish population (i.e., the number of individuals of a particular fish species within Hooksett Pool), but instead, with repeatable methods each year, provides a relative measure of abundance. The 1967-2005 trends analysis made use of available data from the 1960s, 1970s, 1995 and 2000s. Due to limited information regarding lengths and weights of individual fish sampled during the earlier years in the data set, trends in the relative abundance of fish species relied on total catches of juvenile and adult fish because that was the best data available. Population estimates require mark-recapture data and would be required to make any inferences regarding the total numbers of individuals for any fish species residing in Hooksett Pool.

Page 42, Section 5.6.2.1: USEPA states:

> *It is reasonable to assume that each resident fish species in Hooksett Pool is comprised of a single population. Most fish are highly mobile and can move freely within the relatively*

> *slow moving waters of Hooksett Pool, so in EPA's view, significant declines observed throughout the entire pool (i.e., above and below the thermal discharge) are indicative of a population-level effect.*

Normandeau agrees with USEPA's statement that the resident fish in Hooksett Pool comprise a single population due to their high mobility and the lack of barriers preventing individuals from moving around the entire Hooksett Pool. All of Normandeau's analyses of the fish communities in Garvins, Hooksett and Amoskeag Pools based on 2008-2011 (i.e., data collected since USEPA received the 2007 Fisheries Survey Analysis Report (Normandeau 2007a)) present data from sampling points throughout the entire pool (Normandeau 2011a).

Given that USEPA is assuming that the resident fish species in Hooksett Pool comprise a single population, it is unclear why the Agency then proceeds to undertake and present the results of its own analysis of fish captured in the ambient and thermally-influenced zones of Hooksett Pool (see Section 5.6.2 of the §316 Determination Document), rather than examining the pool as a whole.

Page 42, Section 5.6.2.1: USEPA makes reference to "Helsel and Hirsch 1992" but fails to provide an appropriate citation in Section 14.0 (Scientific and Technical References) of the §316 Determination Document so that the reader may identify, obtain and review the referenced document.

Page 43, Section 5.6.2.1.1a: USEPA reviewed the trends analysis (Normandeau 2007a) presented for electrofishing data collected in Hooksett Pool during the 1967-2005 time period, and criticizes Normandeau's methodology on the ground that data collected during the 1960s were not included. As described in detail in the 2007 Fisheries Survey Analysis Report (Normandeau 2007a), the trends analysis was conducted using a standardized design that included electrofish sampling at fixed length transects during the same months of the year. As a result of this approach, not all years of available data were appropriate for use. USEPA states:

> *Merrimack Station released a report in 1970, however, that provides the information necessary to use these data in a trends analysis. According to this report, electrofish sampling was conducted in 500-foot intervals from Station 0 to S-24 and 0 to N-6, and 1,000-foot intervals from N-6 to N-10 (Normandeau 1970). Merrimack Station's consultant, Normandeau Associates, Inc., used a sampling distance of 1,000 feet in establishing CPUE (i.e., the number of fish caught per 1,000 feet sampled). Since this report lists the number of each species caught within the areas north and south of the discharge, as well as the total distance sampled in those areas, a CPUE can be computed using these data.*

USEPA's assumption that it can calculate valid comparable CPUE values for fish catches during the 1960s is incorrect and violates the basic definition of a standardized design for assessing relative abundance trends in a fish population. To determine if observed trends in fish abundance are directly attributable to Merrimack Station, it is necessary to maintain consistency among all other potential variables (sampling location, sampling gear, seasonality, etc.). Table 3-1 in the 2007 Fisheries Survey Analysis Report (Normandeau 2007a) provided USEPA with the standardized design used in the 1967-2005 Hooksett Pool trends analysis. Monthly occurrence of electrofish sampling, location of electrofish sampling and unit of effort were summarized for each year of sampling. The trends analysis was conducted using the set of years offering consistent monthly sampling (August and September), sample locations (N9-N10 E/W, N6-N7 E/W, S0-S1 E/W, S4-S5 E/W, and S-17-S18

E/W, standard effort (1,000 ft transects) and the same gear (boat electrofish). The combination of sample months and location that provided the largest number of years and months sampled was selected.

Although the data reported from the 1960s did indeed provide very general information regarding where electrofishing was conducted, there was no information provided as to how many individuals were captured at specific stations. In its statement above, USEPA claims that one can use the total number of fish from either north or south of the Station and divide by the number of 1,000 foot sections that were supposedly sampled by NHFGD in order to obtain a comparable CPUE value to CPUE values from the other years of sampling. Although it is true that this approach will provide a number of fish per 1,000 feet of shoreline, because catch during the years 1967-1969 were not collected from the same fixed sample locations as used during all the other years included in the 1967-2005 trends analysis (1972, 1973, 1974, 1976, 1995, 2004 and 2005), variation in habitat types sampled will influence the results of that analysis. Collections along the full length of bank either north or south of the plant (as was done during 1967, 1968, and 1969) lead to sampling a greater diversity of shoreline habitat types, bed topography and other biological conditions which can increase the number and abundance of species in the catch as fish are not uniformly distributed along the entire shoreline length of the pool.

In short, the standardized design used in the 1967-2005 Hooksett Pool trends analysis (Normandeau 2007a) relied on data collected from fixed locations in the same months which were sampled during each year. The data collected by NHFGD during the years 1967, 1968 and 1969 did not meet these criteria.

Page 44, Section 5.6.2.1.1a: USEPA states:

> *The appearance and proliferation of two species in particular, bluegill (Leponis macrochirus) and spottail shiner (Notropis hudsonius), masks the declines in resident, indigenous species, such as yellow perch, white sucker, and pumpkinseed. Spottail shiners were not identified in sampling until 1974 when six individuals were collected. In 1995, 1,161 spottail were collected during sampling. Bluegills were not collected in Hooksett Pool electrofishing sampling prior to 1995. In 1995, however, 1,111 bluegills were caught. The combined CPUE of these two species represented 85.3 percent of all fish caught in 1995 sampling.*

USEPA is correct that six individual spottail shiner were collected during boat electrofish sampling during 1974. However, spottail shiner were also collected during the May, June and July 1974 minnow seine surveys conducted at Hooksett Pool monitoring stations N-10, N-7, S-0, S-2 and S-7 (Normandeau 1975a). Abundance peaked during the July sampling, with an average number of spottail shiner of 46.77 individuals in the 65 seine hauls and an approximate total of 2,910 individuals. When all months were combined, an estimated 4,143 individual spottail shiner were collected in seine samples, indicating a higher relative abundance than implied by the six individuals captured in the electrofish sampling. Although seine survey catch for Notropis shiner species during 1975 and 1976 were not identified to species, based on the percentage of Notropis catch (98.5%) identified as spottail shiner during 1974, it can be reasonably assumed that spottail shiner represented a large component of catch during those years as well. Based on the 1970s seine surveys, the spottail shiner is a not a recent edition to the Hooksett Pool community but has been in Hooksett Pool in abundance since the 1970s. Therefore, exclusion of spottail shiner from CPUE analyses would be inappropriate.

USEPA is incorrect that bluegill were not collected in Hooksett Pool electrofish sampling prior to 1995. Bluegills were present in Hooksett Pool and were detected during fish sampling there as early as 1972. Bluegill were observed in the June 1972 electrofish catch (n = 3), June 1974 electrofish catch (n = 1), June 1975 electrofish catch (n = 1), June 1976 seine survey (n = 13), and September 1978 seine survey (n = 2) (Normandeau 1973a, Normandeau 1975a, Normandeau 1976a, Normandeau 1977a, Normandeau 1979a). Although not present in great abundance, bluegill were indeed a component of the fish community in Hooksett Pool during the 1970s, and exclusion of that species from a trends analysis conducted for the years 1972-2005 would be inappropriate.

Additionally, USEPA provided the reader with only a single data point (1995) from which to overstate the contribution of bluegill and spottail shiner to the recent fish community. Examination of relative abundance of Hooksett Pool fish during the standardized August-September time period shows that bluegill and spottail represented 35.0% of the Hooksett Pool fish community during 2004 and 28.7% during 2005. For comparative purposes, the Hooksett Pool fish community was dominated by a single species, pumpkinseed, which represented 58.8%, 55.7%, 48.4%, and 48.9% of the fish community during 1972, 1973, 1974 and 1976, respectively. Normandeau disagrees with USEPA's decision to exclude bluegill and spottail shiner from its analyses, because these two species were clearly a component of the fish community during the 1970s.

Page 45, Section 5.6.2.1.1a: USEPA states:

> *EPA conducted a Kendall-Tau trends analysis for changes in the fish community that existed in Hooksett Pool in 1972, based on electrofishing sampling in the entire Hooksett Pool. The result of this trends analysis for the entire pool exceeded the significance test (p>.05) by only 0.0009, which is why the statistics software EPA used (Statistica®) flagged those correlations as being significant.*

Prior to any statistical analysis, an alpha level is set by the investigator. That alpha value is a predetermined probability at or below which it is concluded that the null hypothesis (in this case, the null hypothesis is that there is no change in fish CPUE for the period 1972-2005) is false. In biological studies, the alpha value is usually equal to 0.05 but is occasionally set at 0.01 (Hampton 1994). The predetermined alpha level (in this case, the standard value of 0.05 was selected) serves as the cut-off for a significant or non-significant finding. When the p-value associated with the analysis being performed is compared to the predetermined value for alpha and is equal to or lower than alpha than the null hypothesis is rejected.

The results of the Kendall-Tau trends analysis for the eleven Hooksett Pool fish species that USEPA elected to include resulted in a p-value of 0.0509. This value is greater than the predetermined alpha (0.05), meaning that there is insufficient evidence to reject the null hypothesis that a significant trend in CPUE values exists during the 1972-2005 time period. USEPA nonetheless contends that there has been a significant decrease in total fish CPUE, on the technically unsupportable ground that its statistics software requires it to treat a p-value that was found to be greater than the predetermined value for alpha as being less than that predetermined value, and to treat this finding as significant. USEPA's disingenuous misuse of a predetermined alpha level defeats the purpose of using a sound statistical approach for assessing trends in fish abundance.

In addition, USEPA used fish species in its analysis that made up less than 1% of electrofish catches (yellow bullhead and golden shiner). Inclusion of these low relative abundance species has the potential to bias the results because a small variation in the absolute number of these species can have a large effect on the relative abundance.

It is worth noting here that the 2011 Fisheries Survey Analysis Report presents the results of Kendall-Tau trend analyses conducted for the four resident RIS (smallmouth bass, largemouth bass, pumpkinseed and yellow perch), along with fallfish and white sucker, and the nine additional resident species (bluegill, golden shiner, rock bass, spottail shiner and yellow bullhead) in Hooksett Pool during the 1972-2011 time period (Normandeau 2011a). In sum, there were no significant trends – either decreasing or increasing – over this time period for four of the six resident RIS (fallfish, largemouth bass, smallmouth bass and white sucker) or five of the nine additional resident species (bluegill, golden shiner, rock bass, spottail shiner and yellow bullhead).

Moreover, of these nine species for which there were no significant trends, annual mean CPUE values were statistically similar to those observed in Garvins Pool for largemouth bass, fallfish and spottail shiner during 2010, bluegill during 2011, and golden shiner, rock bass and yellow bullhead during both years (Normandeau 2011a). During 2010, bluegill had a greater annual mean CPUE in Hooksett Pool than was observed in Garvins Pool. Similarly, during 2011, largemouth bass and fallfish had a greater annual mean CPUE in Hooksett Pool than was observed in Garvins Pool. While spottail shiner annual mean CPUE was greater in Garvins Pool than was observed in Hooksett Pool during 2011, annual mean CPUE was greater for both white sucker and smallmouth bass in Hooksett Pool than was observed in Garvins Pool for years 2010 and 2011. The lack of detection of a significant trend over time, and the similarity in CPUE between Hooksett and Garvins Pools, together support a finding that Merrimack Station's thermal discharge has not caused appreciable harm to these nine fish species.

The Kendall tau b analysis detected a statistically significant decreasing trend over the 1972-2011 time period for two of the six resident RIS (pumpkinseed and yellow perch) and three of the nine additional resident species (brown bullhead, chain pickerel and redbreast sunfish) in Hooksett Pool (Normandeau 2011a). A decreasing trend in the mean annual CPUE was observed for two coolwater fish species (yellow perch and chain pickerel) and three warmwater fish species (pumpkinseed, redbreast sunfish, and brown bullhead). Annual mean CPUE values for brown bullhead and redbreast sunfish were the same or greater in Hooksett Pool as compared to Garvins Pool in 2010 and 2011. The similar catch rates for these two species during 2010 and 2011 in Hooksett Pool and thermally uninfluenced Garvins Pool suggest that the decline observed in abundance of brown bullhead and redbreast sunfish in Hooksett Pool is unrelated to Merrimack Station. Annual mean CPUE values for yellow perch, pumpkinseed and chain pickerel were lower in Hooksett Pool as compared to Garvins Pool in 2010 and 2011. The depressed catch rates in Hooksett Pool for these three species as compared to Garvins Pool in 2010 and 2011 suggest the presence of a limiting factor in Hooksett Pool that has decreased yellow perch, pumpkinseed and chain pickerel abundance. All three of these species show a strong affinity to water bodies with high amounts of submerged aquatic vegetation. Within Hooksett Pool, the amount of submerged aquatic vegetation has decreased with improvements in system water quality since the early 1970s (Normandeau 2011b). Abundance of pumpkinseed is likely reduced due to competition with bluegill. In areas of poor water quality (such as Hooksett Pool during the 1970s), it has been demonstrated that pumpkinseed have advantages over bluegill. In lakes where bluegill and pumpkinseed ranges overlap, it has been theorized that lakes containing only pumpkinseed are due to winterkill of bluegill unable to cope with the hypoxic (low DO) conditions (Osenburg et al. 1992, Fox 1994, Tomacek et al. 2007). Pumpkinseed are more capable of withstanding lower DO levels and fluctuating environmental conditions than bluegill (Fox 1994) allowing them to survive in conditions that effectively eliminate bluegill. It is likely that organic pollution in the Merrimack River prior to the enactment of the Clean Water Act in 1972 led to the low DO levels documented during the 1960s and early 1970s (Normandeau 2011b), conditions that would have been advantageous for a species such as pumpkinseed that are capable of tolerating these extremes. The Kendall tau b analysis detected a statistically significant increasing trend over the 1972-2011 time period for black crappie in Hooksett Pool. There were no detectable differences between annual mean CPUE values for black crappie in Hooksett Pool and Garvins Pool during either 2010 or 2011. Similar catch rates for black crappie during 2010 and 2011 in Hooksett Pool and thermally uninfluenced Garvins Pool suggests that the increase observed in abundance of this species is unrelated to Merrimack Station.

Page 46, Section 5.6.2.1.1a: USEPA states:

> *EPA again looked at Merrimack Station's data for changes in the balanced, indigenous community between 1972 and 2005. Fish species collected in 1972 were again used to best represent the balanced, indigenous community. According to these data, electrofishing CPUEs in the ambient zone for the species that comprised the balanced, indigenous community collectively dropped from 62.2 fish in 1972 to 21.9 fish in 2005 (Table 5-6).*

Although appropriate for evaluating trends in an individual fish species, the use of the Kendall tau test to detect increasing or decreasing trends in abundance for all fish species combined is not appropriate, as changes in abundance with time can potentially be driven by a single species even though the abundance of all other fish species in the community remains unchanged. A more appropriate multivariate statistical approach (cluster analysis and analysis of similarity) for detection of change over time in the Hooksett Pool fisheries community is provided in the 2011 Fisheries Survey Analysis Report (Normandeau 2011a).

That analysis compared electrofish collections from Hooksett Pool during August and September of 1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010 and 2011. Community comparisons were made among decades (1970s, 1990s and 2000s) as well as among years. There were significant differences among each of the decades, indicating a high degree of temporal variability. Many individual years were also significantly different from each other, further illustrating temporal variability. If Merrimack Station's thermal discharge had adversely impacted the abundance and distribution of fish in Hooksett Pool over the 1972-2011 time period, there should have been a consistent increase in the abundance of warmwater fish and an accompanying decrease in abundance of coolwater fish in the Hooksett Pool fish community over the 1970-2011 time period. However, the data indicate no such consistent increases and decreases. The groups from the 1970s (Groups IA and IB) were most similar to each other and least similar to the group from 1995 (Group IIB1) and the 2000s (Groups IIA and IIB2). An increase in the abundance of bluegill, a warmwater fish, contributed most to the differences among the 1970s groups and the 1995 group. However, abundance of bluegill decreased between 1995 and the 2000s, and this decrease made the major contribution to the differences between Group IIB1 (1995) and Groups IIA and IIB2 (2000s). The increase in the abundance of bluegill between the 1970s and 1995 was accompanied by a decrease in the abundance of pumpkinseed. The 1970s were distinguished from the 2000s by a general increase in the abundance of spottail shiner, largemouth bass and bluegill, all warmwater fish. However, a decrease in the abundance of pumpkinseed, another warmwater fish, also distinguished the 1970s from the 2000s.

Among coolwater fish, an increase in the abundance of fallfish and a decrease in the abundance of yellow perch contributed to the differences between these decades. In sum, a combination of increases and decreases in the abundances of both warmwater and coolwater contributed to the differences in the Hooksett Pool fish community between the 1970s and 1995, and the 1970s and the 2000s. None of these findings is consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

Page 47, Section 5.6.2.1.1a: USEPA concludes its assessment of the 1967-2005 Hooksett Pool trends analysis for electrofish catch with:

> *The plant's conclusions were likely influenced by the presence and abundance of two species, bluegill and spottail shiner, which were not captured in Hooksett Pool in the 1960s and early 1970s. These species, and others that appeared later, should not have been included in an analysis of the balanced, indigenous community, except to explain how their presence may have affected the indigenous community. Therefore, EPA finds Merrimack Station's conclusion of "no appreciable harm" in this analysis to be unsupported by the data, as it applies to the balanced, indigenous community.*

As noted above, both spottail shiner and bluegill were components of the fish community present in Hooksett Pool in the early 1970s, as determined by electrofish and seine sampling conducted during multiple years in the 1970s. Exclusion of species that were known to occur in Hooksett Pool during the 1970s from the trends analysis is biasing the results towards a subset of fish species. Although neither species is native to Hooksett Pool, the definition of "balanced, indigenous population" states that "such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications" (40 C.F.R. §125.71). Spottail shiner are a very common bait species and have been introduced to New Hampshire in large quantities (Scarola 1987). Bluegill are considered a highly valuable panfish throughout much of their range and are frequently sought after by recreational anglers.

In addition, Normandeau questions USEPA's description of the Hooksett Pool fish community of the late 1960s and early 1970s as "balanced." Electrofish samples during that period were dominated by pumpkinseed. Due to traditionally low harvest levels as well as an extremely high reproductive potential, pumpkinseed populations can very easily become overpopulated (Scarola 1987). As a result of pumpkinseed overpopulation, and resultant competition with large numbers of pumpkinseed, other fish species such as smallmouth and largemouth bass can be impacted due to loss of food sources, predation on young, and loss of spawning habitat.

Page 47, Section 5.6.2.1.1b: USEPA reviewed the trends analysis (Normandeau 2007a) presented for trap net data collected during the 1967-2005 time period. Use of fisheries catch data collected during the 1960s, 1970s 1995 and 2000s has been misunderstood and misused by USEPA throughout this section of the §316 Determination Document.

Page 48, Section 5.6.2.1.1b: USEPA makes reference to "Normandeau 1969" but fails to provide an appropriate citation in Section 14.0 (Scientific and Technical References) of the §316 Determination Document so that the reader may identify, obtain and review the referenced document.

Page 48, Section 5.6.2.1.1b: With regard to the 2007 Normandeau assessment of 1967-2005 trap net data from Hooksett Pool (Normandeau 2007a), USEPA states:

> *EPA finds that these conclusions in the Fisheries Analysis Report are questionable. EPA also reviewed the 1971 NHFGD Report and the 1969 Merrimack Station Report and finds that while some details are omitted from the former, the latter appears to be based on a review of NHFGD's raw sampling data. In the 1969 Merrimack Station Report, Normandeau provided CPUE data for all species collected and calculated CPUE data down to two decimal places for nine abundant species at 3,000-foot intervals along the entire length of the Hooksett Pool. Given that no such detailed CPUE data were presented in the 1971 NHFGD Report, Normandeau must have had access to the state's raw data. The fact that Normandeau used the data collected by NHFGD from 1967-1969 in the 1969 Merrimack Station report, as well as in other analyses presented in reports as recently as 1997, weakens its current conclusion that the data should not be used for purposes of conducting a historical trends analysis.*

Normandeau Associates does not have, nor is it responsible for retaining for a period of 45 years, field sampling sheets for work conducted by NHFGD. While it does appear that NHFGD granted Normandeau access to Hooksett Pool sampling data for use in the 1969 Normandeau report, those data are no longer available. The fact that the 1971 NHFGD report (Wightman 1971) was completed two years after the 1969 Normandeau report was submitted suggests that the raw data was returned to NHFGD so that it could finish its report. USEPA's claim that the raw NHFGD data has been used in other analyses presented in reports as recently as 1997 is simply not correct. The footnotes in Table 3-3 referencing 1960s catch data in the 1997 *Merrimack Station (Bow) Fisheries Study* report (Normandeau 1997) clearly state that those CPUE values were credited to Stetson-Harza (1993). A review of Stetson-Harza (1993) shows that CPUE values for the sampling years during the 1960s were calculated using values taken directly in summary tables within the 1971 NHFGD report (Wightman 1971). For the purposes of the 1967-2005 trends analysis, Normandeau had access to the same pieces of documentation as did USEPA. USEPA itself agrees that 1971 NHFGD report lacks details necessary to allow use of trap netting data from the late 1960s in a trends analysis.

Page 48, Section 5.6.2.1.1b: With regard to Normandeau not using the early trap net data, USEPA states:

> *In providing a basis for omitting these important early data, Merrimack Station also states in the Fisheries Analysis Report (p.27) that:*
>
> > *The 1971 NHFG (Wightman) Report did not provide information for Areas 1 and 2 that detailed whether nets were fished on the east, west, or both banks.*
>
> *Yet, based on EPA's review of the 1971 NHFGD Report, it appears that sampling locations were included. The 1971 NHFGD Report states that:*
>
> > *Netting sites were delineated by numbered marker posts in Sections 1 and 2 to insure similar net sets during the course of the study, while Area 3 net sites were plotted on aerial photographs to insure similar positioning in this area.*
>
> *Figures 5 and 6 in the 1971 NHFGD Report identify all the sites sampled. According to Figure 5, all Hooksett Pool trapnet sampling sites (Areas 1 and 2) were located on the east side of the river, except for samples collected in the discharge canal (Wightman 1971). In Amoskeag Pool, sampling was conducted on both sides of the river, as portrayed in Figure 6.*

Normandeau disagrees with USEPA's conclusions regarding the placement of all trap net sample sites along the eastern bank of Hooksett Pool during the 1960s data collection. Figure 5 of the 1971 NHFGD report (Wightman 1971) is titled "Station Location – Hooksett Pond & Discharge Canal Merrimack River" and is only referenced in the text on Page 13 for illustration of the portions of the Pool defined as Area 1 and Area 2. There is no mention of which Hooksett Pool stations (some or all) had trap nets set at them or on which bank they were fished. Closer examination of Figure 5 indicates that only Canal Station C-7 and C-14 are highlighted to indicate that trap nets were fished there. USEPA opts to make a major assumption that trap nets were fished at all stations and along only the eastern bank of Hooksett Pool. It seems odd that studies intending to examine impacts to fisheries potentially caused by Merrimack Station would not fish a single net along the side of the river on which the Station is located. Regardless of which bank trap nets were fished on, none of the 1960s summary reports provided detailed station-specific catch totals that would allow for direct comparison with trap net sampling during the 1970s and 2000s.

Figure 6 of the 1971 NHFGD report (Wightman 1971) is titled "Merrimack River Study Area 3 (Fyke Net Stations). In contrast to Figure 5, this figure does provide trap net locations and the banks on which they were fished in Amoskeag Pool (Area 3). The 2007 Fisheries Survey Analysis Report did not use any data from Area 3 (Amoskeag Pool) for any comparative analyses.

Page 49, Section 5.6.2.1.1b: With regard to post-1960s trap net data, USEPA states:

> *Merrimack Station concluded that trapnet (also called "fyke net") data from four of the nine years of sampling — specifically, 1972, 1973, 1978, and 1995 — were unsuitable for use in a trends analysis due to discrepancies in sampling design, poor record keeping, and possible inconsistencies in set duration and frequency. In addition, data from 1977 was not used, but the Fisheries Analysis Report does not explain the omission. Deselecting almost half of the available historical data sets when conducting a retrospective trends analysis unavoidably raises questions and concerns about whether a reasonable and fair analysis was conducted.*

Normandeau strongly disagrees with USEPA's characterization of why certain years of trap net data could not be used. Similar to the use of electrofish data in the trends analysis, a standardized method of sampling that is repeatable each and every year is necessary to produce an "apples to apples" comparison of fish community abundance over time. Standardized sampling for assessment of abundance trends requires use of the same sampling gear set at the same locations during the same season, or any observed changes in fish abundance may not be directly attributable to the stressor being studied but rather may be an artifact of variation in sampling. It is apparent that USEPA opted to ignore the standardized layout of trap net data presented in Table 3-2 of the 2007 Fisheries Survey Analysis Report. Within that analysis, years were selected so that the maximum number of months and locations could be utilized. As already discussed, trap net data from the 1960s was not included as there was no documentation available for which Hooksett Pool stations were sampled, how long net sets were and how often they fished at each Station. In addition, there is no information available regarding construction of nets fished during the 1960s, including mesh size, opening diameter or shape, wing depth or length and lead depth or length.

The year 1972 was not included because a reduced set of months was sampled during that year. Sampling during 1973 also occurred during a reduced set of months, and Normandeau had to determine whether to include that year (1973) in the trends analysis time series or the month of

May across the entire time series. The decision was made to include the month of May across the entire time series, due to its biological importance to fish in Hooksett Pool. An annual report detailing the 1977 fisheries data collection in Hooksett Pool was never generated. Data from that year is presented in the 1979 Summary Report (Normandeau 1979b) but does not include the counts of fish collected at individual stations during the months sampled to allow for inclusion in a trends analysis. Data from 1978 was not included due to discrepancies in the 1978 annual report over which stations were sampled during that year. Data from 1995 was not included due to the fact that 2-inch mesh nets were used. These differ significantly from the ¾ inch mesh used during all other years.

Pages 49-51, Section 5.6.2.1.1b: In this section, USEPA suggests that a Normandeau biologist was wrong about the mesh size of the trap nets used throughout the decades of fish sampling. USEPA states:

> *According to the Fisheries Analysis Report, Merrimack Station concluded that trapnet data collected in 1994-1995 could not be used in the trends analysis because a 2.0-inch mesh size was used, whereas it believes that a 0.75-inch mesh was used throughout the 1970s. The facility bases the latter belief regarding the probable mesh size used in the 1970s on the recollections of one of its biologists. The Fisheries Analysis Report then indicates that the difference in mesh size would be a problem in a trends analysis because a 0.75-inch mesh would tend to capture more smaller-bodied fish that could pass through a two-inch mesh. While that seems a reasonable point about differences between 0.75-inch and 2.0-inch mesh nets, EPA finds it unlikely for several reasons that a 0.75-inch mesh was used during the 1970s.*
>
> *First, the notion that the sampling regime was shifted from a 0.75-inch mesh to a 2.0-inch mesh is not supported by a letter from PSNH to EPA, dated March 1, 1993, which states,*
>
> > *The fyke netting program undertaken by NAI will be repeated in 1994 to provide fish community composition and target species abundance information. (PSNH 1993).*
>
> *This assurance is repeated in a proposal for environmental assessment services from Normandeau Associates, Inc., to PSNH, dated August 1994. This proposal states (p.7),*
>
> > *Fyke net samples will be collected with the same gear used by NAI during the 1972-1978 study. (Normandeau 1994)*
>
> *These statements, which were made closer in time to the actual sampling programs, suggest that the mesh sizes would have been kept constant and appear to contradict the recent recollections by the company's biologist.*
>
> *Second, the purpose of fyke net (i.e., trapnet) sampling in the 1970s was to sample the larger, adult segment of the fish population. This is stated in Merrimack Station's 1975 Merrimack River Monitoring Program Report (p.112) "[f]yke netting was employed to illustrate the distribution of larger fishes within Hooksett Pond in relation to the Merrimack Station thermal discharge." Similar reports from other years in the 1970s say the same thing. EPA regards it unlikely that a 0.75-inch mesh would have been used in a program targeting larger fish and no reason why this would have been the case as has been suggested.*

USEPA is drawing inappropriate conclusions based on fragmentary data. Trap nets fished during the 1970s were identified as being ¾" mesh by two long-time Normandeau employees, a vice-president who has been with the company over 30 years, and a current group manager with 33 years' experience conducting field studies for Normandeau. A photograph of those nets was provided to USEPA in a 2006 Normandeau report (Normandeau 2006b). Those nets were photographed following their use on the Merrimack River and during their subsequent use on both the Chicopee and Penobscot Rivers. The original nets fished during the 1970s were not available when Hooksett Pool sampling recommenced during 1994. Prior to the start of that sampling, the PSNH biologist at the time decided that the 2-inch mesh nets that Normandeau had on hand following their initial use on the Saint Lawrence River were adequate. Based on the foregoing, Normandeau reasserts that the nets used in the 1970s were a different mesh from those used in 1994, and that the data from each of these sampling gears are not comparable.

A detailed examination of trap net catches from the 1970s provides support for the use of ¾" mesh trap nets. The capture of American eels throughout that decade, with the exception of 1977, provides support for the use of ¾" mesh (Normandeau 1979b). American eels are extremely difficult to retain in netting due to their elongated bodies and heavy slime coat. The capture of American eels in trap nets fished during 1995 was limited to a single individual (Normandeau 1997). In addition to American eels, small-bodied fish were collected in trap net catches throughout the 1970s, and USEPA's suggestion that sampling was targeted at larger fish indicates that it did not read the 1970s annual summary reports closely enough (Normandeau 1973a, Normandeau 1974a, Normandeau 1975a, Normandeau 1976a, Normandeau 1977a, Normandeau 1979a). During 1973, age-0 fish captured in the trap nets were only a few months old and included pumpkinseed and smallmouth bass, along with numerous age-1 fish that were unlikely to be retained by the larger 2-inch mesh. Similarly, age-0 and age-1 fish were observed in trap net catches during 1974, 1975 and 1976 and included pumpkinseed, yellow perch and smallmouth bass. Further support of the poor collection efficiency of small-bodied age-0 and age-1 fish from Hooksett Pool was provided by a mesh comparison study (Normandeau 2006b).

In contrast, during 2004-2005 data collection, a single fish with a total length less than 80 mm, zero individuals between 81 and 99 mm and two individuals between 100 and 119 mm were retained by the 2-inch mesh nets, whereas 22 fish less than 80 mm, 31 individuals between 80 and 99 mm and 57 individuals between 100 and 119 mm were retained by the ¾" mesh nets used in the 1970s. As USEPA has questioned Normandeau's knowledge of the previous sampling, the greater retention of small-bodied fish in the ¾" trap nets during the 2006 comparison study as well as the presence of similar small-bodied fish during the 1970s should provide sufficient evidence for the use of ¾" mesh during the 1970s. Examples of several small -bodied fish specimens and their size relative to ¾" and 2" mesh are provided in Figure 3-1.

Figure 3-1. Visual representation of small bodied perch, bass, darter and sunfish relative to 2" trap net mesh (left column) and ¾" trap net mesh (right column).

Page 51, Section 5.6.2.1.1b: USEPA states:

> *In light of the above discussion, EPA does not agree that use of the trapnet data collected in 1994-1995 should be completely abandoned, especially since it represents the only data of its type collected between 1978 and 2004 and, as Normandeau has stated in earlier reports, it targets adult fish (Normandeau 1976).*

PSNH and Normandeau agree with USEPA that the 1995 data set is important. This is why PSNH and Normandeau invested time and effort to develop a correction factor that could adjust the 2" mesh trap net catch from 1995 to a ¾" mesh trap net catch equivalent in order to provide a direct comparison without including biases introduced from different gear types (Normandeau 2006b). As explained in the 2006 draft Normandeau report *An Examination of Fish Catch Between Trap Nets with 0.75-in and 2.00-in Mesh Sizes Deployed in Hooksett Pool of the Merrimack River (Bow, NH)*, it was not possible to derive that adjustment factor because there was insufficient data for estimating which young of year and small-bodied species should be added in what abundance to adjust the 2" mesh to make it comparable to the ¾" mesh.

Page 52, Section 5.6.2.1.1b: USEPA states:

> *As troubling as these results are, declines in total CPUE for the species that made up the balanced, indigenous community in the 1960s are even greater. Data provided in the Fisheries Analysis Report for the 2000s included (warmer water-favoring) species not present in Hooksett Pool in the 1960s and, therefore not part of the balanced indigenous community.*

First, the majority (10 of 16) of the fish species captured in Hooksett Pool during the 1960s were warmwater species. Second, both Wightman (1971) and Normandeau (1969) state clearly that the Hooksett Pool fish community during the 1960s was a warmwater fishery. Normandeau therefore disagrees with USEPA's statement that "[d]ata provided in the Fisheries Analysis Report for the 2000s included (warmer water-favoring) species not present in Hooksett Pool in the 1960s and, therefore not part of the balanced indigenous community." It is Normandeau's position – based on reports by the United States Department of the Interior (1966), among others – that USEPA's proposed use of what it describes as a "balanced indigenous community" from the 1960s would be misguided because the 1960s was a period of extremely poor water quality in Hooksett Pool (Normandeau 2011b). In addition, the "warmer water-favoring" fish that USEPA claims appeared in Hooksett Pool only during the 2000s, bluegill and spottail shiner, were captured in the pool throughout the 1970s. Further, it is Normandeau's position that the increase in abundance for these two species was not related to the thermal conditions in Hooksett Pool, because recent sampling during 2010 and 2011 (Normandeau 2011a) has shown that both of these species are also important components of the fish community in Garvins Pool, which is located upstream of Hooksett Pool and is not influenced by Merrimack Station's thermal discharge. During 2010, these two "warmer water-favoring fish" (bluegill and spottail shiner) represented 1.9% and 51.1% of the total catch in Garvins Pool. During 2011, bluegill and spottail shiner represented 6.3% and 44.8% of the total catch in Garvins Pool. There were no significant differences in spottail shiner CPUE during 2010 between Garvins and Hooksett Pools, and spottail shiner CPUE was greater in Garvins than Hooksett Pool during 2011. Although CPUE for juvenile and adult bluegill during 2010 was greater in Hooksett Pool, there were no significant differences in bluegill YOY during 2010 or bluegill during 2011 (all lifestages pooled) between Garvins and Hooksett Pools (Normandeau 2011a).

USEPA identifies Merrimack Station's thermal discharge as the sole cause of warmwater fish species' purported competitive advantage in Hooksett Pool. However, the data show that the rise in abundance of bluegill and spottail shiner in both Garvins and Hooksett Pools is more likely the result of improved Merrimack River water quality than any thermal impacts from the Station's thermal discharge. As Normandeau has repeatedly noted above, Garvins Pool is not influenced by the Station's thermal discharge. Had the discharge been the sole reason for the rise in abundance of bluegill and spottail shiner in Hooksett Pool, these species would not also have become established in great numbers in thermally uninfluenced Garvins Pool.

Page 55, Section 5.6.2.1.2a: USEPA states:

> *As previously discussed in Section 5.6.2.1.1a, EPA concluded that data from the 1960s was indeed usable for assessing long-term changes in CPUE. Therefore, using this information, EPA calculated yellow perch CPUE values for 1967, 1968, and 1969 (Table 5-11). Including these data points in Merrimack Station's fisheries analysis report graphic for yellow perch more fully describes, based on the best, reasonably available data, changes in yellow perch population since before Unit 2 came on line in 1968 (Figure 5-3).*

As noted above in Normandeau's response to a statement by USEPA on page 49 of the §316 Determination Document (Section 5.6.2.1.1b), inclusion of trap net data collected during the 1960s is inappropriate if one is conducting a standardized analysis of fish abundance in Hooksett Pool over time. In Table 5-11 of the §316 Determination Document, USEPA has calculated a CPUE value that represents the number of yellow perch per 1,000 ft transect in Hooksett Pool. However, USEPA fails to tell the reader that its calculation rests on a major, and unfounded, assumption: that yellow perch are evenly distributed along the entire shoreline of the areas north and south of the Station. As any angler can testify, fish are not evenly distributed along shorelines but rather seek areas of preferred habitat and food sources. This simple fact underlines the importance of a standardized sampling design using the same collection methods, station locations and seasonal timing to accurately assess trends in fish populations over multiple years of sampling. Although the data reported from the 1960s did provide very general information regarding where electrofishing was conducted, there was no information provided as to how many individuals were captured at the specific electrofish sampling stations used during the 1970s, 1990s and 2000s. Since yellow perch catch during the 1960s was not collected from the same fixed locations as used during all other years of the comparison, differences in habitat types sampled would impact the comparison. Collections along the full length of bank either north or south of the Station, as was done in the 1960s, will lead to sampling a greater diversity of shoreline habitat types, bed topography and other biological conditions that can increase the number and abundance of species in the catch.

Pages 56-57, Section 5.6.2.1.2a: USEPA states:

> *Merrimack Station's analysis makes no distinction between juvenile and sexually mature adult fish. This blending of lifestages can obscure the true status of the fishery, especially when an adult, breeding population is depressed. EPA reviewed catch data provided in the Fisheries Analysis Report to determine the approximate number of sexually mature yellow perch that were caught in August and September of 2005. Age-growth studies conducted by NHFGD each year from 1967 to 1969 provide a good estimate of age, based on length. These studies are discussed in the 1971 NHFGD Report. According to the USFWS (Krieger et al. 1983), female yellow perch in Canadian and northern United States waters mature at 3-4 years of*

> *age, one year later than males. Based on this information, the length-age data provided in the 1971 NHFGD Report, and the length-frequency data provided in the Fisheries Analysis Report, EPA conservatively calculated the age and sexual maturity of the fish collected in the 2005 sampling. Of the 52 yellow perch caught in 2005 during August and September, only two fish appear to be old enough to be considered sexually mature. Forty-five of the yellow perch caught were between 85 mm and 136 mm (3.35-5.35 inches), making them one- or two-year old fish. In general, many juvenile fish do not survive to maturity, so the capture of 45 juvenile yellow perch in the Ambient Zone is not indicative of a population rebound.*

Normandeau disagrees with USEPA as the presence of juvenile yellow perch is supportive of successful spawning. Yellow perch form schools based on size and age, with smaller fish staying closer to the shallow littoral zone (Holtan 1990). Larger perch form schools in deeper water and move closer to shore during evening to forage (Holtan 1990). Yellow perch also utilize deeper water in summer months as a thermal refuge (Krieger et al. 1983). During 2008 and 2009 biocharacteristics sampling in Hooksett Pool, a total of 364 yellow perch were assessed for reproductive condition (Normandeau 2011a). Forty-six percent of the yellow perch collected in Hooksett Pool were classified as immature. The remaining 196 yellow perch were classified as gravid, semi-gravid, ripe and running, partially spent, spent or resting. A wide range of ages was observed for yellow perch collected from Hooksett Pool during 2008 and 2009, with individuals from age-0 to age-9 collected. For comparative purposes, 34% of the yellow perch collected in Garvins Pool, located upstream of Hooksett Pool and uninfluenced by Merrimack Station's thermal discharge, were classified as immature.

Page 59, Section 5.6.2.1.2b: USEPA states:

> *Based on our review of all trapnet information provided by Merrimack Station, EPA has concluded that the yellow perch population has declined significantly since 1967, with the steepest declines occurring in the years immediately following the start-up of the plant's Unit. EPA considers this decline in abundance indicative of appreciable harm to this species. This metric is particularly important since trapnet sampling is intended to target the adult segment of the population.*

This statement by USEPA is misleading and underlines the Agency's disregard for fisheries experts' recommendations regarding the proper sampling gear for use in fish collection in riverine systems. As stated above, trap nets are not intended for sampling in such systems and are better suited for the "no flow" conditions found in ponds and lakes (Bonar et al. 2009). USEPA would like the reader to believe that the decline in trap net catch from 1967 to 1968 can be solely attributed to Unit 2 coming online. Although there is a decline in catch of yellow perch between 1967 and 1968, neither Wightman (1971) nor Normandeau (1969) attribute that decline in catch to Unit 2, especially since it had only been on-line for a few weeks before NHFG began sampling in June 1968. Wightman (1971) attributes the decrease in yellow perch catch during 1968 to high flows, which caused continued net fouling. The mean monthly river flow (as measured by USGS gauge 01092000 – Goffs Falls) during the sampling month of June 1968 was nearly 50% greater than that observed during June 1967, and for July 1968 was more than 25% greater than that observed during July 1967. This illustrates both the difficulties of successfully using trap nets in a riverine system and how flow and debris loading can greatly reduce gear efficiency. As for USEPA's contention that the trap nets capture mostly adult fish, Normandeau agrees that trap nets they are effective for adults, but have already demonstrated that the trap nets also capture large numbers of small bodied fish along with the adults.

Page 59, Section 5.6.2.1.3: USEPA states:

> *Pumpkinseed sunfish (then referred to as "common sunfish") was the most abundant species in Hooksett Pool in 1967, according to data collected in both electrofishing and trapnetting studies conducted by NHFGD, and presented in a report by Merrimack Station (Normandeau 1970). Trapnet data for the years 2004 and 2005 ranked pumpkinseed fifteenth in abundance out of the seventeen species (Normandeau 2007a). Results from electrofishing in 2004 and 2005 were similar to trapnet sampling with both indicating that pumpkinseeds maintain little more than a remnant population in Hooksett Pool.*

Rank abundance is not intended to be the sole metric used in the assessment of changes in abundance for a particular species, as it is highly influenced by catch of other species. The abundance for a species of interest may remain consistent across years, but due to increased or decreased catch of other species can rank higher or lower relative to the other species. With regard to pumpkinseed, their abundance in Hooksett Pool has decreased over the 1972-2011 time period (Normandeau 2011a). However, they should not be considered as just a remnant population. Pumpkinseed represented 3.1% of the total catch in Hooksett Pool during the most recent sampling year (2011), and individuals ranging from 50 mm to 131 mm were collected, indicating a range of age classes present.

Pumpkinseed in the northeastern United States are not considered a species intolerant of pollution (Halliwell et al. 1999). Their increased abundance during the 1960s and 1970s may have been due to their ability to withstand the severe pollution present in the Merrimack River (and thus Hooksett Pool) during that time period (Normandeau 2011b). Pumpkinseed have tremendous reproductive potential, and populations can easily become overpopulated and stunted (Scarola 1987). The fact that the Hooksett Pool fish community was dominated by a single tolerant fish species during the 1960s and 1970s is an indication that the fish community was not balanced. Reduction in nutrient loading in Hooksett Pool since the 1970s has led to a decrease in the pool in the abundance of submerged aquatic vegetation beds (Normandeau 2011b), which is a favored habitat of pumpkinseed (Scarola 1987).

Pages 59-60, Section 5.6.2.1.3a: USEPA states:

> *Statistically significant negative (decreasing) trends in annual mean CPUE were observed for pumpkinseed in the trends analysis conducted by Merrimack Station. Merrimack Station suggests, according to the Fisheries Analysis Report, that direct competition with bluegill, an introduced species not observed in Hooksett Pool until 1995 is the cause of the pumpkinseed decline rather than Merrimack Station's thermal discharge.*

USEPA is well aware that the bluegill were a part of the Hooksett Pool fish community during the 1970s, as evidenced by its statement on page 97 (Section 5.6.3.3e) of the §316 Determination Document:

> *In fact, however, according to the 1979 Summary Report, bluegills were being caught in seine net sampling as early as 1972.*

As detailed above in Normandeau's response to USEPA's statement on page 44 (Section 5.6.2.1.1a) of the §316 Determination Document, bluegill were collected from Hooksett Pool throughout the

1970s. They first appeared in the standardized boat electrofish catches during the months of August and September during 1995, but they were collected in electrofish samples in June 1972, June 1974 and June 1975, and in seine collections during June 1976 and September 1978. The data show that bluegill have been present in Hooksett Pool since 1972, not 1995. PSNH is not suggesting that a species first observed during 1995 would be responsible for the decline of pumpkinseed during the 1970s.

USEPA goes on to state:

> *Merrimack Station points out that bluegills spawn over a longer time period than pumpkinseeds, and that the "larger bodied" bluegill will also compete with pumpkinseed for spawning habitat in shallow gravelly habitat. What the Fisheries Analysis Report fails to mention, however, is that bluegill's heat tolerance is considerably higher than that of pumpkinseed.*

Along with habitat preferences and food resources, heat tolerance of bluegill and pumpkinseed is similar. A large-scale 1979 thermal study to determine the preferred, avoided and upper/lower lethal temperatures of fish species resident to Conowingo Pond, Pennsylvania provided a comparison of the final temperature preferenda of both bluegill and pumpkinseed (RMC 1979). The preferred temperature for bluegill (±90% C.I.) was 32.2 ± 1.2ºC (90ºF) and for pumpkinseed was 33.3 ± 2.3ºC (92ºF). In addition to this field study, observations of pumpkinseed from Hooksett Pool have recorded them in thermal conditions well above the avoidance temperature of 88°F (31.1°C) presented in the 2007 Fisheries Survey Analysis Report. USEPA noted that observations of pumpkinseed in trap nets fished in waters up to 93°F (33.9°C) were not accurate, as water temperature was not documented when individual fish actually entered the net. Pumpkinseed were captured during seine samples collected during 1974-1978 in water temperatures from 86-96ºF (30-35.5ºC). In their review of temperature relationships, Wismer and Christie (1987) summarized the upper avoidance temperature for adult pumpkinseed during summer months as ranging from 85-104ºF (29.4-40ºC). The upper avoidance temperature reported for adult bluegill during the summer months ranged as high as 95ºF (35ºC) (Wismer and Christie 1987).

USEPA goes on to state:

> *Fish may be drawn into a thermally undesirable area to forage, or to escape predators. In addition, individual fish of a species may have varying levels of heat tolerance so the mere presence of one or more individuals at a given temperature does not necessarily demonstrate that the temperature is protective of the larger population. Where competition exists for limited forage, as well as spawning and juvenile-rearing habitat in areas exposed to a thermal discharge, it is reasonable to expect species with a greater preference for, and tolerance to, elevated temperatures to out-compete less tolerant species.*

Normandeau disagrees, and contends that pumpkinseed are as thermally tolerant as bluegill. In situations where competition does exist for forage and/or habitat areas in the absence of a thermal discharge, bluegill will outcompete pumpkinseed (Osenburg et al. 1994, Toamcek et al. 2007). In other words, thermal additions are not needed for bluegill to outcompete pumpkinseed. Abundance of pumpkinseed in Hooksett Pool was high through the 1970s and up to the last sampling year during that decade (Normandeau 1979a). If the decline in pumpkinseed abundance was solely due to Merrimack Station's thermal discharge, then it stands to reason that a large decline would have been observed over the ten-year period immediately following Unit 2 coming on-line (1968-1978). As detailed in Normandeau's response above to USEPA's statement on page 59 of the §316 Determination Document (Section 5.6.2.1.3), the observed reduction in nutrient loading in Hooksett Pool since the 1970s and subsequent decline in submerged aquatic vegetation beds likely was a greater contributor to the decrease in pumpkinseed abundance.

Page 60, Section 5.6.2.1.3b: USEPA states:

> *According to the Fisheries Analysis Report (2007), Table 3-17, trapnet CPUE for pumpkinseed dropped from 11.7 fish caught per 48-hours in the 1970s to an average of 0.0 fish in the 2000s. Based on trapnet data, it appears that pumpkinseed, the most abundant fish species in Hooksett Pool prior to the start-up of Unit 2, has nearly disappeared from Hooksett Pool.*

As stated above, pumpkinseed have not disappeared from Hooksett Pool. Pumpkinseed represented 3.1% of the total catch in Hooksett Pool during the most recent sampling year (2011), and individuals ranging from 50 mm to 131 mm were collected, indicating a range of age classes present (Normandeau 2011a). It should also be noted that the average trap net CPUE for pumpkinseed collected in Hooksett Pool during the 2000s was approximately 0.02 individuals per 48-hours, not 0.0 (2 individuals captured from 81 48-hour net sets).

Page 61 Section 5.6.2.1.4a: USEPA states:

> *Based on electrofishing data, Merrimack Station concludes that: [n] o statistically significant negative (decreasing) trend was observed in white sucker annual mean CPUE in Hooksett Pool (Ambient and Thermally-influenced zones combined), supporting a finding of 'no prior appreciable harm' due to Merrimack Station's thermal discharge during this four-decade period. The report also concludes that no decreasing trends were observed in either zone when analyzed individually.*

The electrofish data collected from Hooksett Pool during the 1972-2011 time period supports a finding of no appreciable harm to white sucker in Hooksett Pool from Merrimack Station's thermal discharge. A Kendall tau test was unable to detect a significant trend in white sucker abundance for this time period (Normandeau 2011a). In addition, abundance of white sucker, a coolwater species, was greater in Hooksett Pool than in Garvins Pool for standardized electrofish sampling conducted during both 2010 and 2011. If white sucker were in decline due to impacts from the Station's thermal discharge, their abundance would be significantly lower than that observed in Garvins Pool, an upstream reference area that is not influenced by the Station's thermal discharge.

USEPA goes on to state:

> *EPA reviewed the data, however, and found a significant disparity in abundance values for white sucker between trapnet and electrofishing data from the 1960s, suggesting a possible sampling bias for this species. While electrofishing sampling in 1967, 1968, and 1969 indicate the relative abundance of white sucker was low (1.7 percent averaged over the three- year period), trapnet samples suggest the opposite. According to data provided in the Merrimack River Thermal Study (Wightman 1971), trapnet relative abundance for white sucker averaged 16.2 percent over the same three-year period. It is possible that electrofish sampling may have under-represented bottom-feeding species such as white sucker. They tend to inhabit deeper areas during daylight hours, when electrofishing likely occurred, and*

> *forage in the shallows after dark (Moyle and Cech, Jr. 2004). Trapnets, which are typically deployed for periods up to or exceeding 24 hours are more likely to capture fish that actively feed along the shoreline at night.*

First, Normandeau notes again that according to USEPA's own technical framework document for the development and implementation of large river bioassessment programs, "Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers" (Flotemersch et al. 2006), boat electrofishing is the most comprehensive and effective single method for the collection of fish from streams and rivers. Normandeau further notes again that the American Fisheries Society has concluded that trap nets are intended to be most effective in lentic littoral areas (Bonar et al. 2009). White sucker were observed to be highly susceptible to boat electrofishing during daylight hours within Hooksett Pool and surrounding portions of the Merrimack River. Daytime boat electrofish sampling for assessment of biocharacteristics during 2008 and 2009 collected a total of 961 white sucker from Garvins, Hooksett and Amoskeag Pools (Normandeau 2011a). A wide range of age classes from age-0 to age-12 were observed over those two years, and field crews observed white sucker being collected by boat electrofishing in water depths up to eight feet on more than one occasion in each of the three Merrimack River pools. Because Normandeau strictly adhered to a standardized electrofish sampling design that sampled fixed locations during a similar time period each year and with a similar gear, and because Normandeau's trend analyses of RIS abundance did not use data that was not collected in accordance with this standardized electrofish sampling design (Normandeau 2007a; Normandeau 2011a), Normandeau's assessment of abundance trends of white sucker in Hooksett Pool electrofish data is technically robust and unassailable.

Pages 61-62, Section 5.6.2.1.4b: USEPA states:

> *In 1967, the common white sucker was the fourth-most abundant species in Hooksett Pool, according to trapnet studies conducted by NHFGD (Wightman 1971). During the 1970s, white sucker was the second-most abundant species in upper Hooksett Pool (relative abundance 20.9 percent) and ranked third in the lower Hooksett Pool (relative abundance 16.4 percent) (Normandeau 2007a). By the 2000s, white sucker relative abundance in the upper and lower Hooksett Pool had dropped to 2.7 and 2.1 percent, respectively (See Figure 5-7). Moreover, the mean CPUE dropped two orders of magnitude in Hooksett Pool between the 1970s and 2000s, from 11.0 fish to 0.1 fish.*
>
> *Thus, the trapnetting data obviously provides evidence that white sucker have significantly declined since at least the 1970s. As with other species, Merrimack Station draws no conclusions regarding white sucker based on trapnet data.*

Rank abundance and percent composition data for an individual species are not good indicators of abundance because each can be affected by changes in the abundance of other species. Electrofish CPUE data collected over the 1972-2011 time period are better measures of abundance, and the results of Normandeau's trends analysis based on these CPUE data directly contradict USEPA's comparison of 1970s and 2000s trap net data.

Recent statistical analyses (Normandeau 2011a) were unable to detect a significant trend in white sucker abundance for the 1972-2011 time period. In addition, abundance of white sucker, a coolwater species, in Hooksett Pool was greater than that observed in Garvins Pool for standardized electrofish sampling conducted during both 2010 and 2011. As noted above, if white sucker were in decline due to impacts from Merrimack Station's thermal discharge, their abundance would be significantly lower than that observed in Garvins Pool, an upstream reference area that is influenced by the Station's thermal discharge. Direct conclusions regarding changes in abundance for fish species in Hooksett Pool as sampled by trap net were not made (Normandeau 2007a) due to biases associated with that gear type and issues associated with effectively deploying it within a riverine environment. While data collected by trap net can provide supplemental insight into the Hooksett Pool fish community, Normandeau's trends analysis relied on boat electrofish data, which is the most effective method for collecting fishes (Vincent 1971, Gammon 1973, Novotny and Priegel 1974, Gammon 1976, Davis et al. 1996, Barbour et al. 1999, and Simon and Sanders 1999 *as cited in* Flotemersch et al. 2006).

In addition, biocharacteristics data for white sucker were collected during 2008-2011 from Garvins and Hooksett Pools (Normandeau 2011a). There was no significant difference in the condition of white sucker collected during 2009, indicating that white sucker maintained similar incremental weight gain with increasing length between Hooksett and Garvins Pools. The length-weight curve based on the 2011 catch showed that white sucker in Hooksett Pool grew significantly more rotund (or "fatter") with increasing length than in Garvins Pool. Insufficient numbers of white sucker were collected in Garvins Pool during 2008 and 2010 to allow for a comparison of condition. Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a decreasing slope to the length-weight curve – signifying progressively lower weight for a given length – for a resident fish species over time or in comparison to the same species residing in thermally uninfluenced habitat. Such a decreasing slope indicates a reduction in quality of body condition due to the thermal impact. Here, the observations of similar or increased growth among white sucker residing in Hooksett Pool compared to white sucker residing in thermally uninfluenced Garvins Pool during years of comparable sampling (2008-2011) indicate that there has been no appreciable harm to the BIP in Hooksett Pool.

There were significant differences in the mean length at age of age-2 and age-3 white sucker collected in Hooksett and Garvins Pools during 2009, with larger mean length at age for white sucker in Garvins Pool for both cohorts. Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show lower mean length at age for a resident fish species compared to the same species in a thermally uninfluenced area, due to a reduction in growth rates associated with thermal stress. Here, the observation of reduced mean length at age for white sucker in Hooksett Pool suggests that growth (as estimated by mean length at age) may be reduced for some age classes in Hooksett Pool as compared to the same age classes of white sucker in Garvins Pool. However, the inverse relationship between density and growth (i.e., the larger the fish population in a given water body, the slower the growth of individual fish in that population, due to competition for resources) has been well-studied and documented in other systems for white sucker. Here, abundance of white sucker was greater in Hooksett Pool than Garvins Pool during the sampling period, suggesting that the causes for such lower mean length at age for the species is unrelated to the Station's thermal discharge.

Total instantaneous mortality (Z) did not differ for white sucker within Garvins and Hooksett Pools. Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a greater total mortality (Z) for a resident fish species compared to the same species in a thermally uninfluenced area, due to increased stress associated with thermal impacts. There were no significant differences in the frequency distribution of internal or external parasites on white sucker within Garvins or Hooksett Pools. Resident fish species in aquatic habitat that has been adversely impacted by a thermal discharge characteristically manifest more frequent infestation of internal and external parasites compared to the same species resident in a thermally uninfluenced area, indicating a reduction in the overall health and conditions of the fish due to thermal impacts. These observations support the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool.

White sucker reproductive state was similar between Garvins and Hooksett Pools during the spring sampling period as indicated by mean gonadosomatic index values. The age at 50% maturity was similar for male white sucker and slightly older in Hooksett Pool for female white sucker. The length at 50% maturity was smaller in Hooksett Pool for male white sucker and similar for female white sucker. Estimates of fecundity (i.e., number of eggs per ripe female) were similar for individuals collected in Garvins and Hooksett Pools.

Page 63, Section 5.6.2.1.5a: USEPA states:

> *The electrofishing data analyzed suggests that the populations of neither largemouth nor smallmouth bass have experienced a significant decrease in abundance over time. As with all other trends analyses performed by Merrimack Station utilizing electrofishing data, the plant does not clearly identify what fraction of the fish sampled are juveniles versus adults. A relatively large juvenile population is not necessarily indicative of a stable adult population if juvenile mortality is high. Young-of-year black bass are highly susceptible to predation and cannibalism by larger fish (Coutant and DeAngelis 1983).*

Trends analyses were conducted using available electrofish data from annual summary reports for years during the 1970s and from field data sheets describing collections during 1995 and the 2000s. Age data for fish collected by electrofishing is not provided in the 1970s reports. Although age distributions for catch in trap net samples are available for years during the 1970s, variation in recruitment to those two very different gear types prevents any meaningful application of that distribution to electrofish catch.

Pages 63-64, Section 5.6.2.1.5b: USEPA states:

> *EPA compared the results of electrofishing with those of trapnetting for studies conducted in the 1960s. While the two sampling methods yielded similar results for smallmouth bass, trapnetting for largemouth bass appeared to significantly under-represent the largemouth population compared to electrofishing samples. In this case, EPA concluded that electrofishing sampling was a more reliable indicator of the largemouth bass population, although recognizing the ambiguity associated with lumping juveniles and adults together to assess populations. According to the Fisheries Analysis Report, smallmouth bass ranks first in the 2000s, with an average relative abundance of 42.8 percent. In the 1970s, the relative abundance was only 5.1 percent. While this appears to suggest that the population of smallmouth bass has increased dramatically over the past 30 years, sampling effort data indicates it has not. Drawing again from Merrimack Station's Fisheries Analysis Report (Table 3-17, p.'74), smallmouth bass CPUE has actually declined slightly from 3.1 fish in the 1970s to 2.8 fish in the 2000s. Only because the populations of most resident, indigenous species have declined so dramatically does the smallmouth bass population appear robust by comparison.*

Relative abundance is not the best measure for assessing trends in fish abundance over time, as variable catches of one fish species over time can impact the total contribution of a stable fish species to the whole count. The use of CPUE to compare abundance over time is most appropriate because it standardizes the catch to the level of effort exerted. USEPA's statement that smallmouth bass have declined from the 1970s to the 2000s based on visual examination of a difference in trap net CPUE from 3.1 fish to 2.8 fish is inappropriate. There is no significant difference between smallmouth bass trap net CPUE from the 1970s and smallmouth bass trap net CPUE from the 2000s (ANOVA, F = 0.2903, P = 0.5907). Smallmouth bass in Hooksett Pool are stable as shown by the most recent electrofish trends analysis (Normandeau 2011a). A Kendall tau test was unable to detect any significant trends in the abundance of smallmouth bass for the 1972-2011 time period.

In addition, Normandeau questions USEPA's inconsistency in, on one hand, worrying about the purported "ambiguity associated with lumping juvenile and adults together to assess populations" when commenting on the use of boat electrofishing data but, on the other hand, allowing for such ambiguity when commenting on the use of trap net data. The comparison of 1970s and 2000s trap net data (Normandeau 2007a) included both adult and juvenile fish for all species examined.

Page 64, Section 5.6.2.1.6b: USEPA states:

> *Fish sampling in 2004 and 2005 revealed the continued presence of fallfish in low abundance. Similar to the sampling in 1968 and 1969, fallfish were collected predominantly in the northern area of Hooksett Pool, upstream of the plant's thermal discharge. Of the 54 fallfish captured during August and September sampling (2004-2005), 49 fish (90.7 percent) were found in the ambient zone.*

Abundance of fallfish, a coolwater species, in Hooksett Pool was at its highest recorded level during 2011, with a total of 522 captured and a CPUE of 4.4/1,000 ft., and was significantly greater than the CPUE observed in thermally uninfluenced Garvins Pool (Normandeau 2011a). When the 2010-2011 catch was examined at boat electrofish stations located north and south of Merrimack Station, 65% of the catch was located upstream of the Station and 35% was located downstream of the Station. A total of 18 fallfish were captured during 1967 (13 downstream of Merrimack Station in the portion of Hooksett Pool USEPA claims to have been adversely impacted by the Station's thermal discharge, and 5 upstream of the Merrimack Station).

Page 65, Section 5.6.2.1.7a: USEPA states:

> *According to the Fisheries Analysis Report, of all the years evaluated between 1972 and 2005, alewives were only captured in 2004. This study does not shed much light on changes in the alewife population of the Merrimack River over time, but it does show how early juvenile alewives can descend into Hooksett Pool from rearing habitat in upstream tributaries, such as the Suncook River. While the 2004 Field Season Result of the Fisheries Analysis Report described juvenile alewives being present in the fall months, 19 of the 26 alewives captured were collected during August sampling.*

A review of Table 2-5 from the 2007 Fisheries Survey Analysis Report shows that a total of 81 alewives were captured by boat electrofishing in Hooksett Pool during the 2004 field season. Although the majority (74 of 81) were captured during August, sampling during that month took place on the 30th and 31st. The remainder were collected during September and October of that year. Juvenile alewives can be triggered to move downstream by sudden increases in outflow due to rain events. Mean daily discharge (as measured at Goffs Falls of the Merrimack River) suggests that such a rain event happened several days prior to the collection of those fish in Hooksett Pool.

A total of 20 alewives were captured in Hooksett Pool during standardized boat electrofish sampling conducted during August and September 2011. Of those 20 individuals, 17 were collected during September. In addition, during 2010 several hundred juvenile alewives were collected from Hooksett Pool for use in a bypass effectiveness study at the Garvins Falls Dam. Juvenile alewives collected in Hooksett Pool were larger than those observed in collections from Northwood Lake during the same year. In addition, a number of juvenile shad were collected from Hooksett Pool. Samples were provided to Joe McKeon (USFWS) to illustrate the size differences and to let him determine if the shad were of hatchery origin.

Pages 65-66, Section 5.6.2.2a: USEPA states:

> *Similar to the CPUE analysis, EPA reviewed the taxa richness analysis as it relates to the balanced, indigenous community Taxa richness — in this case, "species" richness — is not in and of itself a useful indicator of "appreciable harm" to the balanced, indigenous fish community. Counting the number of species present in the 2000s does not address the question of whether those species are part of the balanced, indigenous community.*

An examination of the fish species that were present in Hooksett Pool during the 1960s (see Table 5-1 of the §316 Determination Document), after adjusting for species that were not collected from Hooksett Pool itself, indicates that 15 of the 16 fish species present during the 1960s are still present during the 2000s. Walleye, which are not native and were historically maintained as a sport fish through stocking, are no longer present. USEPA considers this 1960s community to be the Hooksett Pool BIP but either fails or refuses to acknowledge that all of these fish species present in Hooksett Pool in the 1960s, with the exception of a stocked sport fish, were still present in the pool in the 2000s.

USEPA goes on to state:

> *In addition, while taxa richness is commonly used as an index for analyzing the effects of pollutants on aquatic organisms, it can be misleading when evaluating the effects of heat on the aquatic environment. Differences in mean temperature strongly influence species richness across sites, with a general increase in species richness from coldwater to warmwater categories (Wehrly et al. 2003). Therefore, an increase in species found in a thermally-influenced waterbody is not necessarily desirable. Such an increase in species richness in the fish community is likely associated with the intentional or accidental introduction of new species.*

Rather than compare the current Hooksett Pool fish community to the historical fish community that was present in the degraded aquatic conditions in Hooksett Pool during the 1960s (Normandeau 2011b), comparisons of taxa richness should be made between the current fish communities in Garvins Pool and Hooksett Pool. Because Garvins Pool is located just upstream from Hooksett Pool and is not influenced by Merrimack Station's thermal discharge, any differences in taxa richness between Garvins and Hooksett Pools would be indicative of any effects of the Station's discharge on the aquatic environment in Hooksett Pool. During standardized boat electrofish community sampling conducted during 2010 and 2011, taxa richness was similar between Garvins and Hooksett Pools (Normandeau 2011a). A total of 20 species was collected in Hooksett Pool during both sampling years, and totals of 18 and 16 were collected in Garvins Pool during 2010 and 2011, respectively.

Resident species collected from Hooksett Pool that were missing in Garvins Pool during both years were represented by fewer than seven individuals in all cases. USEPA is again trying to make the argument that fish species not present in Hooksett Pool in the 1960s – such as bluegill, spottail shiner, black crappie and rock bass – are now present in Hooksett Pool due solely to the effects of Merrimack Station's thermal discharge. However, all four of those species have been detected regularly in Garvins Pool, located upstream and away from any thermal inputs (Normandeau 2011a).

Page 67, Section 5.6.2.3: USEPA states:

> *Rank-abundance builds on taxa richness as a measure of community structure by incorporating a weight to each species based on its relative abundance to the sampled catch as a whole. According to the Fisheries Analysis Report, rank-abundance is a useful index to assist in demonstrating "no prior appreciable harm" to a community by providing a comparable method to track the relative abundance of fish species over time and space. According to EPA's Draft 316(a) Technical Guidance: "Relative abundance can fluctuate seasonally and diurnally; however, it should not be significantly different from year to year. Significant shifts in relative abundance over a period of time are indicative of changes within the fish community."*

Rank abundance is not intended to be the sole metric used in the assessment of changes in abundance for a particular species, as it is highly influenced by catch of other species. The abundance for a species of interest may remain consistent across years but due to increased or decreased catch of other species can rank higher or lower relative to the other species among the years examined.

Pages 68-69, Section 5.6.2.3.1a: USEPA states:

> *These data illustrate the significant decline in relative abundance for some representatives of the balanced, indigenous community (e.g., pumpkinseed and yellow perch) between the sampling periods in the 1960s and 1970s, compared to those of the 1990s and 2000s. For other representative species (e.g., largemouth bass and redbreast sunfish) there is minimal change, or even a notable increase.*

It is misleading and inappropriate for USEPA to declare that the changes in relative abundance of these species are "significant" unless it can provide statistical validation for its conclusory statements. Use of the term "significant" in this context implies that USEPA's conclusions are statistically supported. If USEPA has run a statistical analysis on these relative abundance data, it should make the methodology it used in its analysis available for review.

Page 69, Section 5.6.2.3.1a: USEPA states:

> *In addition to the shift in relative abundance among species, there was a significant decline in number of fish caught during comparable sampling. A total of 1,281 fish, representing 12 species, were collected in 1972 during electrofish sampling in August and September. By comparison, only 446 fish were caught in 2005, a 65-percent decline.*

Again, USEPA's use of the word "significant" implies that USEPA has identified a statistically supported difference; however, USEPA has provided no statistical support. More importantly, USEPA's comparison of raw catch number between the years of 1972 and 2005 is improper. As USEPA should know, raw catch numbers are essentially meaningless unless they have been scaled to represent effort (i.e., CPUE). All of Normandeau's trend analyses have properly used CPUE to evaluate potential declines in abundance (Normandeau 2007a, Normandeau 2011a). If one were to follow the approach that USEPA has used here to its logical conclusion, one would conclude that between 1972 and 2010, there was a 51% increase in number of fish caught during comparable sampling (from a total of 1,281 fish in August and September 1972 to a total of 2,589 fish in 2010). However, this conclusion would be erroneous because the raw catch values have not been scaled for effort, which varies among years.

Page 71, Section 5.6.2.3.2b: USEPA states:

> *The rank-abundance analysis for pumpkinseed based on trapnet data depicts an even greater decline than electrofishing data collected in the 1970s and 2000s. Based on trapnet data, pumpkinseed ranked second only to brown bullhead catfish in 1972. The average relative abundance during the 1970s was 19.5 percent, with 1,208 fish being caught during the years selected for analysis. In 1967, before Unit 2 came on line, 772 pumpkinseeds were caught in September alone, representing 53.4 percent of the total fish caught.*

The overabundance of pumpkinseed in Hooksett Pool during the 1960s and 1970s is an example of an unbalanced and impaired fish population where one or several species dominate catches. Relative abundance of pumpkinseed in Garvins Pool, located upstream from Hooksett Pool and uninfluenced by Merrimack Station's thermal discharge, was 5.5% of the total fish captured in 2010 and 5.9 % in 2011.

Pumpkinseed dominated the fish assemblage sampled below Cromby Generating Station (Schuylkill River, PA) prior to the enactment of the CWA (Normandeau 2011c). Pumpkinseed accounted for 44% of all fish caught during sampling from 1970 through 1973. Pumpkinseed abundance remained extremely high for over 15 years after Units 1 and 2 became operational at Cromby, indicating that thermal effluent was not a major deterrent for this species. However, with the improvements in river water quality that resulted from the CWA, pumpkinseed represented a smaller percentage of the catch during sampling in 1976 (28%), 1989-1990 (25.6%) and 2007 (0.2%) (Normandeau 2011c).

Page 72, Section 5.6.2.4: USEPA states:

> *Species such as bluegill and spottail shiner, not collected during electrofishing and trap net sampling in the 1960s and 1970s, were numerically dominant in sampling conducted in the 1990s and 2,000s. The extent to which the presence and abundance of these two species affects the results of these analyses cannot be readily assessed by EPA with the information provided.*

USEPA was provided with the methodology used for determination of the Bray-Curtis similarity calculation in the 2007 Fisheries Survey Analysis Report (Normandeau 2007a). Determination of the Bray-Curtis similarity value comparing the 1970s to 1995 or the 2000s would not be impacted at all by the presence of a fish species that was only present in one of the two data sets being compared. This index of similarity is determined only by species present in both data sets.

Pages 72-73, Section 5.6.2.4a: USEPA states:

> *EPA reviewed this analysis as it relates to potential impacts to the receiving water's balanced, indigenous community from the facility's thermal discharge. Merrimack Station contends that greater similarities between fish communities in the thermally-influenced zone compared to the ambient zone during sampling conducted in 1995 and the 2000s supports a finding of "no*

> *appreciable harm." Yet, this argument fails to address impacts to the balanced, indigenous community since the balanced, indigenous community is most closely represented in this analysis by the 1970s fish community It is obvious from the sampling data that significant adverse impacts to the Hooksett Pool's balanced, indigenous fish community had already occurred by 1995 (Figure 5-8).*

USEPA states that the fish community observed in Hooksett Pool during the 1970s most closely represents the BIP to which the current Hooksett Pool fish community should be compared to assess the potential impacts of Merrimack Station's thermal discharge. By this statement, USEPA again calls attention to the fact that it is either ignoring or overlooking the fact that the substantial improvements in water quality in the Merrimack River since the enactment of the CWA in 1972 (Normandeau 2011b) have appreciably influenced the fish community in the river, including in Hooksett and Garvins Pools, during the operation of Merrimack Station. Normandeau suggests that the current fish community in Garvins Pool provides a more appropriate point of comparison. Immediately upstream of Hooksett Pool, Garvins Pool is uninfluenced by the Station's thermal discharge but has similarly benefited from the significant water quality improvements that have occurred in the Merrimack River since 1972.

USEPA goes on to state:

> *Data from 1995, 2004, and 2005 show that bluegill, largemouth bass, smallmouth bass, and redbreast sunfish maintain numerical dominance in Hooksett Pool from 1995 to 2005 in the thermally-influenced zone. These species, all members of the sunfish family, have a comparatively high tolerance to heat. The greater similarity between 1995 and the 2000s in the thermally-influenced zone versus the ambient zone suggests to EPA that the most heat tolerant species are likely to remain numerically dominant in the thermally-influenced zone, and generally to fare better throughout Hooksett Pool than less heat-tolerant species. As heat is a regulated pollutant, and the focus of this 316(a) variance request, EPA considers the dominance of heat-tolerant species in Hooksett Pool to be indicative of appreciable harm to the balanced, indigenous community.*

Since Hooksett Pool consists of a single fish population, it makes more sense to compare the abundance of fish species in Hooksett Pool to a thermally uninfluenced portion of the Merrimack River, such as the immediately adjacent upstream Garvins Pool. Recent boat electrofish sampling (2010 and 2011) documented these four fish species occurring in both Garvins and Hooksett Pools (Normandeau 2011a). Rather than focus on relative abundance, which can be influenced by the within-year catchability of other fish species, Normandeau examined CPUE data for bluegill, largemouth bass, smallmouth bass and redbreast sunfish in Garvins and Hooksett Pools. During 2010, CPUE for bluegill, smallmouth bass and redbreast sunfish were greater in Hooksett Pool than Garvins Pool, whereas CPUE for largemouth bass was greater in Garvins Pool. During 2011, there was no significant difference in the CPUE for bluegill between pools, but CPUE for largemouth bass, smallmouth bass and redbreast sunfish was higher in Hooksett Pool.

Page 75, Section 5.6.2.4b: USEPA states:

> *EPA finds Merrimack Station's explanation for a nearly 77-percent change in the balanced, indigenous community since the 1970s unpersuasive and unsupported. Fish species in Hooksett Pool utilize the entire pool. The heated discharge from Merrimack Station has a*

> *capacity to directly affect approximately half of the available habitat in Hooksett Pool. As such, impacts to a particular species south of the discharge are likely to affect the entire pool-wide population.*
>
> *Merrimack Station suggests that introduced centrarchids (sunfish family), and bluegill in particular, caused the change in the Hooksett Pool fish community As insectivores, bluegills likely compete with pumpkinseed sunfish and yellow perch for the same forage. However, Merrimack Station's suggestion that bluegill dominance and other species' decline are unrelated to the plant's thermal discharge is incorrect and overlooks the importance of the thermal preferences and tolerances of these species.*

Throughout the §316 Determination Document, USEPA continually disregards or overlooks the significant beneficial effects that the improvements in Merrimack River water quality starting after 1972 have had on the fish and fauna of both Hooksett and Garvins Pools. Bluegill were the third most abundant species (tied with largemouth bass at 1.7 fish/1000 ft) in thermally uninfluenced Garvins Pool during electrofish sampling in 2011, and they were not present in this pool in the 1960s (Scarola 1987). Therefore, bluegill abundance in Garvins Pool cannot be the result of thermal preferences.

Degraded water quality present in the 1960s and the early 1970s and its impacts on all aquatic life in Hooksett Pool has been overlooked as an important factor. Evidence from changes in the Cromby Generating Station, Schuylkill River PA, fish assemblage from the 1970s to the 2000s provides support for this claim. The continued domination of pumpkinseed within the species assemblage in the Schuylkill River below the thermal discharge for over 15 years with both units operational, and the fact that the species has been documented nesting in water up to 36.1ºC in the vicinity of the Cromby Generating Station, indicate that increased thermal conditions are not a major deterrent to pumpkinseed (Normandeau 2011c) In a recent report titled "Thermal Toxicity Literature Evaluation" (EPRI 2011), it was determined that at acclimation temperatures of 20ºC or greater, all *Lepomis* species tested had Critical Thermal Maximums ("CTMs") greater than 35ºC.

In areas of poor water quality, it has been demonstrated that pumpkinseed do have advantages over bluegill. In lakes where bluegill and pumpkinseed ranges overlap, it has been theorized that lakes containing only pumpkinseed are due to winterkill of bluegill unable to cope with the hypoxic (low dissolved oxygen ("DO")) conditions (Oseburg et al. 1992, Fox 1994, Tomacek et al. 2007). Pumpkinseed are more capable of withstanding lower DO levels and fluctuating environmental conditions than bluegill (Fox 1994), allowing them to survive in conditions that effectively eliminate bluegill. It is likely that organic pollution in the Merrimack River prior to the 1972 enactment of the CWA led to the low DO levels documented in the river during the 1960s and early 1970s (Normandeau 2011b): conditions that would have been advantageous for a species such as pumpkinseed, which can tolerate such extremes.

Given the pumpkinseed's ability to withstand lower DO and fluctuating environmental conditions, it is likely that the Merrimack River's improved water quality in recent years may have contributed to the pumpkinseed's reduced abundance in the current Hooksett Pool fish assemblage, and allowed for a rise in abundance of bluegill.

Page 77, Section 5.6.2.5: USEPA states:

> *As with other analyses in this report, EPA reviewed this analysis within the context of its relevance to support a finding of "no prior appreciable harm" to the balanced, indigenous community of fish. Length-weight data was collected from 1972 through 1978, and provided in the 1979 Summary Report, but was not used in this analysis. Yellow perch, smallmouth bass, and pumpkinseed were analyzed. It is unclear why Merrimack Station chose not to incorporate these important years of data into its analysis. Instead, Merrimack Station states in the Fisheries Analysis Report that it selected four numerically-abundant species for analysis (yellow perch, bluegill, smallmouth bass and largemouth bass) for the years 1995, 2004, and 2005.*

The raw length-weight data collected 36 to 40 years ago (1972-1978) were not available to include in the current analyses. Furthermore, at least part of that data set probably represents a period of transition, when the Merrimack River fish community was recovering from an extended period of poor water quality. To address USEPA's concern that length-weight relation data presented in the 1979 Summary Report was not used to support a finding of no prior appreciable harm, length-weight relation data for yellow perch, smallmouth bass and pumpkinseed data is assessed here.

The condition or relative "fatness" of fish in Hooksett Pool can be described by the relation between total length (L, mm) and total weight (W, g). The curvilinear L-W relation expressed as W = aLb was parameterized by estimating the growth parameters a and b based on coefficients obtained from similar linear regression of log10(W) = log10(a) + log10(L) where log10(a) is the y-intercept and b is the slope (Ricker 1975). An analysis of covariance ("ANCOVA") can be used to compare L-W relations of two or more fish populations. This approach does not require isometric growth or knowledge of an L-W relation of a "standard" population to be a valid metric of condition as does the condition factor and relative weight (Ricker 1975, Cone 1989, Anderson and Neumann 1996, Pope and Krause 2007). However, raw length and weight observations of representative indicator species of fish collected by trap net from 1972 through 1978 were not available to include in an ANCOVA to compare the L-W relations of fish among years or periods (e.g., 1970s versus 2000s). Instead, the Merrimack River Monitoring Program Summary Report (Appendices E-13 to E-15, Normandeau 1979b) reported the parameter estimates of individual regressions describing the L-W relation of pumpkinseed, smallmouth bass and yellow perch from annual trap net catches at each station within Hooksett Pool from 1972 through 1978. To assess whether condition of these three fish species has changed since the 1970s, regression parameter estimates for the L-W relation of trap net catch during 1972-1978 and 2004-2005 were compared.

The comparison of the L-W relation between the 1972-1978 and 2004-2005 populations should be valid assuming the two populations were representatively sampled by gear of similar body size selectivity and at the same locations. The same four stations in Hooksett Pool were sampled by a similar trap net during 2004 (April-October and December) and 2005 (May-September) (Normandeau 2007a). However, sample sizes were insufficient to derive individual L-W regressions at each station to compare to those estimates reported for each station sampled during 1972-1978. Furthermore, some of the parameter estimates derived from the 1972-1978 trap net catch data were based on small sample sizes as few as three individuals, which may result in statistically variable growth parameters that are not representative of the true L-W relation of a species in Hooksett Pool. To remedy the problems of limiting sample sizes and to derive a more robust L-W relation representative of Hooksett Pool, the regression parameter estimates from the L-W relation of the aggregated catch during 2004-2005 was compared to the weighted mean of the reported slope (b) and the y-intercept (log10a) estimates for the 1972-1978 trap net catches. Sample size was used to weight the mean parameter estimate. The regression parameter estimates for the 2004-2005 trap net catch were then statistically compared to the weighted mean estimate for 1972-1978 trap net catch using a one-sample t-test at two-tailed significance level of 0.05. This test assumes the weighted mean parameter estimates for 1972-1978 are known values without error, which is certainly not true since these were also empirically derived from samples. Nevertheless, knowledge of the error associated with the 1972-1978 would not change the conclusion of failing to reject the null hypothesis that a growth parameter derived from the 1972-1978 and 2004-2005 catch was equal. However, assuming no error associated with the 1972-1978 parameter estimates increases the probability of making a Type I error by rejecting a true null hypothesis.

Figure 3-2 compares the L-W relation of smallmouth bass using all 229 individuals collected by trap net in Hooksett Pool during 2004-2005 and the L-W relation based on the weighted mean parameter estimates from the 1972-1978 regressions. The slope (3.10) of the L-W relation for smallmouth bass during 2004-2005 was not significantly different from the weighted mean (3.02) of the slope estimates reported for the 1972-1978 catch ($t = 1.32$, $P = 0.186$). The y-intercept estimate (-5.14) of the L-W relation for smallmouth bass during 2004-2005 was not significantly different from the weighted mean (-5.17) of the y-intercept estimates reported for the 1972-1978 catch ($t = 0.23$, $P = 0.819$). However, the regression for the 2004-2005 data includes observations that were considered statistical outliers if the absolute value of the studentized deleted residual was greater than the t-critical value (Bowman and O'Connell 1990). Figure 3-3 presents the L-W relation of smallmouth bass of the 2004-2004 trap net catch, but without the outliers included in the regression. After removing these outliers, the slope (3.01) of the L-W regression of smallmouth caught during 2004-2005 was not significantly different from the weighted mean (3.02) of the slope estimates reported for the 1972-1978 catch ($t = -0.09$, $P = 0.926$), but the y-intercept parameter for the 2004-2005 L-W relation was significantly higher than that for 1972-1978 estimate ($t = 3.24$, $P = 0.001$).

Figure 3-4 compares the L-W relation of yellow perch using all 15 individuals collected by trap net in Hooksett Pool during 2004-2005 and the L-W relation based on the weighted mean parameter estimates from the 1972-1978 regressions. The slope (3.42) of the L-W relation for yellow perch during 2004-2005 was significantly greater than the weighted mean (2.93) of the slope estimates reported for the 1972-1978 catch ($t = 4.96$, $P < 0.001$). The y-intercept estimate (-5.96) of the L-W relation for yellow perch during 2004-2005 was significantly lower than the weighted mean (-5.01) of the y-intercept estimates reported for the 1972-1978 catch ($t = -4.20$, $P = 0.001$).

A comparison of the L-W relation for pumpkinseed was not made because only four pumpkinseeds were caught by trap net at these stations during 2004-2005. While the two populations of smallmouth bass shared similar incremental weight gain with increasing length, there was evidence that smallmouth bass at a given length during 2004-2005 weighed significantly more (i.e., was in better condition) than those during 1972-1978 once statistically significant outliers were removed from the L-W regression. The L-W relation of yellow perch caught during 2004-2005 showed this population to have significantly higher incremental weight gain with increasing length than that of the population during 1972-1978. Therefore, differences in condition (weight) cannot be compared between the two periods without referencing a length. At larger lengths, yellow perch may have weighed more during 2004-2005 than during 1972-1978 but may have weighed less at smaller lengths during 2004-2005 than during 1972-1978.

Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a decreasing slope to the length-weight curve – signifying progressively lower weight for a given length – for a resident fish species over time or in comparison to the same species residing in thermally uninfluenced habitat. Such a decreasing slope indicates a reduction in quality of body condition due to the thermal impact. Analysis of yellow perch and smallmouth bass length-weight data during the 2000s do not show a reduction in condition when compared to catch from the 1970s. These observations are not consistent with the hypothesis that Merrimack Station's thermal discharge has caused appreciable harm to the BIP in Hooksett Pool.

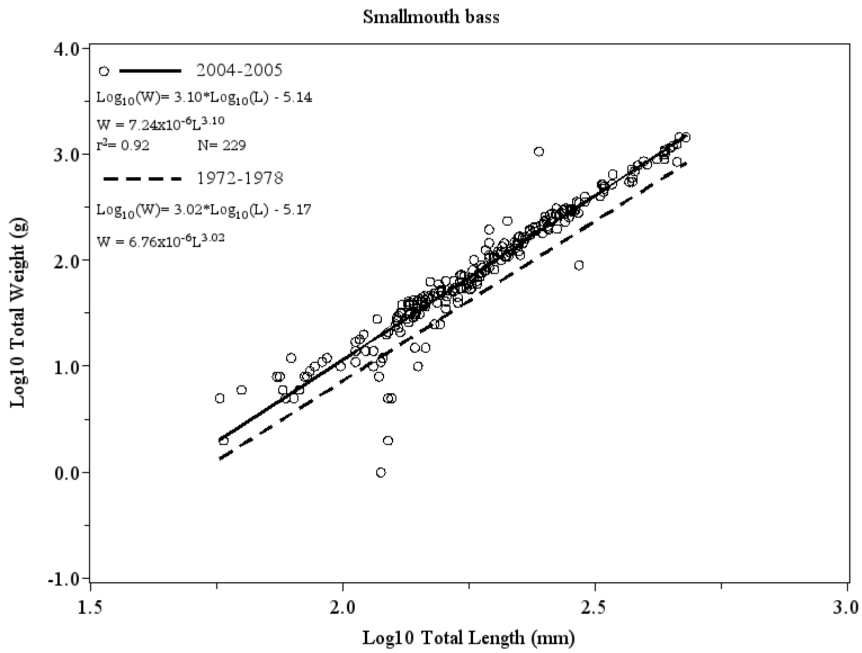

Figure 3-2. Relation between total length (L, mm) and total weight (W, g) of smallmouth bass caught by trap net in Hooksett Pool during 2004-2005 and compared to the L-W relation based on the weighted means of the growth parameter estimates reported for the 1972-1978 trap net catch (Normandeau 1979b).

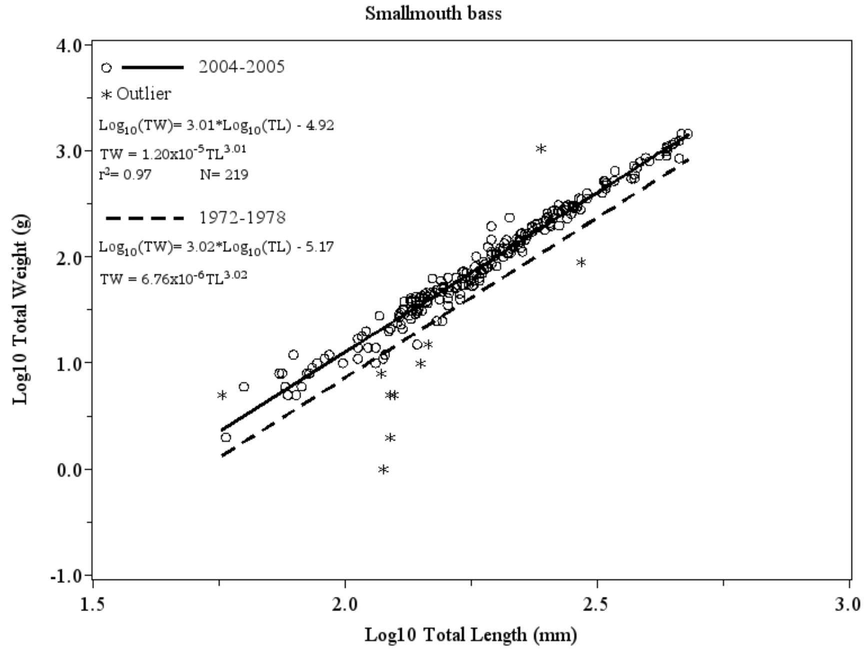

Figure 3-3. Relation between total length (L, mm) and total weight (W, g) of smallmouth bass caught by trap net in Hooksett Pool during 2004-2005 and compared to the L-W relation based on the weighted means of the growth parameter estimates reported for the 1972-1978 trap net catch (Normandeau 1979b), after removing statistical outliers (stars) were excluded from the regression.

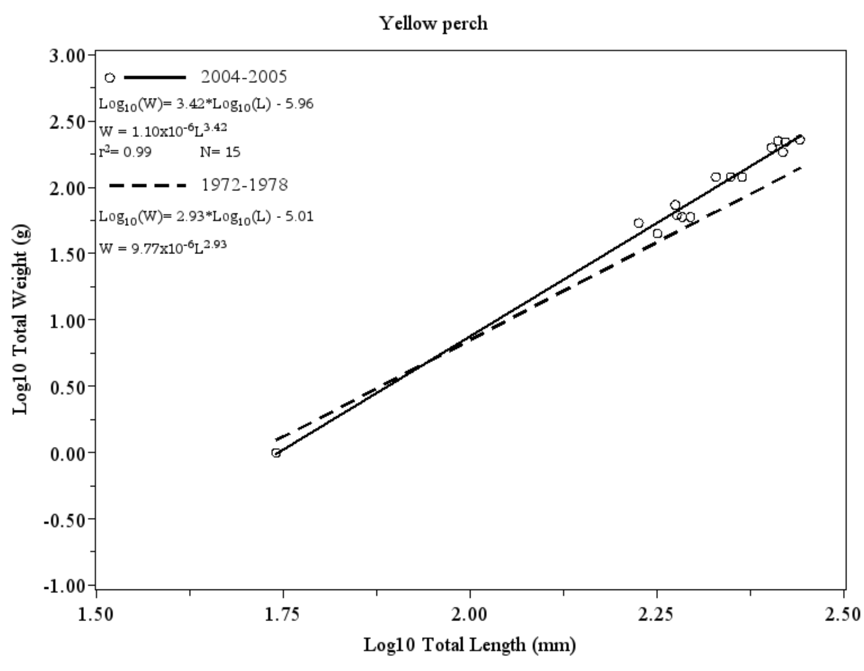

Figure 3-4. Relation between total length (L, mm) and total weight (W, g) of yellow perch caught by trap net in Hooksett Pool during 2004-2005 and compared to the L-W relation based on the weighted means of the growth parameter estimates reported for the 1972-1978 trap net catch (Normandeau 1979b).

Pages 77-78, Section 5.6.2.6: USEPA states:

> *Merrimack Station compared the changes in biomass between the years 1995 and 2005 for the trophic guilds represented by the fish community of Hooksett Pool. These trophic guilds include filter feeder, generalist, herbivore, insectivore, and piscivore. Merrimack Station concludes that, over the past 10 years, insectivore guild biomass has remained relatively stable, there has been a reduction in the generalist guild, and an increase in the omnivorous and piscivorous guilds. Merrimack Station's conclusion is that these results support a finding of no prior appreciable harm to the balanced, indigenous population found in Hooksett Pool "during the evaluation period." As with the length-weight relationship analysis, the "evaluation period" Merrimack Station selected is from years when the "balanced, indigenous populations" had already been impacted by Merrimack Station's increased thermal discharges, despite the availability of data from the 1970s. Therefore, this analysis also does not address the pertinent question of prior appreciable harm to the balanced, indigenous community.*

A second review of the 1970s annual reports (Normandeau 1973a, Normandeau 1974a, Normandeau 1975a, Normandeau 1976a, Normandeau 1977a, Normandeau 1979b) indicates that values for total weight of all individuals (by species) captured by boat electrofishing at each unique sampling station and sampling month are not provided. Minimal weight data from the 1960s is available (Normandeau 1969). However, this report provided only a total weight (by species) for all fish collected from Hooksett Pool. Without more detailed information indicating at which what sampling station those fish were captured, at it is inappropriate to make a direct comparison with total weight data collected during 1995, 2004 and 2005.

Due to the absence of weight data required to directly assess changes in biomass, a series of four community metrics were used to examine changes in the Hooksett Pool fish community during the 1972-2011 time period (i.e., for August and September of 1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010 and 2011)(Normandeau 2011a). Electrofish data from the 1972-2011 time period was evaluated in this analysis, and species richness, Shannon diversity, percent omnivores/generalists, and percent tolerant individuals were calculated.

As explained in detail in the 2011 Fisheries Survey Analysis Report, species richness in Hooksett Pool has increased slightly from 1972 to 2011 (Normandeau 2011a). The number of taxa observed during 1972 and 1976 were the lowest overall of the nine sample years considered (12 species) while the greatest number of taxa were observed during 2011 (19 species). Within the Hooksett Pool time series, taxa richness increased from 12 species sampled during 1972 to 19 sampled in 2011 (with expected variability from sample year to sample year), supporting a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool over the 1972-2011 time period. Of the 12 species observed during the August-September electrofish sampling effort in 1972, only brown bullhead was not represented within the most recent (2011) August-September electrofish sampling effort.

Examination of the Shannon Diversity Index values for the fish community in Hooksett Pool suggests that relative to 1972, diversity in Hooksett Pool during the most recent sampling year (2011) has increased (Normandeau 2011a). However, examination of diversity index values for all years reveals a pattern of year-to-year variability.

The percentage of omnivores/generalists in a community increases as the physical and chemical habitat deteriorates (Barbour et al. 1999). Examination of the percent omnivore/generalist values for Hooksett Pool peaked during the 1970s, indicating a degraded environment (Normandeau 2011a). More specifically, of the twelve fish species recorded in August and September of 1972 (the first year of available data with consistent and documented sampling effort), seven were listed as generalist feeders and the remainder were listed as piscivores. Of the nineteen fish species recorded in August and September of 2011 (the most recent year of available data with consistent and documented sampling effort), nine were listed as generalist feeders. The remaining fish species detected during 2011 represented the insectivore and piscivore trophic guilds. The percentage of generalist feeders in Hooksett Pool was highest during 1976 (75.7%) and lowest during 2010 (22.3%). The decrease in percent generalist feeders from the 1970s to present can be attributed to the decrease in abundance of pumpkinseed, a generalist feeder that represented more than 50% of the Hooksett Pool fish community during the early 1970s. As noted above, decreases in pumpkinseed are likely linked to improved water quality, which led to decreases in submerged aquatic vegetation and an increase in competition for resources with bluegill. The reduced percentage of generalist feeders in Hooksett Pool from 1972 to 2011 supports a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool.

The percentage of tolerant individuals in a community increases as the physical and chemical habitat deteriorates (Barbour et al. 1999). Of the twelve fish species recorded in August and September of 1972, five were listed as pollution-tolerant, with the remainder listed as intermediate in their tolerance to pollution. Of the nineteen fish species recorded in August and September of 2011, six were listed as pollution-tolerant, with the remainder listed as intermediate in their tolerance to pollution. The percentage of pollution-tolerant species in Hooksett Pool was highest during 1995 (42.0%) and lowest during 1973 (5.2%). The increased abundance of bluegill in Hooksett Pool during 1995 is the principal factor in the elevated percentage of pollution-tolerant species in Hooksett Pool observed during that year. The percentage of tolerant individuals was higher during recent sampling than was observed during most years of the 1970s due to the shift from pumpkinseed to bluegill in the pool (Normandeau 2011a). The predominance of bluegill in recent years was due to the ability of pumpkinseed to outcompete bluegill in the degraded water quality of the 1970s.

Page 78, Section 5.6.3: USEPA states:

> *EPA finds Merrimack Station's arguments for a finding of "no prior appreciable harm" to the balanced, indigenous community unsupported by the data. The absence of any substantive analysis utilizing data collected in the 1960s — the period immediately prior to and following the start-up of Unit 2 — is probably this demonstration's greatest deficiency.*

Normandeau wholeheartedly disagrees with USEPA's selection of the 1960s Hooksett Pool fish community as the Hooksett Pool BIP. As described by Normandeau (Normandeau 2011b), the Merrimack River was substantially polluted due to anthropomorphic input from the early 1800s through the 1970s. Both the river's water quality and the diversity and abundance of those organisms living in and around the river reflected this substantially polluted state. Improvements in water quality began with the passage of New Hampshire's first water pollution control act in 1947. This statute established the New Hampshire Water Pollution Commission "to investigate pollution of surface waters, to recommend classification of surface waters, and to enforce such classification," and required towns and cities to take steps to protect water quality (NH Laws 1947, ch. 183). Efforts at improving Merrimack River water quality were dramatically strengthened in 1974 when, following the 1972 enactment of the federal CWA, New Hampshire mandated secondary treatment for all wastewater discharges in the state (NEIWPCC 2011). The Merrimack River has been in a continuing state of recovery probably since the decline in its river-based manufacturing, but, according to available data, certainly since the early 1970s.

Given this, the Agency's selection of the 1967-1969 fish community as the Hooksett Pool BIP, and its failure, in making this selection, to account in any way for the severe, non-thermal discharge-related water quality impairments that adversely affected the Merrimack River during the 1960s, are the most significant and pervasive flaws in USEPA's §316(a) analysis. In its desire to link *all* of the changes that have occurred in Hooksett Pool since the 1960s to Merrimack Station's thermal discharge after May 1968 (when Unit 2 came on-line), USEPA has overlooked both these severe water quality impairments and how pollution of that magnitude negatively impacts and alters biological communities. Evidence of the Merrimack River's poor water quality during the 1960s is well-documented in the ecological reports produced during the 1960s and 1970s, including USDI (1966). Moreover, USEPA, PSNH and Normandeau specifically discussed the potential impacts of the Merrimack River's non-thermal discharge-related water quality impairments during the late 1960s on the biological community in Hooksett Pool during those years at a 2006 meeting. However, USEPA does not raise this issue once in the §316(a) Determination Document. This is puzzling, given that the improvement in water quality is likely the greatest ecological change to have occurred in the river over the past forty years.

The fish community in Hooksett Pool has changed dramatically between 1967-1969 and the present day (Table 2-1 above). By not providing an accurate picture of the current fish community in Hooksett Pool in the Draft NPDES Permit, USEPA obscures the obvious differences. Many of the fish species in the current Hooksett Pool fish community could not have survived the conditions found in the Hooksett Pool of 1967-1969. The high numbers of yellow perch, pumpkinseed, white sucker, brown bullhead and golden shiners captured in 1967-1969 will not be seen in Hooksett Pool again, because that fish community was a result of the severely impaired water quality that existed in the Merrimack River at the time. Even so, USEPA inappropriately bases the bulk of its §316(a) analysis on these five fish species in an attempt to demonstrate that the drop in abundance for these species was caused solely by the Station's thermal discharge into Hooksett Pool. Omitting any discussion about the improvements in Merrimack River water quality in the Draft NPDES Permit or the §316(a) Determination Document allows USEPA to advance the false argument that all of the changes to the Hooksett Pool BIP since the 1960s are solely attributable to Merrimack Station's thermal discharge. Indeed, the changes to the Hooksett Pool fish community that have occurred over the decades as water quality has so significantly improved should not be characterized as a negative outcome. Rather, because of these water quality improvements, the aquatic community that exists in Hooksett Pool today is healthy and more diverse than the community that existed during the 1960s.

Instead of embracing this error of fact and law, USEPA should have adopted one of the following two approaches. It should have found, based on the fisheries and macroinvertebrate sampling data from 1972-2011, that the current fish community in Hooksett Pool is the proper BIP for the purpose of considering PSNH's request for renewal of Merrimack Station's §316(a) variance. The current fish community in Hooksett Pool meets USEPA's definition of "balanced indigenous population," because it is a community characterized by (1) diversity at all trophic levels, (2) the capacity to sustain itself through cyclic seasonal changes, (3) the presence of necessary food chain species, and (4) non-domination by pollution-tolerant species (40 C.F.R. §125.71(c)). In the alternative, USEPA should have found that the current fish community in Garvins Pool provides a more appropriate point of comparison that may allow the identification of trends in Hooksett Pool that are potentially due to Merrimack Station's thermal discharge. Immediately upstream of Hooksett Pool, Garvins Pool is uninfluenced by the Station's thermal discharge but has similarly benefited from the significant water quality improvements that have occurred in the Merrimack River since 1972.

Pages 79-80, Section 5.6.3.2: USEPA states:

> *The forage for all life stages of fish, but especially the larval and juvenile stages, can also be affected by Merrimack Station's thermal plume. Forage such as zooplankton, phytoplankton, and aquatic insects, come in contact with the thermal plume as it moves down the river, or they may avoid it, if able. Many plankters drifting down the river are pulled through the plant with the cooling water and discharged back into the river within the thermal plume. Merrimack Station has historically entrained a large fraction of the planktonic community passing the plant, given the plant's demonstrated capacity to withdraw 75-100 percent of the river's available flow under low-flow conditions. It continues to do so at its present capacity, which withdraws 62 percent of the flow under 7Q10 low-flow conditions, and up to 83 percent on a single day (e.g., August 14, 2001) (See Section 11.2.1b). Organisms entrained through the cooling system suffer mechanical and thermal stresses to such a degree that most are likely killed or impaired. For assessing entrainment impacts of cooling water intake structures, EPA typically assumes 100- percent mortality.*
>
> *Data presented from one of the earliest studies of Hooksett Pool's plankton community was provided in NHFGD's report, "Merrimack River Thermal Study." According to this report, which covered the years 1967-1969, "[t]here appears to be a reduction in the frequency of occurrence of plankton in the surface waters south of the Bow Steam Plant." (Wightman 1971). It also states: "Zooplankton such as ciliates, rotifers, flagellates and cladocera appear to be adversely affected by the heated effluent while desmids, diatoms and blue green algae indicated similar effects among the phytoplankton."*

It appears that USEPA failed to consider the extensive plankton sampling that Normandeau performed in Hooksett Pool from 1971 through 1978, the results of which are summarized in the 1979 Normandeau report *Merrimack River Monitoring Program Summary* (Normandeau 1979b). In that report, Normandeau concluded about indigenous periphyton communities in Hooksett Pool (a component of the pool's phytoplankton community) (Normandeau 1979b) that:

> Periphyton densities in Hooksett Pond were not significantly affected by the operation of Merrimack Station from 1971 through 1978 (Table 5-1). Diatom abundance was significantly reduced within the mixing zone (Stations 0-W and S-4) from 1973 to 1975, but not at the far-field station S-17, indicating downstream recovery. Diatom abundance did not differ significantly among river stations throughout the remaining study years. Similarly, green algae densities did not vary significantly among river stations during any sampling season. However, green algae often accounted for a higher portion of the discharge canal community than the river communities. Blue-green algae typically contributed a higher percentage of the periphyton community within the discharge canal and in the mixing zone

> than at ambient or far-field locations. This is most likely the result of their affinity for higher temperatures than diatoms or green algae.
>
> The absence of long-term changes in the Hooksett Pond periphyton community is most likely the result of minimal water temperature increases from ambient to far-field stations (Figure 3-3). As the water temperature exceeds the optimal range for a given organism that species cannot successfully compete with other periphyton species, and is reduced in abundance. When water temperatures again become optimal for that organism, it competes successfully and becomes re-established (Patrick, 1971: Cairns, 1956). In Hooksett Pond, decreased diatom density and increased green algae abundance within the discharge canal were temporary responses to elevated temperatures. Other periphyton studies have indicated similar patterns of temporary species reductions and downstream recovery at the far-field stations where water temperatures were similar to ambient (Trembly, 1960: Patrick 1954)

Normandeau (1979b) concluded with regard to planktonic algae, another primary producer in Hooksett Pool, that:

> Throughout the study period, chlorophyll a concentrations were significantly reduced at the discharge canal compared to ambient and far-field concentrations. Similar chlorophyll a concentrations at both ambient and far-field stations suggest that the phytoplankton standing crop recovered downstream of the discharge canal mouth. Decreased phytoplankton standing crop at the discharge canal, as estimated by chlorophyll a concentrations, confirms the observation that periphyton and phytoplankton densities are often lower within the mixing zone than in ambient regions. However, recovery of these primary producers downstream of the mixing zone has been indicated by periphyton, net phytoplankton, and chlorophyll a studies. Therefore, any effects of Merrimack Station on the primary producers of Hooksett Pond appear to be temporary and limited to near-field regions.

Zooplankton results were similar (Normandeau 1979b):

> The lack of among-station differences in the net zooplankton communities, coupled with apparent minimal entrainment mortality, in terms of the numbers of organisms entrained, suggests no reduction or adverse change in the Hooksett Pond zooplankton community due to the operation of Merrimack Station.

These data show that the plankton community was temporarily affected within the Station's cooling canal and recovered at stations located in Hooksett Pool downstream of the discharge. This does not support a finding of appreciable harm under CWA §316(a).

Page 80, Section 5.6.3.2: USEPA states:

> *Despite the importance of potential thermal impacts on the microscopic forage base for the early life stages of many fish species in Hooksett Pool, Merrimack Station's Fisheries Analysis Report provides no information on the subject. Where forage is limited, it is reasonable to expect competition between individuals and among species to be more intense. Elevated temperatures raise fish metabolism and increase the need for food, further intensifying inter-species competition. In such cases, species more tolerant to elevated temperatures would be expected to have a physiological advantage over species with lower tolerance. This phenomenon was observed in studies by Taniguchi et al. (1998), which demonstrated that,*

> *as temperatures increased, species having higher temperature tolerances competed more effectively for food than species less tolerant. This study also identified the loss of appetite of less heat-tolerant species contributing to a reduction in competitive success at higher temperatures.*

USEPA assumes forage is limited in Hooksett Pool, yet presents no data to support this assumption. As stated above, Normandeau (1979b) demonstrated no adverse impacts to phytoplankton and zooplankton, which are both important food sources, in Hooksett Pool. In addition, Normandeau calculated condition for a number of fish species collected in Garvins and Hooksett Pools during 2008-2011(Normandeau 2011a). If forage were limited in Hooksett Pool, one would expect a decreasing slope to the length-weight curve – signifying progressively lower weight for a given length – for resident fish species over time or in comparison to the same species residing in thermally uninfluenced habitat. Such a decreasing slope indicates a reduction in quality of body condition due to the thermal impact. Adequate length-weight data was available for 17 within-year condition comparisons representing ten fish species in Garvins and Hooksett Pools. In 15 of the 17 comparisons, the length-weight curves showed the fish species in Hooksett Pool grew either equally or significantly more rotund with increasing length than the same species in Garvins Pool. Only in two instances did a fish species grow significantly more rotund with increasing length in Garvins Pool than was observed in Hooksett Pool (Normandeau 2011a).

Page 80, Section 5.6.3.2: USEPA makes reference to "Dembeski et al. 2006" but fails to provide an appropriate citation in Section 14.0 (Scientific and Technical References) of its §316 Determination Document so that the reader may identify, obtain and review the referenced document.

Pages 82-83, Section 5.6.3.2b: USEPA states:

> *Temperature and dissolved oxygen ("DO") studies were conducted by PSNH during 2002 and 2003 as part of its hydroelectric licensing requirements for the Merrimack River Hydroelectric Project, which includes both Hooksett and Garvins Falls dams. Comprehensive diurnal studies conducted in July and August 2002 revealed considerable temperature and DO stratification just above Hooksett Dam, and periodic DO depressions at depth (Gomez and Sullivan Engineers 2003). PSNH, which also owns the hydroelectric plant at Hooksett Dam, attributed the elevated temperatures just above the dam to the thermal plume from Merrimack Station, according to the PSNH draft application to FERC, dated July, 2003.*

Normandeau disagrees with USEPA's contention that Hooksett Pool water quality is currently impaired. This is an odd assertion, given that the State of New Hampshire granted a CWA §401 Water Quality Certification to PSNH for the Merrimack Hydroelectric Project in (which comprises the Garvins Falls, Hooksett and Amoskeag Dams and Hydroelectric Stations) following the completion of water quality monitoring in 2002-2003 (Gomez and Sullivan 2003). In addition, a recently released U.S. Army Corps of Engineers report stated that water quality within the Merrimack River impoundments is good (USACOE 2011).

Page 83, Section 5.6.3.2c: USEPA states:

> *In addition, the larvae of many fish species, including American shad, white sucker, and yellow perch, may not be able to readily avoid thermally-stressful surface temperatures. Since the highest water temperatures from the plant exist closest to the discharge point, the*

> *potential for the thermal plume to cause acute lethality or impairment to drifting organisms, such as fish larvae, is most likely to occur in the waters near the discharge.*

USEPA is correct that the greatest thermal impact occurs very close to the Station's cooling canal discharge. However, this discharge represents a small percentage of the entire Hooksett Pool, especially during the relatively high spring flows when yellow perch and white sucker spawn. Moreover, there are nearly three miles of ambient water upstream of Merrimack Station in Hooksett Pool, and the Station's thermal discharge decreases in temperature as it moves downstream (Normandeau 2007c).

In addition, American shad, white sucker, and yellow perch all have successfully spawned in the pool. Yellow perch and white sucker were the target of intensive biocharacteristics studies conducted during 2008 and 2009 (Normandeau 2009a; Normandeau 2011a). Gravid, ripe and running, partially spent and spent white sucker and yellow perch were collected in Hooksett Pool during that study, providing evidence of spawning activity. The presence of multiple-year classes of both species indicates successful growth from larvae to adult is occurring in the pool. With regard to American shad, they have been documented as spawning directly at the cooling canal outfall when canal temperatures were 31° C (Normandeau 1979c). During that sampling, live American shad eggs and juveniles were collected following their successful spawning in Hooksett Pool.

Page 88, Section 5.6.3.3a: USEPA states:

> *According to results from entrainment sampling conducted by Merrimack Station in 2007, approximately 25,000 "herring" larvae were caught at the plant's intake on or about June 11 (Normandeau 2007c). Merrimack Station's 21-year temperature data set (Appendix A) indicates that the temperature of the plant's discharge entering the Hooksett Pool at Station S-0 has reached as high as 94.1°F (34.5°C) on June 11, on or about the date river herring larvae were present. According to test data provided in Wismer and Christie (1987), alewife larvae exposed to this same temperature (94.1°F) died after only 30 minutes.*

There are at least two significant problems with USEPA's statements above. First, the Agency fails to disclose that in fact "approximately 25,000 'herring' larvae" were <u>not</u> caught at the Station's CWIS "on or about June 11," 2007. Rather, Normandeau's <u>estimate</u> of 25,000 "herring" larvae is based on the capture of a <u>single</u> post-yolk sac herring larvae entrained at Unit 2 on June 13, 2007 and then extrapolated out over a seven-day period (June 10-16, 2007) of Station cooling water intake withdrawals.

Second, the mean average temperature recorded at the end of the Station's cooling canal (Station S-0) is 83.7ºF, and the minimum average daily temperature recorded at this location is 64.4ºF (Normandeau 2007c). However, USEPA inexplicably provides only the maximum average daily water temperature (94.1°F (34.5°C)). This value represents the highest daily average temperature recorded over a 21-year period. That is, USEPA has used a Merrimack River water temperature that is clearly documented to have occurred once in 21 years, not on an annual basis, as it implies.

According to Wismer and Christie (1987), alewife larvae exposed to 88.5ºF (the closest value to the average June 11 temperature value in Hooksett Pool based on 21 years of record) suffered lethality after 24 hours of exposure. Based on the average water velocity in Hooksett Pool (as recorded during late May 2008) the average drift time for a larva to transit the entire length of Hooksett Pool would be only about eight hours. Given this, it is reasonable to conclude that alewife larvae would be well past and downstream of the Station's thermal discharge in a 24-hour period during an average year. The maximum average daily water temperature recorded for June 11 downstream of the Station's discharge at Station S-4 was 86.9ºF. The distance from Station S-0 (the Station's cooling canal discharge) to Station S-4 is approximately 2,000 ft. If it takes a larva eight hours to drift the entire length of Hooksett Pool (5.8 miles or 30,624 ft), then it should take about 31 minutes for that larva to drift from the station discharge (S-0) to Station S-4. Given the difference in mean average daily water temperatures between Station S-0 and S-4 and the short transit time, it does appear that alewife larvae could successfully pass the Station's thermal discharge without suffering 100% mortality.

Throughout the §316 Determination Document, USEPA has limited its presentation of thermal data to only maximum average daily water temperatures. This is misleading, given that these temperatures constitute a 1 in 21 year occurrence. The mean average daily temperature is more appropriate for representing an average spring condition. The mean average daily temperature at Station S-4 on June 11 is 70.1ºF, well below the lethal thermal limit for alewife larvae (34.5°C; 94.1°F).

Page 90, Section 5.6.3.3b: USEPA states:

> *EPA's assessment of potential thermal effects to American shad has focused primarily on the larval and juvenile forms since they are the lifestages most likely to be present in Hooksett Pool long enough to be impacted. Unless American shad actually spawn in Hooksett Pool, their eggs are not likely to be exposed to elevated temperatures associated with Merrimack Station's discharge, and most or all spawning would be expected to occur in waters upstream of the Hooksett Pool and Merrimack Station's discharge.*

As previously stated in response to USEPA's statement on page 34 of the §316 Determination Document (Section 5.3.1), American shad were documented successfully spawning in Hooksett Pool during a 1978 study (Normandeau 1979c). The majority of that spawning occurred between Stations N-1 and S-8. Although Unit 2 was offline during that study, Hooksett Pool water temperature (as measured at the Station's cooling canal mouth) was 31º C (87.8°F) on the dates they spawned. Juvenile American shad were first collected in Hooksett Pool beginning July 25th, and of the 313 captured, the majority were captured between Stations 0-W and S-4-E. Surface water temperatures during the capture of shad juveniles ranged from 23.9° C (75.0°F) to 28.2° C (82.8°F) during July and August.

Page 90, Section 5.6.3.3b: USEPA makes reference to "ASMFC 2009" but fails to provide an appropriate citation Section 14.0 (Scientific and Technical References) of its §316 Determination Document so that the reader may identify, obtain and review the referenced document.

Page 90-91, Section 5.6.3.3b: USEPA states:

> *In addition, post-spawn adults should not reside in Hooksett Pool after spawning upstream. Adults move downstream soon after they spawn, returning to the sea until the next spawning season (Scott and Crossman 1973).*
>
> *According to the Fisheries Analysis Report, 1,861 adult shad were stocked in Hooksett Pool in 2002, and up to 750 juvenile shad were captured after passing through the Amoskeag Dam fish bypass during the fall. Merrimack Station suggests these juvenile fish were a result of successful spawning and growth in Hooksett Pool. While the appearance of juvenile American shad emigrating out of Amoskeag Pool is encouraging, as it relates to successful*

> *spawning in the main stem of the Merrimack, there is insufficient information to know whether spawning actually occurred in Hooksett Pool or downstream in Amoskeag Pool. Even if spawning did occur in Hooksett Pool, the drifting surface-oriented shad larvae may have passed over Hooksett Dam and developed into juveniles in Amoskeag Pool. Similarly, larvae that developed into juveniles in Hooksett Pool could have dropped down into Amoskeag Pool if conditions in Hooksett Pool were unsuitable, and remained there until emigrating in the fall.*

Based on observations of adult shad spawning in Hooksett Pool during 1978, it is likely that the adults stocked into Hooksett Pool during 2002 also spawned there. During 2002, PSNH operated an underwater camera in the Amoskeag Dam's fish ladder and recorded a group of adult shad moving downstream on July 18. Following discussions with the resource agencies, it was determined that 1,861 adults had been stocked directly into Hooksett Pool during spring 2002. Since outmigrating adult shad were not observed for more than a month after they would be expected to have spawned, it is reasonable to conclude that they were delayed upstream of Hooksett Dam; otherwise, it is more than likely that they would have appeared on the camera at the Amoskeag Dam fish ladder sooner than late July. As USEPA acknowledges (Page 90, Section 5.6.3.3b), adult shad move downstream soon after they spawn; they return to the sea until the next spawning season (Scott and Crossman 1973). In addition, juvenile shad that were spawned in the system during 2002 did not appear at the downstream bypass at the Amoskeag Dam until the last week in October, suggesting they were upstream of Hooksett Dam and developed in Hooksett Pool. If they were spawned and developed in Amoskeag Pool, they likely would have appeared at the Amoskeag fish ladder much earlier.

Page 91, Section 5.6.3.3b: USEPA states:

> *Maximum survival of American shad larvae is reported by Klauda et al. (1991) to be between 59.9° and 79.7°F (15.5 and 26.5°C) However, a USFWS report identifies temperatures greater than 80.1°F (26.7°C) to be unsuitable for the hatching of American shad eggs and development of larvae (Stier and Crance 1985).*

On page 12 of Stier and Crance (1985), the authors state that "[o]ptimal near-surface water temperatures for American shad egg and larval development range from 15 to 25º C. Temperatures below 10º C and above 30º C are unsuitable."

Page 91, Section 5.6.3.3b: USEPA states:

> *Looking again at Merrimack Station's 21-year temperature data set, the averaged daily mean water temperature at Station S-4 reaches or exceeds 80.1°F (26.7°C) every day but one for the entire month of July (Normandeau 2007b).*

USEPA's statement is technically incorrect, as there are a total of only three days in July (July 1, July 11 and July 12) on which the averaged daily mean water temperature at Station S-4 reaches or exceeds 80.1°F (26.7°C) (Normandeau 2007c).

Page 92, Section 5.6.3.3b: USEPA states:

> *According to Merrimack Station's 21-year data set, American shad larvae drifting past Station SO as early as May 26 could be exposed to temperatures exceeding 92.3°F (33.5°C). Maximum temperatures exceeding 92.3°F (33.5°C) at Station S-0 have been reported on all but nine dates in June and July (Appendix A).*

USEPA has limited its presentation of thermal data to only maximum average daily water temperatures. As noted above, this is misleading given that these temperatures constitute a 1 in 21 year occurrence. Based on the mean average daily water temperature at Station S-0, there are only seven dates during June and July when this temperature has been recorded as exceeding 92.3º F.

Page 92, Section 5.6.3.3b: USEPA states:

> *Similar lethal temperatures were also identified by PSNH's consultant, Normandeau Associates, Inc. According to a 1992 draft report by PSNH, American shad larvae and juveniles small enough to have difficulty avoiding the thermal plume will be present through the month of July (Saunders 1993). This report refers to site-specific studies conducted by Normandeau Associates, Inc., that demonstrate significant mortality occurs at temperatures greater than 91.9°F (33.3°C) after only a 30-minute exposure to the plume. This temperature was reached or exceeded at Station S-0, where Merrimack Station's discharge plume enters the river, on all but six dates in the month of June, according to Merrimack Station's 21-year temperature data set (Appendix A). In July, 91.9°F (33.3°C) was exceeded on every date at Station S-0, with 13 dates reporting temperatures at or above 100°F (37.8°C).*

USEPA has limited its presentation of thermal data to only maximum average daily water temperatures. As noted above, this is misleading given that these temperatures constitute a 1 in 21 year occurrence. If mean average daily water temperature at Station S-0 is considered for all dates in June and July, 91.9ºF is not reached at all during June and is only reached on ten dates during July. In addition, at Station S-4, the maximum average daily temperature does not reach 91.9º F at all during June and is only reached on 14 dates during July. The mean average daily water temperature at Station S-4 is well below 91.4º F for all dates in June and July (the highest value is 83.3°F on July 26).

USEPA then states:

> *Results from similar laboratory bioassay studies conducted in 1975 by Normandeau Associates, Inc., indicated that temperature rises of 18°-20°F (10°-11.1°C) for 10 minutes followed by gradual cooling were lethal to larval shad (Normandeau 1976b). Historical temperature data in Hooksett Pool for June and July demonstrate that the difference between maximum ambient river temperatures (Station N-10) and temperatures recorded at the mouth of the discharge canal (Station S-0) routinely exceeded 18°F (10°C) (Appendix A).*

However, USEPA failed, at least expressly in the §316 Determination Document, to address the following point made in the 1979 Normandeau report *Merrimack River Anadromous Fisheries Investigations: 1978* (Normandeau 1979c):

> *Bioassays conducted by NAI(1977b) revealed that exposure of shad larvae to temperatures below 33.30C and Δts less than 12.8^{o}C for up to 30 min caused no significant mortality differences between control and treatment groups (acclimation temperatures = 17.2 to 21.2 ^{o}C). Regression analysis showed that mortality was directly related to larval age; younger larvae showed a higher thermal resistance than the older groups. Overall, exposure to temperatures above 34.4^{o}C or Δ's greater than 11.1^{o}C for 10 min were required to significantly influence mortality in shad larvae older than 200 hr; more extreme conditions (temperature > 35^{o}C and Δt > 15^{o}C) were necessary to effect the same results in younger larvae.*

Normandeau (1979c) details how American shad eggs, larvae and juveniles were all exposed to the Station's thermal discharge, with the majority of juveniles being captured at monitoring stations within or in close proximity to the thermal plume from that discharge. As the report notes, observed growth rates were excellent, and "[j]uveniles reared in Hooksett Pond appear to be somewhat more robust than those collected from Amoskeag Pond, based on the slope of the length-weight equations" (Normandeau 1979c). Juvenile shad were collected in July and August 1978 predominantly in the river reach between Stations S-0 and S-4, at water temperatures of 23 to 28.2ºC.

Page 92, Section 5.6.3.3b: USEPA states:

> *PSNH studied thermal impacts to larval American shad in 1975. The report on this study provided some information on flow rates in Hooksett Pool, but not for the months of June and July. Current speed data collected on August 15, 1975, the closest date to the June-July time period, indicates surface current speed in proximity to the discharge averaged 0.15 knots, or 0.27 feet/second (Normandeau 1976b).*

Rather than rely on flow data from the middle of August, which likely represents a low flow period when larval shad would not be drifting through Hooksett Pool, USEPA should use the more appropriate value it calculated for June (Section 8.3.1.4b of the §316 Determination Document). This value is 0.55 ft/second, which would result in a transit time of 60 minutes and 36 seconds.

In addition, USEPA reported the incorrect value from Table 2 in the 1976 Normandeau report *Merrimack River Anadromous Fisheries Investigations: Annual Report for 1975* (Normandeau 1976b). The correct surface current speed in the proximity of the Station's thermal discharge was 0.17 knots (0.29 ft/sec) and would produce an estimated transit time of less than two hours.

Page 93, Section 5.6.3.3b: USEPA states:

> *EPA has concluded that it is reasonable to expect shad larvae, when present in Hooksett Pool, to be subjected to stressful, and possibly lethal, surface temperatures related to the plant's thermal discharge. This conclusion takes into account the scientific literature on thermal effects described above, <u>including studies conducted specifically for Merrimack Station</u>.*

It appears that USEPA has excluded data presented in Normandeau (1979c), which suggests that the Agency has failed to consider all of the available scientific literature in its analysis.

Page 93, Section 5.6.3.3b: USEPA states:

> *The upper end of the optimal temperature range for juvenile shad is identified as 75°F (23.9°C) by both Klauda et al. (1991a) and a study published by the U.S. Fish and Wildlife Service (Stier and Crance 1985). Further, these studies both identify temperatures near 86°F (30°C) to be the maximum natural limit for juvenile shad, with 85°F (29.4°C) being "completely unsuitable," according to the Habitat Suitability Model developed by Stier and Crance (1985). Average maximum temperatures at Station S-4 exceed 29.4°C (85°F) on every date from June 25 to September 3, according to Merrimack Station's 21-year data set (Appendix A).*

Please note that the correct terminology for thermal data presented in Appendix A of the 2007 Normandeau report *A Probabilistic Thermal Model of the Merrimack River Downstream of Merrimack Station* (Normandeau 2007c) is "maximum average daily temperature," not "average maximum temperature." The maximum average daily temperature represents the highest of 21 daily averages for a particular date. USEPA has limited its presentation of thermal data to only maximum average daily water temperatures. As noted above, this is misleading given that these temperatures constitute a 1 in 21 year occurrence. If mean average daily water temperature at Station S-4 is considered for all dates during the period June 25 to September, the average Station S-4 temperature exceeds 85° F on only a single date in August.

Page 93, Section 5.6.3.3b: USEPA states:

> *Klauda et al. (1991) also noted that juvenile American shad acclimated to 75.2°F (24°C) experienced 50- percent mortality when exposed to 88.9°F (31.6°C).*

A review of Klauda et al. (1991) reveals that the 50% mortality in 88.9° F (31.6° C) water was following 96 hours of continuous exposure. Klauda et al. (1991) cites Marcy (1976a) and states that "young American shad avoid effluent temperatures greater than 30º C by swimming below the power plant outflow." Based on this, it is reasonable to conclude that juvenile American shad in Hooksett Pool would behave in a similar fashion. Evidence for such behavior is provided by the successful spawning and growth of American shad in Hooksett Pool during 1978 and again in 2002.

Pages 93-94, Section 5.6.3.3b: USEPA states:

> *This temperature scenario is similar to conditions found in Hooksett Pool in mid-June when ambient temperatures (e.g., on June 15 at Station N-10) averaged 67.8°F (19.9°C) and the averaged maximum recorded temperatures at Station S-0 reached 92.9°F (33.8°C).*

In this case, USEPA opted to use a mean daily water temperature, but did so to maximize the thermal difference between ambient and thermally-influenced portions of Hooksett Pool for the date of June 15. The Agency has artfully based its analysis on the difference between the mean daily water temperature at Station N-10 and the average daily maximum water temperature at Station S-0 in order to supply a larger difference in temperature.

Page 94, Section 5.6.3.3b: USEPA states:

> *This study also references work by Moss (1970) demonstrating that young American shad die rapidly when temperatures are suddenly raised from 75.2°-82.4°F (24°-28°C) to 90.5°F (32.5°C). In July, the mean ambient temperature in Hooksett Pool is 75.2°F (24°C) while the mean temperature where Merrimack Station's discharge plume enters the river at Station S-0 is 91.1°F (32.8°C).*

USEPA does not mention that Moss (1970) observed captive juvenile shad exposed to rapid temperature increases of 4ºC above acclimation in a tank study. In addition, Moss (1970) concluded that young shad are behaviorally capable of avoiding potentially lethal temperature changes. It is reasonable to conclude that juvenile shad in Hooksett Pool are capable of avoiding prolonged exposure to elevated thermal conditions, based on both tank (Moss 1970) and field (Marcy 1976a, Normandeau 1979c) observations, and the capture of juvenile shad in the pool in during August in 2010 and 2011.

Page 94, Section 5.6.3.3c: USEPA states:

> *While out-migrating adult and juvenile shad may be able to avoid stressful temperatures by swimming below the thermal plume, juvenile shad that are residing in the pool could be*

> *precluded from feeding at their preferred depths due to the persistence of high temperatures in the upper water column of the lower pool throughout the summer.*

Massman (1963) suggests that juvenile American shad can readily feed on both terrestrial and aquatic insects. Ross et al. (1997) observed juvenile American shad in riverine nursery habitat readily feed on a variety of prey from both aquatic and terrestrial origin. Based on these studies, it is reasonable to conclude that American shad in Hooksett Pool would not be limited to feeding on surface drift of terrestrial insects within only thermally influenced portions of Hooksett Pool when they could also consume aquatic insects below the surface or feed on surface drift in the upper half of Hooksett Pool. American shad are free to move about the entire 5.8 miles of Hooksett Pool and, as demonstrated by Moss (1970) and Marcy (1976a), are behaviorally capable of avoiding potentially lethal temperature changes.

Page 95, Section 5.6.3.3c: USEPA states:

> *Concerns remain, however, as to whether or not smolt exposure to the thermal plume may adversely affect their ability to adapt successfully to life in the marine environment. Studies conducted on migrating smolts in the Connecticut River suggest that temperature is a factor in the loss of smolt characteristics, with exposure to elevated temperatures accelerating the loss of some characteristics, such as seawater tolerance (McCormick et al. 1999). The presence of dams can further delay smolt migration. Smolts probably do not spend much time in Hooksett Pool during outmigration, but they may be foraging en route.*

Atlantic salmon smolts typically move downstream at night (Hesthagen and Garnas 1986, McCormick et al. 1998, Moore et al. 1998) and as a result, foraging is most likely limited. Radio-telemetry equipment was deployed at the Hooksett Dam during 2003 and 2005 to monitor smolts following their passage at Merrimack Station, and there were no delays to downstream migration due to Hooksett Dam. The radio-tagged smolts released in upper Hooksett Pool moved successfully and rapidly past the Station's thermal discharge and lower Hooksett Pool (Normandeau 2006a).

Page 95, Section 5.6.3.3c: USEPA states:

> *The study conducted by Merrimack Station also did not address the possible thermal effects on mature salmon migrating upstream to spawn. At present, poor returns of sea-run salmon and restricted upstream access prevent adult anadromous Atlantic salmon from reaching Hooksett Pool. In fact, most returning salmon are captured at Essex Dam in Lawrence, Massachusetts and transferred to a hatchery for egg production (Normandeau 2007a). Both NHFGD and USFWS are committed to restoring Atlantic salmon to the Merrimack River watershed. Therefore, thermal conditions in Hooksett Pool will have to be protective of in-migrating Atlantic salmon when NHFGD and USFWS determine that the salmon population has sufficiently recovered, and that upstream access to Hooksett Pool is warranted.*

As noted above in response to USEPA's statement on page 34 (Section 5.3.1) of the §316 Determination Document, there have been observations of stocked adult salmon successfully passing through Hooksett Pool from their stocking locations in Garvins Pool to the Amoskeag fish ladder.

Page 95-96, Section 5.6.3.3d: USEPA states:

> *While the relative abundance for largemouth and smallmouth bass in the 2000s is as high, or greater than those of the 1960s, relative abundance for other species that make up the balanced, indigenous community have declined dramatically. Yellow perch relative abundance, based on electrofishing sampling, dropped three-fold from 19.8 percent to 6.6 percent. Pumpkinseed dropped from 37.8 percent in the 1960s to 2.8 percent in the 2000s.*

As noted above, USEPA has chosen to disregard the documented fact that the fish population that resided in Hooksett Pool in the 1960s and early 1970s was impaired and dominated by fish that could withstand the severe pollution and nutrient loading that occurred during those years. Two of the tolerant fish species that dominated catches in the 1960s were yellow perch and pumpkinseed. Both of these fish had an advantage in the 1960s over more sensitive fish species because they could withstand the low DO levels that occurred as a result of the severe pollution and biological oxygen demand ("BOD") activity in Hooksett Pool and dropped DO levels down to 1 mg/l or less (Normandeau 1969) on some dates in the summer months. As a point of reference, USEPA considers levels below 5 mg/l harmful to aquatic biota (Normandeau 2011b). (See also Normandeau's response to USEPA's comment on Page 107, Section 5.5.3.3f for more information regarding the ability of these two fish species to withstand low DO levels and poor water quality.)

USEPA uses relative abundance above to make its point about the drop in abundance for yellow perch and pumpkinseed across decades, but this is disingenuous because these two fish alone comprised more than 60% of the electrofish collections in the 1960s (Normandeau 1970). When a small number of fish species dominate a community, it is a clear sign that the community is impaired. The decrease in relative abundance of the pollution-tolerant fish species that dominated Hooksett Pool during the 1960s is not a negative outcome for the Hooksett Pool fish community.

Furthermore, these changes in relative abundance cannot be solely attributed to Merrimack Station's thermal discharge because they occurred as Merrimack River water quality improved. The Merrimack River in the early 1960s and early 1970s was classified as Class D, and it has improved since that time to the Class B water that exists today. The number of fish species captured has increased nearly two-fold in Hooksett Pool. When all gear types were combined, there were 16 fish species captured during the 1960s, 24 fish species captured in the 1970s and 27 species captured in the 2000s. No intolerant fish species were able to survive in Hooksett Pool during the 1960s. Relative abundance changed over the decades due to a more balanced fish community that was not dominated by a few species that could withstand the poor water quality conditions that existed in the Merrimack River in general, and Hooksett Pool in particular, in the 1960s.

Page 96, Section 5.6.3.3d: USEPA states:

> *The relatively stable population of largemouth bass in Hooksett Pool over the past 40 years is not surprising given their preference for warm water, and their appetite for a variety of forage, including other heat-tolerant fish species.*

Largemouth bass are indeed a warmwater fish species (Eaton et al. 1995). However, they are a common resident species in thermally uninfluenced Garvins Pool as well, and their abundance was greater in Garvins Pool than in Hooksett Pool during the 2010 community fish survey (Normandeau 2011a). The diet of largemouth bass is varied and is likely only limited by their capture ability and gape size (Scarola 1987). Largemouth bass are capable of sustaining in Hooksett Pool with or without the presence of heat-tolerant fish species.

Page 96, Section 5.6.3.3d: USEPA states:

> *Based on the information provided in the Fisheries Analysis Report, it appears that the high relative abundance of largemouth bass in the 2000s, particularly in the thermally-influenced portion of the pool, comes at the cost of other species less tolerant to heat. According to Merrimack Station, NHFGD expressed concern in the 1960s that the plant's thermal effects would result in an increase in the largemouth bass population at the expense of other gamefish species (Normandeau 1970).*

Normandeau (1970) concludes that a comparison of largemouth bass catches over a three-year (1967-1969) period for the Merrimack River portion north of Merrimack Station and the river portion south of the Station does not reveal significant changes attributable to Station operations. Rather than rely on relative abundance, which can be easily influenced by the catch of other fish species within a given year, Normandeau determined the annual mean electrofish CPUE for largemouth bass captured in Hooksett Pool in August and September of the years with standardized sampling during the 1972-2011 time period (Normandeau 2011a). Largemouth bass have been collected in Hooksett Pool during each sample year, with their highest annual mean electrofishing CPUE values for the August and September period occurring in 2004. There was no significant trend in largemouth bass annual mean CPUE in Hooksett Pool within the time series, supporting a finding that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in Hooksett Pool over the 1972-2011 time period. A comparison of annual mean CPUE values for largemouth bass shows that the most recent estimates in Hooksett Pool did not differ significantly during 2010, and were significantly greater than those observed during 2011 in Garvins Pool, which is not influenced by the Station's thermal discharge (Normandeau 2011a). This also supports a finding that the discharge has not caused appreciable harm.

Page 96, Section 5.6.3.3d: USEPA states:

> *It should be noted that it is unknown whether smallmouth or largemouth bass have been stocked in Hooksett Pool over the past 40 years. According to the NHFGD, neither bass species has been stocked by the State during that time period, and the Department is not aware of any private effort to enhance bass stocks in Hooksett Pool (personal communication). Enhancing the bass populations through stocking efforts would confound the ability to accurately conduct a population trends analysis, and may obscure their true status.*

It is unclear what USEPA is attempting to convey to the reader with this statement. Regardless of how largemouth and smallmouth bass originally entered Hooksett Pool, they are part of the Hooksett Pool fish community now, and there is no statistical evidence of a change in smallmouth or largemouth bass abundance between 1972 and 2011 (Normandeau 2011a).

Page 97, Section 5.6.3.3c: USEPA states:

> *While competition with introduced species such as bluegill may be one factor contributing to the decline of pumpkinseeds, sampling data suggests the decline began before bluegills first appeared in electrofishing and trapnetting samples. According to electrofishing data*

> *presented in the Fisheries Analysis Report (p.64), pumpkinseed CPUE in Hooksett Pool declined from 37.65 fish in 1972 to 19.45 fish in 1976.*

As noted above, bluegill were present in Hooksett Pool during the 1970s. Declines in pumpkinseed during the 1970s may have also been linked to improvements in water quality. Nutrient levels in the Merrimack River decreased during the 1970s (Normandeau 2011b). Potentially linked to that decrease in nutrients, a decrease in submerged aquatic vegetation also took place in Hooksett Pool. Pumpkinseed have a tremendous reproductive potential and can quickly overpopulate areas with their preferred weedy habitat (Scarola 1987). It is likely that the decline in pumpkinseed during the 1970s is attributable to improved water quality and the subsequent reduction in their preferred habitat. Given pumpkinseed's similar thermal preferences to bluegill (RMC 1979), it is likely that their numbers were reduced due to their poor ability to compete with bluegill for remaining food and habitat.

Page 97, Section 5.6.3.3c: USEPA states:

> *Long-term fish sampling in Vernon Pool of the Connecticut River provides an opportunity to review how bluegill and pumpkinseed have co-existed in a nearby river. Vernon Pool and Hooksett Pool are both major river impoundments in New Hampshire that largely share the same resident fish community*

Any direct comparison of bluegill/pumpkinseed coexistence within Vernon and Hooksett Pools is confounded by the percentage of available habitat that is beyond the direct influence of the thermal discharges in those two systems. Vermont Yankee is located 0.75 miles up-river of the Vernon Dam, relegating the majority of the thermal discharge effects in Vernon Pool to a small stretch of river. Vernon Pool is approximately 26 miles long, bounded by Bellows Falls Dam on the northern end, is 2,481 surface acres and contains 1.4 billion ft^3 of water at full pond. The width of the Connecticut River in Vernon Pool ranges from 400 ft to 3,000 ft and the depth from 15 to 50 ft (average of 16 ft). Hydraulic retention in Vernon Pool is two days under mean annual flow ("MAF") and 16 days under regulated minimum flow (Entergy 2006). In contrast, Merrimack Station is located 2.9 miles upstream from Hooksett Dam at the midpoint of Hooksett Pool. Hooksett Pool is 5.8 miles long, only 22% of the length of Vernon Pool. The deepest portions are greater than 20 ft, but depth averages 6-10 ft. in most areas under normal flow conditions. Hooksett Pool has a surface area of 350 acres (14% of that of Vernon Pool) and a storage volume of 130 million ft^3 at full pond. Hydraulic retention at MAF conditions is 8 hrs and 5 days at 7Q10 flow conditions (Normandeau 2011c). The larger size of Vernon Pool compared to Hooksett Pool may provide more varied habitat where both species could coexist.

Page 99, Section 5.6.3.3e: USEPA states:

> *Electrofish sampling conducted by NHFGD in Garvins Pool on August 6, 2007 provides a limited, but interesting assessment of how pumpkinseeds and bluegills are faring in the impoundment just upstream from Hooksett Pool. Bluegill was second-most abundant with 20.1 percent of all fish caught, while pumpkinseed was ranked third with a relative abundance of 18.9 percent (Table 5-20). This sampling is discussed further in the next section (5.6.3.3f) as it applies to yellow perch, which ranked first. If this sampling accurately represents the Garvins Pool fish community, then it would appear that the populations of these two species (bluegill and pumpkinseed) are similar.*

Relative abundance data do not represent abundance well because they are influenced by the abundance of other species. Sampling intended to assess the fish assemblage present in Garvins Pool was conducted by boat electrofishing during August and September of 2010 and 2011 (Normandeau 2011a). CPUE values were slightly higher for pumpkinseed during 2010 (2.2 vs. 0.8 fish/1,000 ft) and similar for both species during 2011 (1.7 bluegill / 1,000 ft vs. 1.6 pumpkinseed / 1,000 ft). These data, as well as those collected by NHFG (NHFGD 2007), support the argument of decreased pumpkinseed abundance in Hooksett Pool for two reasons. First, bluegill have become a major component of the Garvins Pool fish assemblage, which has evolved in a portion of the Merrimack River that is not subjected to any thermal influence from Merrimack Station. Second, it is less likely that pumpkinseed in Garvins Pool are limited by reduced area of submerged aquatic vegetation and as a result are better able to coexist with bluegill. Garvins Pool is larger than Hooksett Pool and contains greater habitat diversity than is observed in Hooksett Pool, including extensive oxbow and backwater areas that are heavily inundated with submerged aquatic vegetation and are preferred by pumpkinseed. Aquatic habitat mapping conducted during September and October 2010 noted submerged aquatic vegetation beds covered a larger percentage of mapped habitat in Garvins Pool than Hooksett Pool (Normandeau 2011d). Survey dates for Garvins Pool sampling occurred later in the season than those in Hooksett Pool, so it is likely that submerged aquatic vegetation coverage in Garvins Pool is conservative, as vegetation had already begun to die off towards the end of the survey period.

Page 100, Section 5.6.3.3e: USEPA states:

> *The interactions of these fish species in response to changes in their thermal environment is complex. Nevertheless, under no reasonable interpretation of potential causes and effects can a persuasive argument be made that the decline of pumpkinseed, from being the most abundant fish species prior to the start-up of Unit 2 to one that has virtually disappeared in the mid-2000s, supports a finding of no prior appreciable harm to the balanced, indigenous population of fish in Hooksett Pool. To the contrary, a reasonable argument can be made that increased thermal discharges related to the operation of Unit 2 have contributed to the decline of pumpkinseed by altering the thermal environment in much of the Hooksett Pool, in combination with the introduction of heat-tolerant, non-native species, such as bluegill.*

USEPA contends that the correlation between Unit 2 coming on-line in 1968 and the decrease in abundance of pumpkinseed in the Hooksett Pool fish community at some point after 1976 (when CPUE was 19.5/1,000 ft) can only be related to Merrimack Station's thermal discharge. However, this contention is based on USEPA's misinterpretation of the relevant data, and disregard of the findings of the peer-reviewed scientific literature regarding pumpkinseed thermal tolerance. Without any justification, the Agency ignores the obvious fact, that this decrease did not start until at least <u>eight</u> years after Unit 2 came on-line. In addition, it ignores the documented facts that:

1) Pumpkinseed are capable of survival in high temperatures, comparable to other *Lepomis* species (i.e., bluegill and redbreast sunfish). EPRI (2011) indicates that all *Lepomis* species have a Critical Thermal Maximum (CTM) of greater than 35^{o}C.

2) Pumpkinseed have a competitive advantage over other species in fluctuating and low DO environments such as the Merrimack River in the 1960s and early 1970s. A review of the peer-reviewed scientific literature indicates that in areas where the species are known to coexist, water bodies in which bluegill are absent likely only support pumpkinseed due to

pumpkinseed's increased ability to withstand more hypoxic conditions than bluegill, particularly during low DO winter periods (Osenburg et al. 1992, Fox 1994, Tomacek et al. 2007). Low DO was present in Merrimack River during the 1960s and 1970s due to high input of raw sewage and nutrients (Normandeau 2011b). The ability of pumpkinseed to withstand lower DO and fluctuating environmental conditions better than bluegill (Fox 1994) would have given them a competitive advantage during this period when the Merrimack River was heavily polluted.

Pumpkinseed populations in the vicinity of Cromby Generating Station, located on the Schuylkill River in Pennsylvania, provide a useful comparison. These populations dominated (44% of the total catch during sampling in 1970-1971) the fish community sampled below Cromby Generating Station's thermal discharge more than 15 years after both units came on-line (Normandeau 2011c) These fish were observed surviving and spawning in temperatures as high as 97^{o}F (36.1^{o}C). Pumpkinseed continued to be the most abundant or one of the most abundant species in 1976 (28%) and 1989-1990 (26%) until sampling in 2007 where they represented 0-4% (Normandeau 2011c).

Pages 101-102, Section 5.6.3.3f: USEPA states:

> *While yellow perch reproduction strategies appear to have evolved in response to prolonged winter ambient temperatures of 10°C or lower, the elevated temperatures in the discharge canal during winter months more closely correspond with otherwise preferred yellow perch temperatures of 64-77°F (17.8-25.1°C) (Krieger et al. 1983). According to Merrimack Station, the canal population of yellow perch sampled by electrofishing represented a significant portion of the overall Hooksett Pool population on an annual basis (Normandeau 1997). Yellow perch catches were highest within the "winter chill" period, with the highest CPUE in March. Even periodic excursions into elevated temperatures during the winter chill would reduce the required exposure to temperatures at or below 10°C. This could result in incomplete gonadal development and reduced production of viable eggs if the minimum duration of exposure by yellow perch to temperatures at or below 10°C is not reached. Studies to determine the extent of time that yellow perch or other species remain within the discharge canal during the winter chill period have never been conducted at Merrimack Station.*

Reproduction of yellow perch was examined during field sampling conducted during the spring of 2008 and 2009 (Normandeau 2011a). A total of 364 yellow perch were examined for reproductive condition during those two years. Of those, 46% were considered immature. A limited number of gravid female perch (n = 5) were collected from Hooksett Pool and were examined for fecundity. Estimates of total number of eggs for gravid female perch in Hooksett Pool were comparable to those observed for gravid female perch in thermally uninfluenced Garvins Pool (Normandeau 2011a). Field sampling in both Garvins and Hooksett Pools occurred towards the end of the perch spawning period, as evidenced by the observation of a large percentage of yellow perch classified as partially spent, spent or resting.

Page 104, Section 5.6.3.3f: USEPA states:

> *According to the data on thermal tolerance of larval yellow perch presented in the peer-reviewed scientific literature discussed, adverse impacts leading to reduced survival to larval yellow perch have been observed at temperatures as low as 65.8°F (18.8°C)*

Natural Merrimack River conditions can exceed the larval yellow perch thermal tolerance value selected for use in this analysis by USEPA. A review of Merrimack Station's 21-year temperature data set recorded at ambient monitoring station N-10 indicates that Hooksett Pool water temperature naturally exceeds the peer-reviewed scientific literature-reported reduced survival temperature of 65.8°F (18.8°C) for larval yellow perch on six days when considering the mean average daily water temperature, and on 29 days when considering the maximum average daily water temperature for the larval perch period of May 1 to June 14.

Page 104, Section 5.6.3.3f: USEPA states:

> *According to Merrimack Station's 21-year temperature data set, average daily maximum water temperatures at Station S-0 during the period when larval yellow perch were collected at Merrimack Station's intake structures (Station N-5) in 2006-2007 (May 1—June 14) ranged from a low of 79.2°F (26.2°C) on May 3 to a high of 94.3°F (34.6°C) on June 12.*

This is another example of where USEPA has limited its presentation of thermal data to only maximum average daily water temperatures which implies to the reader that these thermal conditions exist every spring, rather than the 1 in 21 year occurrence during which they have been documented. If mean average daily water temperature at Station S-0 are considered during the period when larval yellow perch were collected at Merrimack Station's intake structures (Station N-5) in 2006-2007 (May 1—June 14) then temperatures ranged from a low of 69.2°F (20.7°C) on May 3 to a high of 84°F (28.9°C) on June 12. USEPA identified the lethality of yellow perch larvae as occurring after 30 minutes of exposure to 88.3°F (31.3°C), and 10 minutes at 92.7°F (33.7°C), when acclimated to 59.0°F (15.0°C).

USEPA continues by saying:

> *Based on yellow perch temperature tolerances provided in the scientific literature, and long-term temperature data collected by Merrimack Station, it appears <u>likely</u> that yellow perch larvae were exposed to <u>potentially</u> lethal temperatures within Merrimack Station's thermal plume. Average daily <u>maximum</u> temperature data provided by Merrimack Station indicates that temperatures at Station S-0 can exceed 88.3°F (31.3°C) as early as May 20, and can exceed 89.6°F (32.0°C) as early as May 22 (Normandeau 2007b). Temperatures well exceeding 89.6°F (32.0°C) at Station S-0 continue for the duration of the yellow perch larval period, which EPA estimates to be June 15 based on Merrimack Station's entrainment studies (Figure 5-13).*

USEPA has limited its presentation of thermal data to only maximum average daily water temperatures which may mislead the reader into assuming these thermal conditions exist every spring, rather than the 1 day in 21 year occurrence during which they have been documented. Mean average daily water temperature data provided by Merrimack Station indicates that temperatures at Station S-0 do not exceed 84.0°F (28.9°C) during the period May 1 to June 14 (Normandeau 2007c).

Page 106, Section 5.6.3.3f: USEPA states:

> *Therefore, Merrimack Station's thermal habitat analysis does not provide convincing evidence of the scope of thermal impacts to fish habitat in Hooksett Pool from the plant's discharge. To strengthen the analysis, EPA reviewed additional temperature monitoring data collected and submitted by Merrimack Station for the 21-year period from 1984 to 2004.*

> *According to these data, average daily maximum water temperatures on 30 of the 62 days in July and August reached or exceeded 100°F (37.8°C) at Station S-0, with the highest temperature reaching 104°F (40.0°C)., Average daily maximum water temperatures exceeded 83.0°F (28.3°C) — the temperature Merrimack Station identified as an avoidance temperature for adult and juvenile yellow perch — every day at Station S-4 from June 15 to September 10.*

USEPA has limited its presentation of thermal data to only maximum average daily water temperatures which may mislead the reader into assuming these thermal conditions exist every year, rather than the 1 day in 21 year occurrence during which they have been documented. The mean average daily water temperature did not reach or exceed 100°F (37.8°C) at Station S-0 on any dates during July or August (actual highest mean average daily temperature was 93.9°F on August 3 and 4). The mean average daily water temperature exceeded 83.0°F (28.3°C) — the temperature identified as an avoidance temperature for adult and juvenile yellow perch — on 9 days at Station S-4 from June 15 to September 10. As the plume is known on occasion to extend down to a maximum depth of 6 feet in the vicinity of (Normandeau 1979b), an adequate zone of passage for juvenile and adult perch exists in the portion of the river below the thermal plume. Adult and juvenile yellow perch can move away from areas of non-preferred water temperatures.

Page 106, Section 5.5.3.3f: USEPA states:

> *Length-weight relationships were studied by Merrimack Station in 1975 and 1976 for three species, including yellow perch. The Merrimack River Monitoring Program Report of 1976 stated that it had analyzed length-weight relationships, which reflect the condition, or "robustness," of the fish (Normandeau 1977). According to this report (p.108), data analysis for yellow perch collected at Station S-2-W may suggest deleterious conditions that worsened yellow perch condition. The report goes on, however, to suggest that there is no evidence of thermal effects (Normandeau 1977).*

Biocharacteristics data for yellow perch was collected during 2008, 2009, 2010 and 2011 from Garvins Pool, located upstream of Merrimack Station and uninfluenced by the thermal discharge, and Hooksett Pools (Normandeau 2011a). There was no significant difference between pools in the condition of yellow perch collected during 2009, indicating that yellow perch maintained similar incremental weight gain with increasing length between Hooksett and Garvins Pools. The length-weight curve based on the 2008 catch showed yellow perch in Hooksett Pool grew significantly more rotund (or "fatter") with increasing length than in Garvins Pool whereas the length-weight curve based on the 2011 catch showed yellow perch in Garvins Pool grew significantly more rotund (or "fatter") with increasing length than in Hooksett Pool. Insufficient numbers of yellow perch were collected in Hooksett Pool during 2010 to allow for a comparison of condition. The lack of a consistent pattern in yellow perch condition between Hooksett and Garvins Pools is supportive of the conclusion that the thermal discharge has not affected the condition of yellow perch in Hooksett Pool..

Page 107, Section 5.5.3.3f: USEPA states:

> *During summer months, when higher temperatures prevail, physiological rates, demand for resources, and the intensity of interspecific interactions are likely to be at a maximum (Brandt et al. 1980). Therefore, one plausible reason why bluegills can out-compete*

> *yellow perch in Hooksett Pool is that they prefer, and are more tolerant of, elevated temperatures.*

Fisheries data from Garvins Pool, located upstream of Merrimack Station and uninfluenced by the thermal discharge, provides useful information on the potential influence of thermal discharge on the abundance of bluegill. Table 5-20 on page 108 of the §316 Determination Document summarizes fisheries sampling conducted by NHFG in Garvins Pool and shows that bluegill were the second most abundant fish (as measured by CPUE) captured by electrofishing in 2007. Bluegills were not present in the upper Merrimack River during the 1960s studies (Scarola 1987), indicating they became a dominant fish species in Garvins Pool over the past decades by out competing the other fish species in the absence of thermal enrichment. Therefore, Normandeau believes bluegills rose in abundance in Garvins Pool due to their ability to outcompete other fish species, including yellow perch and pumpkinseed once the water quality in the river improved. One major advantage that yellow perch and pumpkinseed had over the bluegill in the 1960s and early 1970s was their ability to withstand the polluted water and low dissolved oxygen (DO) conditions that existed at the time. Once water quality improved, yellow perch and pumpkinseed no longer had that competitive advantage and bluegill increased in abundance. The following quote about yellow perch was taken from Holtan (1990):

> *One reason yellow perch are so prevalent in state waters is that they are a very tolerant fish. While they prefer clear, fertile water (water supporting moderate to large amounts of plant growth), yellow perch can adjust to a variety of conditions. This hardy species is renowned for its ability to survive low oxygen levels. That trait allows yellow perch to inhabit deep water that often has reduced oxygen levels and helps it survive winterkill conditions (mortality in fish associated with lack of oxygen under frozen lakes) that suffocate other species like bluegill, bass and walleye. After winterkill occurs, a lake will often provide an excellent yellow perch fishery for several years. Perch are also tolerant of eutrophic (nutrient rich) and turbid (containing suspended solids) water and a wide temperature range.*

Over the geographic range where pumpkinseed and bluegill coexist, there are lakes which support only pumpkinseed. It has been theorized that these situations are due to winterkill of bluegill from hypoxic (low DO) conditions (Oseburg et al. 1992; Fox 1994; Tomecek et al. 2007). Based on these studies, pumpkinseed are more capable of withstanding lower DO levels and fluctuating environmental conditions than bluegill, allowing them to survive in conditions that eliminate bluegill (Fox 1994). The ability to withstand lower DO levels created an advantage for pumpkinseed over bluegill and helps explain why pumpkinseed abundance was so high in the early years when the water quality in Hooksett Pool was poor. Bluegill often dominate pumpkinseed in lakes in which they coexist and hypoxic conditions don't occur (Tomacek et al. 2007).

Page 108, Section 5.6.3.3f: USEPA states:

> *The relative abundance of yellow perch has averaged 35.5 percent in Vernon Pool from 1991-2002, based on electrofishing data. Relative abundance of yellow perch was even higher when sampled with trapnets, representing 44.7 percent of the fish community from 1991-1999. Despite increased competition associated with the introduction of bluegill and other centrarchids (e.g., rock bass), the yellow perch population in Vernon Pool remains robust. There are many variables that can affect interspecies competition. One reasonable explanation for the dramatic difference in yellow perch populations found in*

> *Vernon and Hooksett pools is the percentage of available habitat that is beyond the direct influence of the thermal discharges.*

USEPA's comparison of relative fish abundance within Vernon and Hooksett Pools is inappropriate. It is unclear how its review of fisheries data collected in the Vernon Pool of the Connecticut River and the interactions of yellow perch and introduced bluegill there are pertinent to Hooksett Pool given the dramatic differences between the two systems. Vermont Yankee is located 0.75 miles up-river of the Vernon Dam, relegating the majority of the thermal discharge effects in Vernon Pool to a small stretch of river. Vernon Pool is approximately 26 miles long bounded by Bellows Falls Dam on the northern end and is 2,481 surface acres and contains1.4 billion ft3 of water at full pond. The width of the Connecticut River in Vernon Pool ranges from 400 ft to 3,000 ft and the depth from 15 to 50 ft (average of 16 ft). Hydraulic retention in Vernon Pool is two days under mean annual flow (MAF) and 16 days under regulated minimum flow (Entergy 2006). In contrast, Merrimack Station is located 2.9 miles up-river from Hooksett Dam at the midpoint of Hooksett Pool. Hooksett Pool is 5.8 miles long, only 22% of the length of Vernon Pool. The deepest portions are greater than 20 ft, but averages 6-10 ft. in most areas under normal flow conditions. Hooksett Pool has a surface area of 350 acres (14% of that of Vernon Pool) and a storage volume of 130 million ft3 at full pond. Hydraulic retention at MAF conditions is 8 hrs and 5 days at 7Q10 flow conditions (Normandeau 2011c). As stated above by USEPA, the larger size of Vernon Pool as well as the significantly larger reach of river located upstream of the thermal discharge when compared to Hooksett Pool likely explains the difference between yellow perch populations and reduces the appropriateness of the comparison made in the §316 Determination Document.

Page 110, Section 5.6.3.3f: USEPA states:

> *Merrimack Station estimates that 297 yellow perch were impinged in "Year 1" (June 2005—June 2006), and 39 were impinged in "Year 2" (July 2006—June 2007). If 100-percent mortality is assumed, which EPA does expect given the design of Merrimack Station's existing fish return system, the loss in adult equivalents is 110 yellow perch in Year 1 and 31 perch in Year 2. By combining 2006 entrainment data with Year 1 impingement data, and 2007 entrainment data with Year 2 impingement data, the total loss of adult yellow perch from entrainment and impingement in 2006/Year 1 is estimated to be 132 fish, and 226 fish in 2007/Year 2. These numbers of fish lost to entrainment and impingement are considerable given that the total number of yellow perch caught during electrofishing and trapnet sampling, conducted from April through December, was 101 fish in 2004 and 117 fish in 2005. In addition, many of the fish caught in 2004 and 2005 sampling were juveniles and, as such, the total number of yellow perch representing adult equivalents would be appreciably lower in both years sampled.*

There is no relationship between the number of adult equivalent yellow perch lost to impingement and entrainment during 2006-2007 and the number of yellow perch captured during electrofish and trap net sampling during 2004-2005. The adult equivalent estimate is an abstract estimate of the number of adults that might have resulted if entrainment and impingement did not occur. The electrofish and trap net sampling is just that; sampling rather than a complete census of the number of yellow perch in Hooksett Pool. Without an accurate population estimate of yellow perch in Hooksett Pool, the relative contribution of impingement/entrainment losses to the Hooksett Pool yellow perch population cannot be determined. USEPA's comparison between adult equivalent estimate and CPUE from sampling gear is not relevant.

Pages 110-111, Section 5.6.3.3g: USEPA states:

> *However, prior to the start-up of Unit 1968, fallfish were more evenly distributed throughout Hooksett Pool, according to data provided by Merrimack Station (Normandeau 1970). Fish sampling results indicate that the abundance of fallfish in Hooksett Pool has been relatively low since sampling commenced in 1967.*

Fallfish abundance in Hooksett Pool was at its highest recorded level during 2011 with a total of 522 captured (Normandeau 2011a). Of the 2010-2011 catch, 65% of the catch was located upstream of Merrimack Station and 35% was located downstream of Merrimack Station. A total of 18 fallfish were captured during 1967 (13 downstream of Merrimack Station and 5 upstream of Merrimack Station).

Page 111, Section 5.6.3.3h: USEPA states:

> *This 1976 report by Merrimack Station suggests that while white sucker is perhaps the least thermally-tolerant resident species in Hooksett Pool, their abundance both north and south of the discharge indicates successful growth and reproduction (Normandeau 1977). The report concludes that existing Merrimack Station discharges appear to have had no discernible deleterious effects on Hooksett Pool white suckers. Thirty years later, Merrimack Station maintains the same conclusion despite significant reductions in both pool-wide trapnet CPUE, from 11.0 fish in the 1970s to 0.1 fish in the 2000s, and relative abundance, from 18.2 percent in the 1970s to 2.1 percent in the 2000s (Normandeau 2007a).*

PSNH still maintains that there have been no major impacts to the abundance of white sucker in Hooksett Pool. Electrofish data collected over the time 1972-2011 time period(Normandeau 2011a) directly contradicts the trap net data comparing the 1970s to 2000s (Normandeau 2007a). The USEPA manual for bioassessment on non-wadeable streams and rivers identifies electrofishing as the most comprehensive and single most effective of fish from streams and river (Flotemersch et al. 2006). Recent statistical analyses (Normandeau 2011a) indicated that there was no significant trend in white sucker abundance for the 1972-2011 time period. In addition, abundance of white sucker in Hooksett Pool was greater than that observed in Garvins Pool for standardized electrofish sampling conducted during both 2010 and 2011. If white sucker were in decline due to thermal impacts from Merrimack Station then it reasons that their abundance would be significantly lower than that observed in an upstream reference area that is not subjected to any thermal inputs (i.e. Garvins Pool). Changes in abundance should be assessed using CPUE as relative abundance is easily biased by increased or decreased contribution of catch of other fish species to the total catch within a given sample year. The 2011 trends analysis relied on boat electrofish data which is the most effective method for collecting fishes (Vincent 1971, Gammon 1973, Novotny and Priegel 1974, Gammon 1976, Davis et al. 1996, Barbour et al. 1999, and Simon and Sanders 1999 *as cited in* Flotemersch et al. 2006).

Page 112, Section 5.6.3.3h: USEPA states:

> *Based on a 21-year temperature data set provided by Merrimack Station, the averaged daily <u>maximum</u> temperature at Station S-0 exceeds the UILT for white sucker larvae on June 4 when larva concentrations in Hooksett Pool were at peak abundance.*

This is another example of where USEPA has limited its presentation of thermal data to only maximum average daily water temperatures. As noted above, this is misrepresentative given that these temperatures actually constitute a 1 in 21 year occurrence. A reader may be misled into assuming these thermal conditions exist every spring, rather than the 1 in 21 year occurrence during which they have been documented.

Pages 114-115, Section 5.6.3.3h: USEPA states:

> *Twomey et al. (1984) consider white suckers greater than 150 mm (total length) to be adults for purposes of their study. Based on this length threshold, only 3 of the 44 suckers caught in the summer months of 2004-2005 were juveniles. The data suggests that adult white sucker largely avoided the thermally-influenced portion of Hooksett Pool during summer months. It also suggests that the information provided in the Fisheries Analysis Report does not adequately address impacts to shallower areas where juvenile white sucker are likely to inhabit, as demonstrated during seining studies conducted in the 1970s. The thermal plume would be expected to occupy a greater percentage of the shoreline shallows given that it can extend three- feet deep or more below the surface.*

Length at maturity data for white sucker observed in the Platte River Basin, Colorado (Twomey et al. 1984) is not appropriate for application to Hooksett Pool in New Hampshire. Data collected from Hooksett Pool suggests that the length at 50% maturity for male white sucker is 221 mm and for female white sucker is 401 mm (Normandeau 2011a). Normandeau assumes that USEPA meant juvenile white sucker where it states "[t]he data suggests that adult white sucker largely avoided the thermally-influenced portion of Hooksett Pool during summer months," as it was established in the previous sentence that 93% of the white sucker were adults.

During 2008 and 2009 biocharacteristics sampling in Hooksett Pool, a total of 601 white sucker were assessed for reproductive condition (Normandeau 2011a). Fifty-one percent of those white sucker were classified as immature. The remaining 296 white sucker were classified as gravid, semi-gravid, ripe and running, partially spent, spent or resting. A wide range of ages were observed for white sucker collected from Hooksett Pool during 2008 and 2009 with individuals from age-0 to age-12 collected. For comparative purposes, 48% of the white sucker collected in Garvins Pool, located upstream of Hooksett Pool and away from Merrimack Station's thermal discharge, were classified as immature.

Page 115, Section 5.6.3.3h: USEPA states:

> *EPA reviewed the 21-year temperature data set provided by Merrimack Station in order to assess its ability to impair white sucker habitat downstream from the discharge. Average daily <u>maximum</u> water temperatures exceeded 85.8°F (29.9°C) every day at Station S-4 from June 25 to September 1 (Normandeau 2007b). This temperature represents the high end of the temperature avoidance range for juvenile white sucker.*

Again, USEPA has limited its presentation of thermal data to only maximum average daily water temperatures, which may mislead the reader into assuming these thermal conditions exist every spring, rather than the 1 in 21 year occurrence during which they have been documented. Mean average daily water temperature data provided by Merrimack Station indicate that temperatures at Station S-4 did not exceed 85.2°F (29.6°C) during the period June 25 to September 1 (Normandeau 2007c).

Page 116, Section 5.6.3.3h: USEPA States:

> *While juvenile fish are typically impinged, being too large to be entrained, Merrimack Station estimates that 32,682 young-of-year juvenile white suckers were entrained in June 2007. This equates to an additional loss of 2,618 adult equivalents for a total two-year entrainment loss of 17,044 white sucker adults (Normandeau 2007c).*

Samples from June 2007 were removed from storage and reexamined. White sucker are classified as young of year following the development of their fins and full complement of fin rays as well as migration of the mouth from terminal to subterminal. When extrapolated to estimate catch for a seven day period, a total of two individual white sucker were responsible for the estimate of 32,682 young of year. Based on reexamination, the two individuals previously classified as post-larval were in fact post-yolk sac larvae. Following correction of this error, a total of 1,153,611 white sucker PYSL were entrained and 0 white sucker YOY were entrained during 2007. The total of 32,682 white sucker which were reclassified as post-yolk sac larvae equates to an additional loss of 207 adult equivalents.

3.2 Detailed Comments on Section 6 of the §316 Determination Document

Page 117, Section 6.1: USEPA states:

> *Abundance for all species combined that comprised Hooksett Pool's balanced, indigenous community in the 1960s, has declined by 94 percent compared to the 2000s, based on trap net sampling. Moreover, combined CPUE dropped from 60.1 fish caught per 48 hours in the 1970s to 3.6 fish caught in the 2000s. See Section 5.6.2.1.1b & Table 5-9.*

As discussed in detail above, USEPA's selection of the 1967-1969 Hooksett Pool fish community as the Hooksett Pool BIP is deeply flawed. The fish community that existed during those three years was shaped by the severe pollution present in the Merrimack River prior to improvements in water quality following the passage of the CWA. Despite this, the §316 Determination Document makes no mention of either the significant system-wide pollution that existed in the Merrimack River during the 1960s and early 1970s, or how this extreme level of pollution can dramatically alter biological communities. By its statement, USEPA again calls attention to the fact that it overlooking the substantial improvements in water quality in the Merrimack River since the enactment of the CWA in 1972 (Normandeau 2011b) have appreciably influenced the fish community in the river, including in Hooksett and Garvins Pools, during the operation of Merrimack Station. Normandeau suggests that the current fish community in Garvins Pool provides a more appropriate point of comparison. Immediately upstream of Hooksett Pool, Garvins Pool is uninfluenced by the Station's thermal discharge but has similarly benefited from the significant water quality improvements that have occurred in the Merrimack River since 1972.

As also discussed in detail above,, USEPA's reliance on trap net data as the most representative of the fish community in Hooksett Pool is at best questionable. USEPA's own technical framework document for the development and implementation of large river bioassessment programs, "Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers," identifies electrofishing as the most comprehensive and effective single method for the collection of fish from streams and rivers (Flotemersch et al. 2006). Boat electrofishing is one of several active sampling methods that are recommended for sampling warmwater fish in rivers.

Normandeau also considered both gear types (boat electrofish and trap net) in its assessment of the Hooksett Pool fish community over time. Normandeau agrees that trap nets are effective at capturing certain selected fish species. However, passive gears, such as trap nets, can be most effective for specific species, guilds or size classes of fish and, as a result, may only effectively sample a segment of the fish community. The American Fisheries Society states in its book "Standard Methods for Sampling North American Freshwater Fishes" that the use of trap nets is more appropriate for standing waters such as lakes and ponds (Bonar et al. 2009). Effectiveness of trap nets at steep-sided locations such as Hooksett Pool is limited. In addition, deployment of trap nets in a riverine system such as Hooksett Pool can be problematic due to varying river flows and debris loading interfering with the ability of the gear to properly sample resident fish. Observations by the experienced field crews conducting fisheries sampling in Hooksett Pool provide support for the high susceptibility of trap nets fished in Hooksett Pool to impacts from river currents. Twists in the lead and/or net wings lead to severe impairment of the gear to properly sample fish.

Page 117, Section 6.1: USEPA states:

> *Abundance for all species combined that comprised the Hooksett Pool fish community in the 1970's has declined by 89.5 percent compared to community found in the 2000s, based on trap net sampling. See Section 5.6.2.1.1b & Table 5-8.*

As noted above, USEPA has chosen, without any adequate justification, to focus solely on trap netting data and disregard its own approved methodology for the assessment of fish communities in non-wadeable river systems (Flotemersch et al. 2006).

Page 117, Section 6.1: USEPA states:

> *The combined relative abundance for the five most abundant fish species in the 1960s has declined by 94.8 percent based on trap net sampling. Combined relative abundance dropped from an average 86.8 percent (1967-1969) to 4.5 percent (2004-2005). See Section 5.6.2.3.1b & Table 5-16.*

Again, as noted above, USEPA has chosen, without any adequate justification, to focus solely on trap netting data and disregard its own approved methodology for the assessment of fish communities in non-wadeable river systems (Flotemersch et al. 2006).

Further, USEPA is overlooking the fact that the substantial improvements in water quality in the Merrimack River since the enactment of the CWA in 1972 (Normandeau 2011b) have appreciably influenced the fish community in the river, including in Hooksett and Garvins Pools, during the operation of Merrimack Station. Normandeau (2011b) details the major shift in Merrimack River and Hooksett Pool water quality that has taken place since the enactment of the CWA. The Merrimack River today has improved overall quality, as evidenced by the change in classification from the equivalent of Class D during the 1960s to Class B now. The Hooksett Pool fish community that existed during the 1960s was shaped by the severe pollution that impacted the river at that time. It would be expected that, as conditions in the river system have improved, there would also be changes to the relative abundance of species present in the pool. This includes not only the fish community but all species, including vegetation, macroinvertebrates, etc.

For example, the addition of large amounts of nutrients from sewage discharges has been documented to enhance the presence of algae and submerged aquatic vegetation within an aquatic system

(Mackenthum 1965). Looking at presence-absence data, a decline in overall extent of submerged aquatic vegetation in Hooksett Pool is implied between the 1970s data and the most recent data collected during 2002 and 2010 (Normandeau 2011b). Macroinvertebrate communities are an excellent indicator of the health of an aquatic system. Due to their limited mobility, they are unable to avoid adverse environmental conditions and are often eliminated from areas where stresses exceed tolerance levels. During the 1960s, benthic organisms were "totally absent" in the lower 57 miles of the river and less than 15 miles of the total 115 miles of the Merrimack River that was studied contained benthic organisms (USDI 1966).

A comparison of the benthic invertebrate communities sampled during 1972, 1973 and 2011 at Stations N10, Zero, S4 and S17 indicate that water quality has improved (Normandeau 2012a). The top five fish species collected in Hooksett Pool during the 1967-1969 fish sampling – pumpkinseed, yellow perch, brown bullhead, white sucker and golden shiner – represented 89.8% of the total catch and are all capable of withstanding low DO conditions (Fox 1994, Terrell et al. 1982, Scarola 1987, Twomey et al. 1984, Becker 1983). Three of those species – white sucker, brown bullhead and golden shiner – are also classified as tolerant to pollution (Barbour et al. 1999). It stands to reason that the increased abundance of these five fish in Hooksett Pool during the 1960s is attributable to their ability to withstand introduced pollutants that were greatly reduced following enactment and enforcement of clean water regulations in the Merrimack River. Their relative contribution to the community as a whole would be expected to drop with improvements in water quality that allowed for the increase in number and diversity of other fish species that were either outcompeted or could not survive in the pollution during the 1960s. Pumpkinseed dominated fish catches during the 1960s. Due to traditionally low harvest levels as well as an extremely high reproductive potential, pumpkinseed populations can very easily become overpopulated (Scarola 1987). As a result of pumpkinseed overpopulation, other fish species such as smallmouth and largemouth bass can be impacted due to loss of food sources, predation on young, and loss of spawning habitat due to competition with large numbers of pumpkinseed.

Page 117, Section 6.1: USEPA states:

> *A calculated Bray-Curtis Percent Similarity Index of 23.2 percent when comparing Hooksett Pool fish community of the 1970s with that of the 2000s. The closer the Bray-Curtis value is to 100 percent, the greater the similarity of the two communities. Therefore, the fish communities of the 1970s and 2000s are dissimilar by 72.8 percent. See Section 5.6.2.4.*

The most recent review of fisheries data from Hooksett Pool shows a Bray-Curtis Percent Similarity Index value of 50% when comparing the 1970s with the 2000s. As detailed in the previous comment, the difference in community similarity between the 1970s and 2000s is not surprising given the major reduction in pollutants within the Merrimack River over this time period. When electrofish sampling data from Hooksett Pool is compared to Garvins Pool, Bray-Curtis Percent Similarity Index values of 64% and 43% were calculated for 2010 and 2011, respectively (Normandeau 2011a).

Page 117, Section 6.1: USEPA states:

> *The Hooksett Pool fish community has shifted from a mix of warm and coolwater species that existed in the 1960s and early 1970s to a community dominated by thermally tolerant species, primarily centrarchids (i.e., sunfish family), in the 1990s and 2000s. See Section 5.6.2.4.*

Normandeau disagrees. The Hooksett Pool fish community is still composed of a mix of warmwater and coolwater species. In fact, of the 16 fish species that were recorded in Hooksett Pool during the 1960s sampling, 15 are still present. Only the walleye, a non-native fish species that was sustained through stocking for sport fishing purposes, was not found during the 2000s. Within its §316 Determination Document, USEPA cites the presence of bluegill and spottail shiner in Hooksett Pool as evidence of the proliferation of thermally tolerant fish species. However, any link between Merrimack Station's thermal discharge and the presence/abundance of those two species in Hooksett Pool is weakened by the data collected in Garvins Pool for these two species. A comparison of annual mean CPUE values for bluegill shows that the most recent estimates in Hooksett Pool were significantly greater during 2010 but did not differ significantly to those observed during in Garvins Pool (Normandeau 2011a). A comparison of annual mean CPUE values for spottail shiner shows that the most recent estimates in Hooksett Pool did not differ significantly during 2010 and were significantly lower than those observed during 2011 in Garvins Pool. These findings are not consistent with the hypothesis that Merrimack Station's thermal discharge has caused an increase in the abundance of warmwater species and a decrease in the abundance of coolwater water species in Hooksett Pool.

Page 117, Section 6.1: USEPA states:

> *Yellow perch abundance in Hooksett Pool significantly declined between 1967 and 2005, based on electrofishing CPUE data. See Section 5.6.2.1.2a and Table 5-15 and Figures 5-3 and 5-8. Yellow perch abundance also significantly declined during the same time period, based on trap net sampling. See Section 5.6.2.1.2b.*

Normandeau's most recent trends analysis using electrofish data from years with consistent and comparable sampling methodology indicates that the abundance of yellow perch in Hooksett Pool for the 1972-2011 time period has significantly declined (Normandeau 2011a). If the Station's thermal discharge had adversely impacted the abundance and distribution of fish in Hooksett Pool over the 1972-2011 time period, the abundance of resident coolwater species in the pool should have significantly decreased during this time period. However, no such significant decrease in abundance was observed for three out of the five coolwater fish species resident in Hooksett Pool. Among the five fish species in Hooksett Pool considered to be coolwater species, abundance of chain pickerel and yellow perch decreased, while there were no significant trends for fallfish and white sucker. Abundance of the remaining coolwater species, black crappie, increased in Hooksett Pool during the operation of Merrimack Station. These observations on the time series of abundance of coolwater fish in Hooksett Pool are not consistent with the hypothesis that the Station's thermal discharge has consistently resulted in a decrease in the abundance of coolwater species and thereby caused appreciable harm to the BIP in Hooksett Pool.

Page 117, Section 6.1: USEPA states:

> *Pumpkinseed abundance in Hooksett Pool significantly declined between 1972 and 2005, based on electrofishing CPUE data. Trap net sampling data support the electrofishing data analysis. Pumpkinseed, the most abundant fish species in 1967 (53% relative abundance), has virtually disappeared from Hooksett Pool. See Sections 5.6.2.1.3 & 5.6.2.3.2a and b.*

Normandeau's most recent trends analysis using electrofish data from years with consistent and comparable sampling methodology indicates that the abundance of pumpkinseed in Hooksett Pool for the 1972-2011 time period has significantly declined (Normandeau 2011a). However, pumpkinseed in Hooksett Pool should not be considered as just a remnant population. Pumpkinseed represented 3.1% of the total catch in Hooksett Pool during the most recent sampling year (2011), and scale samples were collected that ranged from 50 mm to 131 mm, indicating a range of age classes present. The fact that the Hooksett Pool fish community was dominated by a single fish species during the 1960s and 1970s is an indication that the fish community was not balanced. Reduction in nutrient loading in Hooksett Pool since the 1970s has led to a decrease in the abundance of submerged aquatic vegetation beds within the pool (Normandeau 2011b) which is a favored habitat of pumpkinseed (Scarola 1987). In areas of poor water quality, pumpkinseed have advantages over bluegill. In lakes where bluegill and pumpkinseed ranges overlap, it has been theorized that lakes containing only pumpkinseed are due to winterkill of bluegill unable to cope with the hypoxic (low DO) conditions (Oseburg et al. 1992, Fox 1994, Tomacek et al. 2007). Pumpkinseed are more capable of withstanding lower DO levels and fluctuating environmental conditions than bluegill (Fox 1994) allowing them to survive in conditions that effectively eliminate bluegill. It is likely that organic pollution in the Merrimack River prior to the enactment of the CWA in 1972 led to the low DO levels documented during the 1960s and early 1970s (Normandeau 2011b), conditions that would have been advantageous for a species capable of tolerating these extremes.

Page 117, Section 6.1: USEPA states:

> *White sucker abundance in Hooksett Pool significantly declined between the 1970s and 2000s, based on trapnet CPUE data. White sucker trapnet CPUE dropped from 11 fish (caught per 48 hours) in the 1970s to 0.1 fish in the 2000s. Relative abundance dropped from 18.2 percent to 2.1 percent during the same during the same period. See Sections 5.6.2.1.4b.*

Again, as noted above, USEPA has chosen, with any adequate justification, to focus solely on trap netting data and disregard its own approved methodology for the assessment of fish communities in non-wadeable river systems (Flotemersch et al. 2006).

Normandeau's most recent trends analysis of electrofish data from years with consistent and comparable sampling methodology indicates that there was no significant trend in the abundance of white sucker in Hooksett Pool for the 1972-2011 time period (Normandeau 2011a). When compared with Garvins Pool, there was no significant difference in the 2010 CPUE of young of year white sucker, and the CPUE for juvenile and adult white sucker was greater in Hooksett Pool than was observed in Garvins Pool. During 2011, the CPUE of white sucker (all life stages pooled) was significantly greater in Hooksett Pool than was observed in Garvins Pool. These findings are not consistent with the hypothesis that Merrimack Station's thermal discharge has caused a decrease in the abundance of white sucker in Hooksett Pool and thereby caused appreciable harm to the BIP in Hooksett Pool.

Page 119, Section 6.1: USEPA states:

> *Based on a 21-year data set provided by PSNH, the averaged daily maximum water temperature reached or exceeded 100°F (37.8°C) at Station S-0 on 30 days in July and August, with the highest temperature reaching 104°F (40.0°C). See Sections 3.2, 3.4, & 5.6.3.3f.*

USEPA almost exclusively presents only the maximum average daily water temperatures throughout its §316 Determination Document. Its use of the thermal data provided by Merrimack Station is misleading and gives the mistaken impression that those thermal conditions exist every year rather than the 1 in 21 year occurrence during which they have been documented.

Page 119, Section 6.1: USEPA states:

> *The thermal plume extends across the entire width of Hooksett Pool during typical summer conditions. As a result, surface-oriented organisms, including larval yellow perch, white sucker, and American shad, which have limited or no ability to avoid stressful thermal conditions, are exposed to plume temperatures while drifting past the discharge canal that have been demonstrated in controlled studies to cause acute lethality to these species. See Sections 5.5, 5.6.3.3b, 5.6.3.3f, & 5.6.3.3h.*

USEPA has selected temperature values to present a worst case scenario to the average reader. Its determination is based primarily on maximum average daily water temperatures, which is misleading to the reader and gives the mistaken impression that those thermal conditions exist every year rather than as the 1 in 21 year occurrence during which they have been documented.

Normandeau questions USEPA's use of drift rates calculated using data from the middle of August, which is the lowest flow period time of the year, rather than the value it calculated for June (as discussed in Section 8.3.1.4b of the §316 Determination Document). Using the lower flows from August is inappropriate because yellow perch, white sucker and American shad larvae are not present in Hooksett Pool during August. Moreover, use of August data creates an artificially slow drift time for larvae between S0 and S4 and suggests longer exposures to elevated water temperatures than may be occurring. In addition, USEPA inexplicably makes little to no mention of the ΔT for river flow moving the 2,000 ft between Monitoring Station S0 and S4.

Page 119, Section 6.1: USEPA states:

> *Dissolved oxygen ("DO") studies revealed low-DO conditions immediately above Hooksett Dam. The study, conducted by PSNH, stated that the thermal plume from Merrimack Station caused stratification that contributed to low-DO conditions. See Section 2.4.*

Normandeau disagrees with USEPA's contention that Hooksett Pool water quality is currently impaired. This is an odd assertion, given that the State of New Hampshire granted a CWA §401 Water Quality Certification to PSNH for the Merrimack Hydroelectric Project in (which comprises the Garvins Falls, Hooksett and Amoskeag Dams and Hydroelectric Stations) following the completion of water quality monitoring in 2002-2003 (Gomez and Sullivan 2003). In addition, a recently released U.S. Army Corps of Engineers report stated that water quality within the Merrimack River impoundments is good (USACOE 2011). These governmental actions are not consistent with the contention of poor water quality in Hooksett Pool.

The Gomez and Sullivan (2003) report explains why low DO was measured on this one date in 2002. According to the report, these were worst-case conditions due to very low flows (below the 95% exceedence interval for low flows), there was no rainfall, and there were above normal air temperatures. Because this was a diurnal study, the low DO values measured were near dawn, when BOD would have caused the low DO readings. Gomez and Sullivan (2003) identify the cumulative effects of a wastewater discharge into the river above Hooksett Dam as a possible cause.

Page 120, Section 6.1: USEPA states:

> *Once-abundant populations of coolwater species, such as yellow perch and white sucker, have significantly declined since the 1960s and 1970s. Heat-tolerant species such as bluegill, largemouth bass and smallmouth bass, now dominate. See Section 5.6.2.4, 5.6.3.3d, 5.6.3.3f, & 5.6.3.3h.*

Normandeau's most recent trends analysis conducted using electrofish data from years with consistent and comparable sampling methodology indicates that the abundance of yellow perch in Hooksett Pool for the 1972-2011 time period has significantly declined, whereas there was no significant trend in CPUE for white sucker (Normandeau 2011a). The inconsistency of these findings is not consistent with the hypothesis that Merrimack Station's thermal discharge has appreciable harm to the BIP in Hooksett Pool. If the Station's thermal discharge had adversely impacted the abundance and distribution of fish in Hooksett Pool over the 1972-2011 time period, the abundance of resident coolwater species in the pool should have significantly decreased during this time period. However, no such significant decrease in abundance was observed for three out of the five coolwater fish species resident in Hooksett Pool. Among the five fish species in Hooksett Pool considered to be coolwater species, abundance of chain pickerel and yellow perch decreased, while there were no significant trends for fallfish and white sucker. Abundance of the remaining coolwater species, black crappie, increased in Hooksett Pool during the operation of Merrimack Station. These observations on the time series of abundance of coolwater fish in Hooksett Pool are not consistent with the hypothesis that the Station's thermal discharge has consistently resulted in a decrease in the abundance of coolwater species and thereby caused appreciable harm to the BIP in Hooksett Pool.

Page 120, Section 6.1: USEPA states:

> *Yellow perch and white sucker largely avoided areas of the Hooksett Pool experiencing elevated temperatures associated with Merrimack Station's thermal discharge during August and September. The averaged daily maximum water temperature exceeded 83.0°F (28.3°C) — the temperature Merrimack Station identified as an avoidance temperature for yellow perch — every day at Station S-4 from June 15 to September 10. See Sections 5.6.3.3f & 5.6.3.3h.*

Again, USEPA has limited its presentation of thermal data to only maximum average daily water temperatures, which may mislead the reader into assuming these thermal conditions exist every year, rather than as the 1 in 21 year occurrence during which they have been documented. In addition, the Agency makes no mention of either the 2.9 miles of habitat located upstream of Merrimack Station that is available to yellow perch in Hooksett Pool, or the thermal zone of passage (i.e., cooler water) that is located beneath the plume (which has been described as a surface lens extending to a depth of several feet) (Normandeau 1979b).

3.2 Detailed Comments on Section 8 of the §316 Determination Document

Page 178, Section 8.3: USEPA states:

> *Because freshwater fishes cannot regulate their body temperature through physiological means, water temperature affects virtually all of their biochemical, physiological, and life history activities (Beitenger et al. 2000). Water temperature is so important to fish that it has been called the "abiotic master factor" (Smith and Hubert 2003).*

There are numerous abiotic factors that influence freshwater fish populations, including, for example DO levels, nutrient levels, river flow and physical habitat. It is the combination of these factors as a whole that drives fish assemblages and relative contributions within a system. The importance of any one abiotic factor may differ greatly among fish species. A review of Smith and Hubert (2003) revealed that the term "abiotic master factor" should properly be credited to Brett (1971) and was based on observations of the thermal relations on the physiology and ecology of sockeye salmon.

Page 179, Section 8.3.1: USEPA states:

> *EPA reviewed scientific literature for the following resident species to determine which would be the most sensitive to elevated temperatures at various life stages: yellow perch, white sucker, pumpkinseed, fallfish, largemouth bass, smallmouth bass, bluegill, golden shiner, spottail shiner, and brown bullhead.*

USEPA does not provide the reader with citations to any of the "scientific literature" used in its review of thermal requirements for these ten resident fish species.

USEPA states:

> *From this review, EPA determined that yellow perch was the resident fish species in Hooksett Pool most sensitive to temperature for each life stage evaluated.*

Normandeau (1979b) states "[w]he white sucker is the least heat tolerant species that resides in Hooksett Pool." Yoder and Gammon (1976) noted that white sucker were the most deleteriously affected species by thermal additions from an Ohio power station. A review of EPRI (2011) notes that white sucker are considered as "one of the most thermally sensitive warmwater species."

Normandeau's most recent trends analysis conducted using electrofish data from years with consistent and comparable sampling methodology did not detect a significant trend in abundance of white sucker. A direct comparison of white sucker CPUE observed in Hooksett Pool with that of a comparable section of the Merrimack River uninfluenced by Merrimack Station's thermal discharge (Garvins Pool) was conducted during the 2010 and 2011 electrofish sampling. The abundance (CPUE) of white sucker in Hooksett Pool was greater than that observed in Garvins Pool during both years. During intensive biocharacteristics sampling in Hooksett Pool during 2008 and 2009, a wide range of ages and reproductive conditions were observed, indicating that white sucker are successfully spawning and maintaining a population in Hooksett Pool (Normandeau 2011a).

Page 181, Section 8.3.1.1a: USEPA states:

> *Based on EPA's review of Merrimack Station's 21-year water temperature data set, the average daily mean water temperature in ambient portions of Hooksett Pool drops below 10°C (50°F) on October 26, and does not rise above 10°C until May 1 (Normandeau 2007b). This indicates that the minimum temperatures needed for proper gonadal development exist in the ambient waters of Hooksett Pool for 185 days, on average. However, based on Hokanson's studies (1977), a chill period of 185 days at 10°C (50°F) equates to only 30-percent spawning success of all females exposed during the study. The spawning success rate increased to nearly 58 percent when females were exposed for a chill period of 170 days at 8.0°C (46.4°F).*

A review of peer-reviewed yellow perch literature suggests that the temperature required for proper gonadal development, and the duration of time spent at that temperature, varies with latitude. For example, Hinshaw (2006) states that "*[y]ellow perch must be exposed to cold temperatures for* *their eggs to develop and mature. In the states bordering Canada and northward, the maximum temperature for this "chill period" is as low as 6 °C; it may be closer to 10 °C (50 °F) at the southernmost fringe of perch distribution. The necessary duration of the exposure to cold temperatures was determined to be at least 185 days for fish in Minnesota, but the optimum exposure time for perch from other areas is unknown. In general, yellow perch from more southern latitudes do not require a period of cold exposure that is as long or as cold as that needed by fish from more northern areas."*

Pages 181-182, Section 8.3.1.2: USEPA states:

> *In addition to being an important factor in proper gonadal development, water temperature is an important cue triggering the onset of spawning. Artificially high water temperatures may cause resident species to reach maturity earlier in the spawning season than they would otherwise, and even to spawn earlier than they would naturally, in the absence of elevated water temperatures. Spawning has been noted to take place earlier by fish in a discharge canal as compared to fish in nearby waters under ambient conditions (Marcy 1976). This disruption in the timing of spawning may severely decrease the survival rate of the early life stages of the affected species. Under normal conditions, spawning is timed to allow the emergence of newly hatched larvae and young-of-year fish to coincide with spring peaks in their favored prey. Early spawning may result in these life stages occurring in the lower basin before their prey is abundant. This could have a serious impact on the survival of the early lifestages of these species.*

Although the phenomenon of fish species spawning earlier in regions of a water body exposed to elevated water temperatures has been documented (Trembly 1960, Adair and DeMont 1971, Langford 1972 *as cited in* Marcy 1976b), Marcy (1976b) did not directly observe spawning to occur earlier within the discharge canal. Detailed study of brown bullhead and white catfish in that system did note that ovaries developed earlier in fish in the canal, and it was theorized that they may consequently spawn earlier than normal and development of their young may not be synchronized with their food sources. Marcy (1976b) speculated that the early ovarian development would have little impact to the river catfish population. No damage to the ovaries attributable to overwintering in the canal was observed during their study.

In addition, it is unclear to what geographic region USEPA is referencing in the sentence "[e]arly spawning may result in these life stages occurring in the lower basin before their prey is abundant." There is no "lower basin" in Hooksett Pool.

Page 182, Section 8.3.1.2: USEPA states:

> *Sampling data that documented the presence of adult- stage residence fish species in Hooksett Pool were available, although this information did not directly address the spawning condition.*

Normandeau requests that USEPA review Normandeau (2011a), which provides information related to the spawning condition of two important coolwater fish species, yellow perch and white sucker, in Hooksett Pool based on data collected during 2008 and 2009.

Page 182, Section 8.3.1.2a: USEPA states:

> *Hartel et al. (2002) and Scott and Crossman (1973) both reported that yellow perch spawning occurs at night in shallow areas, when water temperatures are between 6.7° and 12.2°C (44°54°F). Hokanson (1977) reported that successful reproduction of yellow perch depends on rising temperatures during spawning and early life stages. According to Krieger et al. (1983), temperatures from approximately 8.5° to 12°C (47.3°-53.6°F) represent a spawning Habitat Suitability Index of 1.0 (completely suitable), which are comparable to the conclusions of Hartel et al. (2002) and Scott and Crossman (1973).*

Although the optimum spawning temperature of yellow perch was identified as 12°C (53.6°F), USEPA's own 1974 draft thermal discharge guidance states that yellow perch spawning occurs successfully over a range of water temperatures from 7° to 15°C (44.6°-59.0°F) (USEPA 1974).

Page 186, Section 8.3.1.4a: USEPA states:

> *Ambient water temperature data for the earliest date that yellow perch larvae were collected were not included in Merrimack Station's Entrainment and Impingement Report (Normandeau 2007c). Therefore, to estimate the water temperature on this date, EPA averaged the daily mean ambient temperatures for the first seven days of May using Merrimack Station's 21-year temperature data set (Appendix A). Based on this calculation, the first yellow perch larvae were collected in entrainment sampling at temperatures approximating 11.2°C (52.1°F).*

Water temperatures were recorded at Merrimack Station during entrainment sampling and would be representative of ambient conditions as they were measured upstream of the Station's cooling canal. Those temperatures averaged 9.9º C on the sample date during the first week of May 2007. Water quality associated with entrainment sampling at Merrimack Station was provided to USEPA in Appendix Table A-1 of Normandeau (2007b).

Page 187, Section 8.3.1.4a: USEPA states:

> *EPA considered the poor status of the existing yellow perch population in Hooksett Pool, the range of ambient temperatures during the period when yellow perch larvae are likely to be present, published studies, and the particular vulnerability of surface-oriented yellow perch larvae to Merrimack Station's thermal discharge plume.*

Although the abundance of yellow perch in Hooksett Pool is lower than that observed in thermally uninfluenced Garvins Pool (Normandeau 2011a), a review of biocharacteristics data is not supportive of the term "poor." Biocharacteristics data for yellow perch collected during 2008-2011 do not indicate that yellow perch in Hooksett Pool are faring poorly relative to yellow perch in Garvins Pool (Normandeau 2011a).

Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a decreasing slope to the length-weight curve – signifying progressively lower weight for a given length – for a resident fish species over time or in comparison to the same species residing in thermally uninfluenced habitat. Such a decreasing slope indicates a reduction in quality of body condition due to the thermal impact. There was no significant difference in the condition of yellow perch collected during 2009, indicating that yellow perch maintained similar incremental weight gain with increasing length between Hooksett and Garvins Pools. The length-weight curve based on the

2008 catch showed yellow perch in Hooksett Pool grew significantly more rotund (or "fatter") with increasing length than in Garvins Pool, whereas the opposite was true during 2011. Insufficient numbers of yellow perch were collected in Garvins Pool during 2010 to allow for a comparison of condition.

Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show lower mean length at age for a resident fish species compared to the same species in a thermally uninfluenced area, due to a reduction in growth rates associated with thermal stress. Although there were no significant differences in the mean length at age of age-0 yellow perch collected in Garvins and Hooksett Pools during 2009, the mean length at age of age-1, age-2 and age-3 yellow perch collected in Garvins Pool during 2009 were larger than those collected in Hooksett Pool. This observation of reduced mean length at age in Hooksett Pool suggests that growth (as estimated by mean length at age) may be reduced for some age classes of yellow perch in Hooksett Pool as compared to the same age classes of yellow perch in Garvins Pool. However, the inverse relationship between density and growth (i.e., the larger the fish population in a given water body, the slower the growth of individual fish in that population, due to competition for resources) has been well-studied and documented in other systems for yellow perch. Here, abundance of white sucker was greater in Hooksett Pool than Garvins Pool during the sampling period, suggesting that the causes for such lower mean length at age for one of the coolwater fish species in question are unrelated to the Station's thermal discharge.

Where aquatic habitat has been adversely impacted by a thermal discharge, sampling data typically show a greater total mortality (Z) for a resident fish species compared to the same species in a thermally uninfluenced area, due to increased stress associated with thermal impacts. Total instantaneous mortality did not differ for yellow perch between Garvins and Hooksett Pools. This finding supports the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool.

Resident fish species in aquatic habitat that has been adversely impacted by a thermal discharge characteristically manifest more frequent infestation of internal and external parasites compared to the same species resident in a thermally uninfluenced area, indicating a reduction in the overall health and conditions of the fish due to thermal impacts. There were no significant differences in the frequency distribution of external parasites on yellow perch within Garvins or Hooksett Pools. Internal parasites were more prevalent in yellow perch collected in Garvins Pool than was observed in Hooksett Pool. These observations support the hypothesis that Merrimack Station's thermal discharge has not caused appreciable harm to the BIP in the Hooksett Pool.

Thermally degraded habitat conditions in Hooksett Pool could affect the reproductive conditions of fish populations. Yellow perch reproductive state was similar between Garvins and Hooksett Pools during the spring sampling period, as indicated by mean gonadosomatic index values. The age at 50% maturity was older in Garvins Pool for male and female yellow perch. The length at 50% maturity was smaller in Hooksett Pool for male yellow perch and similar for female yellow perch. Estimates of fecundity (number of eggs per ripe female) were similar for individuals collected in Garvins and Hooksett Pools. These findings are not consistent with the assertion that yellow perch are of poor status.

Page 192, Section 8.3.1.5a: USEPA states:

> *McCormick (1976) found maximum growth rates at 28°C (82.4°F) for juvenile yellow perch.*

A review of McCormick (1976) shows that growth rates observed at 28°C did not differ significantly from those observed within the range of 26 to 30°C.

Page 194, Section 8.3.1.6a: USEPA states:

> *As discussed in section 5.6.3.3f of this document, fish sampling conducted in 2004 and 2005 by Merrimack Station indicates that adult yellow perch largely abandon the southern portion of Hooksett Pool during summer conditions. This suggests that adult yellow perch are being effectively precluded from habitat downstream of the discharge canal. As a result, considerably less area of the pool is available to support the population, which may reduce production (NAS/NAE 1972).*

Abandonment of the southern portion of Hooksett Pool could in fact be movement to deeper portions inaccessible to e-fishing. Yellow perch often move into deeper water during warmer summer month using these areas as a thermal refuge, stressing the importance of variable habitat types (Kreiger et al. 1983).

Page 200, Section 8.3.2.2: USEPA states:

> *There have been documented cases where alewives and American shad have successfully spawned in the pool (Normandeau 2007a). According to an anadromous fisheries report completed by Merrimack Station in 1976, many places in Hooksett Pool represent suitable spawning areas for American shad (Normandeau 1976b).*

USEPA is correct that spawning of American shad has taken place in Hooksett Pool. Normandeau's 1979 report *Merrimack River Anadromous Fish Investigation* (Normandeau 1979c) details the stocking of 624 adult American shad within Hooksett Pool following their capture and successful trucking from the Connecticut River in 1978. Findings from this study were apparently overlooked by USEPA as they were not mentioned as part of its analysis. The report documented that stocked shad spawned in Hooksett Pool, as indicated by eggs captured throughout June in drift net collections. The majority of eggs were collected at Stations 0-E (discharge canal) and S-8-E, and based on high capture rates at those locations combined with a paucity of eggs collected upstream, it was determined that the majority of spawning occurred between N-1 and S-8. That area can be characterized as the deeper region south of the discharge canal as well as the shallow water just north of the discharge. Normandeau (1979c) also documented that they began capturing juvenile shad in Hooksett Pool on July 25 and juvenile shad catches continued into the fall (Normandeau 1979c, Table 6). A total of 313 juvenile shad were captured seining and out of these, all but 13 were captured between discharge station 0-W and S-4-E, in the thermal plume. Even with Unit two offline, the surface water temperatures during the capture of shad juveniles ranged from 23.9º C to 28.2º C during July and August.

Page 203, Section 8.3.2.4d: USEPA states:

> *This report refers to site-specific studies conducted by PSNH's consultant, Normandeau Associates, Inc., that demonstrate that significant mortality occurs at temperatures greater than 33.3°C (91.9°F) after only a 30-minute exposure to the plume. This temperature was*

> *reached or exceeded at Station S-0, where Merrimack Station's discharge plume enters the river, on all but six dates in the month of June, according to Merrimack Station's 21- year temperature data set (Appendix A). In July, 33.3°C (91.9°F) is exceeded on every date at Station S-0, with 13 dates reporting temperatures at or above 37.8°C (100°F).*

This is yet another example of USEPA's limiting its presentation of thermal data to only maximum average daily water temperatures. As noted above, this is misleading given that these temperatures constitute a 1 in 21 year occurrence. When the mean average daily water temperature at Station S-0 is considered, 33.3°C (91.9°F) was not exceeded on any dates during June and on ten dates during late July.

4.0 316(B)

4.1 Detailed Comments on USEPA's §316(b) Determination

This section provides detailed comments regarding USEPA's 316(b) determination (Sections 11 and 12.4 of the §316 Determination Document). These comments highlight the flaws in USEPA's 316(b) analysis. A number of the most significant flaws and misleading statements in its analysis include:

- Assumption and lack of supporting data for the assertion that eggs and larvae are equally distributed throughout the river.
- Criticism of the Merrimack Station impingement-entrainment study design even though it was submitted to USEPA for review prior to the start of sampling.
- Misinterpretation of May 2006 entrainment estimates presented in the Report "Entrainment and Impingement Studies Performed at Merrimack Generating Station from June 2005 through June 2007" (Normandeau 2007b).

4.1.1 Detailed Comments on Section 11 of the §316 Determination Document

Page 243, Section 11.2.1: USEPA States:

> *The plankton community generally consists of all microscopic plant and animals present in the water column. For this analysis, however, EPA primarily evaluated impacts to fish eggs and larvae, also known as "icthyoplankton."*

Please note that the correct spelling of the word is "ichthyoplankton." This word is misspelled throughout the §316 Determination Document.

Page 243, Section 11.2.1: USEPA States:

> *Merrimack Station currently utilizes a once-through (or open-cycle) cooling system designed to withdraw up to 286 million gallons per day (MGD) of water from the Hooksett Pool portion of the Merrimack River (85 MGD for Unit 1 and 201.6 MGD for Unit 2), and then to discharge the heated water back to the river. The fraction of the river that runs through the plant, and the corresponding fraction of the plankton community that is entrained with it, varies with the river flow.*

There is no evidence that entrainment varies with river flow. Entrainment will vary directly with the volume of water withdrawn by the Station and the density of ichthyoplankton in the river, neither of which are influenced by river flow.

Page 245, Section 11.2.1a: USEPA States:

> *No direct assessment can be made of the fraction of the total number of eggs and larvae present in Hooksett Pool that are lost to entrainment through Merrimack Station's CWISs because no in-river ichthyoplankton sampling was conducted during PSNH's entrainment study. If eggs and larvae are assumed to be equally distributed throughout the river, however, then the fraction of available water that is withdrawn for cooling can provide the basis for an estimate of the percentage of the Pool's eggs and larvae that are lost to entrainment.*

USEPA provides no evidence for the assertion that eggs and larvae are equally distributed throughout the river. In fact, the peer-reviewed scientific literature indicates that ichthyoplankton have a very patchy spatial and temporal distribution. USEPA provides no basis for its assumption that the percent of water withdrawn for cooling can provide an estimate of the percentage of the ichthyoplankton lost to entrainment. The percentage of the water withdrawn is a factor in determining entrainment, but density of ichthyoplankton in Hooksett Pool over space and time are also important factors. Existing entrainment and withdrawal data do not support the Agency's assumption that entrainment is proportional to percent water withdrawal because the months with the greatest percentage withdrawal are also the months with the lowest ichthyoplankton densities.

Figure 4-1 presents a plot of percent withdrawal on the x axis versus total entrainment on the y axis (Table 3-7; Normandeau 2007b). There is no apparent positive relationship between percent withdrawal and total monthly entrainment. In fact, a non-parametric Spearman Rank Correlation analysis indicates that there is a negative relationship (-0.41) between percent withdrawal and total monthly entrainment. The raw data are presented in Table 4-1. The months with the greatest percent withdrawal, August and September 2006, also have the lowest entrainment because ichthyoplankton are not common in Hooksett Pool during those months. The highest entrainment occurred in June of 2006 and 2007 when percent withdrawal was relatively low (June 2006), or above average (June 2007) but entrainment was highest due to the high density of ichthyoplankton in Hooksett Pool. The conclusion to be drawn from this analysis of empirical data is that percent water withdrawal alone is not a major factor in determining entrainment at Merrimack Station. Density of ichthyoplankton in Hooksett Pool is also an important factor and the greatest percent withdrawals occur in the months when ichthyoplankton density is low.

It can be seen that during May, low ichthyoplankton densities are the norm, and that the entrainment estimate for May at Unit 2 is driven by the relatively large amount of ichthyoplankton collected on the night of 31 May (Table 4-2). The data from the night of 31 May might be considered the outlier rather than the 0 counts at Unit 1, but Normandeau included all data in the analysis because there are no methodological reasons to exclude them. Empirical data should not be excluded because it appears to be "different," but may only be excluded if there is some methodological reason that would justify the exclusion, such as abnormal field sample collection or mishap during laboratory analysis. These incidents did not occur. Therefore, USEPA's rationale for excluding the data for Unit 1 from May, and substituting the Unit 2 data for the Unit 1 data is not valid. Normandeau's data estimated 3.2 million larvae per year were entrained, and USEPA improperly changed this number to 3.8 million larvae entrained.

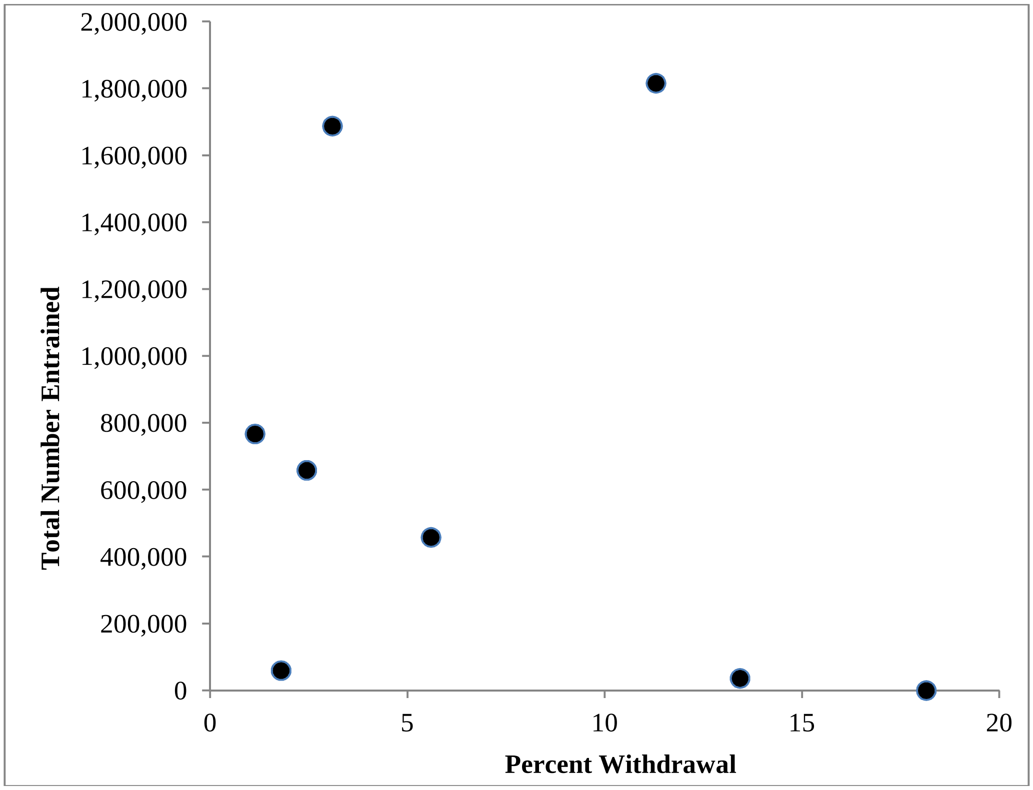

Figure 4-1. Percent withdrawal versus total number entrained during Merrimack River entrainment studies (2006-2007) (Normandeau 2007b).

Table 4-1. Monthly river flow, plant withdrawal and larval entrainment at Merrimack Station, 2006-2007 (Normandeau 2007b).

Year	Month	River Flow (million gallons)	Plant Flow (million gallons)	Percent Withdrawal	Entrainment
2006	May	331,811	3,778	1.14	767,330
	June	236,747	7,344	3.1	1,687,784
	July	141,833	7.944	5.6	457,974
	August	59,157	7,944	13.43	36,445
	September	28,681	5,206	18.15	0
2007	April	290,628	5,245	1.8	59,724
	May	177,852	4,361	2.45	658,544
	June	65,656	7,418	11.3	1,815,937

Table 6-2. Number of larvae collected at Units 1 and 2 of Merrimack Station on 25 and 31 May, 2006 (Normandeau 2007b).

Date	Unit	Diel Period	Amount of Ichthyoplankton collected in sample
31-May	1	Day (10:35-14:37)	0
31 May- 1 June	1	Night (21:15-01:49)	0
25-May	2	Day (12:53-16:31)	0
25 May- 26 May	2	Night (21:43-01:21)	1
31-May	2	Day (09:56-14:12)	2
31 May-1 June	2	Night (21:16-01:08)	28

Page 247, Section 11.2.1a: USEPA States:

> *During sampling in 2006 and 2007, fish larvae were collected from April to August. None were collected in September. Since sampling was not attempted in March of either year, it is unknown whether larvae were present during that month.*

USEPA had the opportunity to provide comments on the sampling design and did not do so.

Page 248, Section 11.2.1a: USEPA States:

> *In addition to entrainment of eggs and larvae, sampling conducted by Merrimack Station in 2007 revealed significant entrainment of post-larval, young of year white suckers. According to the plant's report (Normandeau 2007c), and estimated 32,682 post-larval white suckers were entrained in both units during the month of June 2007.*

Samples from June 2007 were removed from storage and reexamined. White sucker are classified as young of year following the development of their fins and full complement of fin rays as well as migration of the mouth from terminal to subterminal. When extrapolated to estimate catch for a seven-day period, a total of two individual white sucker were responsible for the estimate of 32,682 young of year. Based on reexamination, the two individuals previously classified as post-larval were in fact post-yolk sac larvae. Following correction of this error, a total of 1,153,611 white sucker PYSL were entrained and 0 white sucker YOY were entrained during 2007.

Page 250, Section 11.2.1a: USEPA States:

> *An adult equivalent loss analysis is one factor to consider in approximating the overall magnitude of the adverse impact of entrainment. It is not, however, the only factor to consider and such analyses have a number of important limitations.*

Adult equivalency is an accepted standard method used to estimate impacts to fish populations. Although USEPA discounts the adult equivalent analysis, the best estimates of the number of equivalent adult fish lost to entrainment and impingement is approximately 13,000. The biomass of organisms entrained is not necessarily lost to the system. Even if 100% mortality is assumed, dead and moribund organisms are discharged back to Hooksett Pond where they can be consumed by predators or recycled as nutrients to the Merrimack River.

Page 251, Section 11.2.1a: USEPA States:

> *A review of recent sampling data provided by PSNH puts the loss of 195 adult-equivalent yellow perch (in 2007) into some context. According to PSNH (Normandeau 2007a), the total of two years (2004, 2005) of electrofish sampling and trapnetting resulted in the capture of only 76 yellow perch, many of which were likely juveniles. PSNH conducted additional sampling in the spring and fall of 2008. Interestingly, this sampling collected a total of 76 yellow perch, as well, but 33 perch (44%) were identified as juveniles, either age-0 or age-1 fish (Normandeau 2009a). In light of the relatively low numbers of adult yellow perch caught over three years of sampling, the loss of 195 adult-equivalents takes on greater significance.*

Equivalent adult estimates cannot be compared to the results of a sampling program that was not intended to be a complete census of the yellow perch population in Hooksett Pool. A sampling program results in just that: a sample of the total population, not a complete census of the population.

The catch of yellow perch in trap nets is at best proportional to the total population in Hooksett Pool and in no way represents a total census of the yellow perch population. CPUE is an indicator of population size, not the population size itself, and cannot be compared to an equivalent adult estimate.

Page 251, Section 11.2.1a: USEPA States:

> *The entrainment study did not include sampling from October to April. The decision not to sample during late fall through early spring was likely based on life history information for the species residing in Hooksett Pool indicating that entrainable life stages are not likely to be present during that period. It is certainly possible, however, that some larvae exist in Hooksett Pool during March (most likely late March), given their presence in April, although EPA expects that their numbers would be relatively low. Larva entrainment was at its highest from May to July, tapering off in August. No larvae were collected in September sampling conducted in 2007 (Table 11-4). Additionally, no eggs or larvae of anadromous fish species were collected.*

Based on the life histories of fish species in Hooksett Pool, sampling for ichthyoplankton during the fall and winter seasons is unnecessary. With regard to the commencement of entrainment sampling during May, USEPA had the opportunity to provide comments on the sampling design and did not do so.

Page 252, Section 11.2.1b: USEPA States:

> *EPA states that certain aspects of PSNH's entrainment estimates in 2006 and 2007 are questionable. EPA questions the validity of May 2006 entrainment sampling at Unit 1 due to differences compared to the sampling in the same time period at Unit 2.*

Empirical data cannot be discarded without some good reason with regard to either the collection methods or the methods used for laboratory analysis. Examination of the raw entrainment data indicates that the data collected on 31 May 2006 at Units 1 and 2 of Merrimack Station are valid, and that there are no methodological reasons for deleting these data. At Unit 1, two samples were collected on 31 May. At Unit 2, two samples were collected on each of 25 May and 31 May. Raw data are presented in Table 6-2.

Page 253, Section 11.2.1b: USEPA States:

> *The Hooksett Pool has a limited capacity to recruit a new "year class" to the larger fish community due to the physical barriers to fish movement from the Garvins Falls and Hooksett dams.*

USEPA presents no evidence why larval drift from the upstream Garvins Pool could not result in significant recruitment to Hooksett Pool.

Page 253, Section 11.2.1b: USEPA States:

> *The plant's study did not differentiate larval sunfish, bass, and minnows to the species level.*

Larval sunfish and bass were grouped as "sunfish family" (Centrarchidae) as these species cannot always be readily distinguished in the larval lifestage. Minnows were grouped separately as "carp and minnow family" (Cyprinidae) because this family is also very difficult to distinguish in the larval lifestage. This level of taxonomy is consistent with Regional Case Studies for the Section 316(b) published by USEPA (2004).

Page 253, Section 11.2.1b: USEPA States:

> *White sucker and yellow perch were the numerically-dominant indigenous species in the 2007 entrainment sampling, representing 46 and 18 percent, respectively, of all species sampled. Both species have larval stages that are particularly prone to entrainment.*

USEPA provides no rationale for the assertion that white sucker and yellow perch are particularly prone to entrainment.

Page 253, Section 11.2.1b: USEPA States:

> *The relative abundance of yellow perch and white sucker in the 1960s was 26 percent and 16 percent, respectively. By the 2000s, those numbers had both dropped to 2 percent. While the recovery of these species will require reduced thermal discharges, EPA expects that continued entrainment at this level would likely interfere with a recovery.*

The fish community in the Merrimack River in the 1960s cannot be compared to the current community due to vast improvements in water quality. USDI (1966) found that benthic organisms were "totally absent" in the lower 57 miles of the river; less than 15 miles of the total 115 miles of the Merrimack River that was studied contained benthic organisms. Levels of nutrients such as nitrite, nitrate, and total organic phosphorus have declined by an order of magnitude since the late 1960s (Normandeau 2011b). In fact, with the reduced eutrophication, the current status of the fish community in the Merrimack River is likely closer to an undisturbed state than the community in the 1960s. USEPA provides no rationale in this section that recovery of yellow perch and white sucker will require reduced thermal discharges.

USEPA refers to the relative abundance of white sucker and yellow perch. However, relative abundance tells us little about the absolute abundance of a given species. Relative abundance can decrease due to an increase the abundance of other species. Table 4-3 presents the electrofish CPUE of white sucker and yellow perch from the same sampling station in Hooksett Pool in 1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010 and 2011 (Normandeau 2011a). There were no significant trends in CPUE of white sucker, but there was a significant negative trend in the CPUE of yellow perch. The fact that CPUE of one coolwater fish increased over time (white sucker) yet CPUE of another coolwater fish decreased is not a clear indication that Merrimack Station's thermal discharge is responsible for the changes.

Table 4-3. Electrofish CPUE for white sucker and yellow perch during August and September of all years with consistent sampling effort in Hooksett Pool (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, and 2011).

Year	White sucker CPUE	Yellow Perch CPUE
1972	1.4	8.3
1973	0.2	5.5
1974	4.65	3.95
1976	2	1.05
1995	0.2	0.2
2004	0.75	0.65
2005	0.4	2.6
2010	0.26	0.11
2011	1.29	1.84

Page 253, Section 11.2.1b: USEPA States:

> *American shad is another species particularly vulnerable to entrainment. While larval shad may not currently be abundant in Hooksett Pool, new state and federal efforts to restore American shad to the Merrimack River should result in greater numbers of their larvae present in Hooksett Pool.*

USEPA provides no rationale why American shad larvae would be "particularly vulnerable to entrainment" compared to any other species.

Page 254, Section 11.2.1b: USEPA States:

> *Merrimack Station's flow withdrawal rates, as a percentage of available river flow, are even greater in August, a month when eggs and larvae are still present in Hooksett Pool. EPA calculated the mean monthly flow withdrawal rate for August to be 25 percent, based on a 15-year average (1993-2007).*

As demonstrated above using empirical data (see Normandeau's response to USEPA's comment on page 245, Section 11.2.1a of the §316 Determination Document), there is no positive relationship between withdrawal rate by Merrimack Station and entrainment because ichthyoplankton densities are very low during the months when withdrawal is highest.

Page 254, Section 11.2.1b: USEPA States:

> *The loss of eggs and larvae from all fish species, as well as other zooplankton, represents a significant reduction in available forage for older juvenile fish and other aquatic organisms that typically prey on them.*

Organisms entrained and impinged are not completely lost to the Merrimack River ecosystem because they are returned to the river where they can be preyed upon or recycled as nutrients.

Page 254, Section 11.2.1b: USEPA States:

> *EPA has concluded that entrainment at Merrimack Station represents a significant adverse environmental impact based on the available entrainment data, the capacity of Merrimack Station to withdraw a significant fraction of the river's flow and planktonic community (and as a result, cause substantial mortality to fish eggs and larvae), the poor status of the Hooksett Pool fish community, and the limited ability for the fish community to recover under current conditions in the pool.*

Normandeau has demonstrated that there is no significant positive relationship between water withdrawal by the Station and entrainment because the greatest water withdrawals occur in months when ichthyoplankton abundance is lowest. Normandeau has also demonstrated that the current fish community in the Merrimack River cannot be compared to that of the 1960s due to large improvements in water quality. Normandeau does not consider the current condition of the Hooksett Pool fish community to be "poor," but rather more representative of an undisturbed condition than the community of the 1960s.

Page 260, Section 11.2.2b2: USEPA States:

> *According to the Merrimack Station impingement report (Normandeau 2007c), the impingement of an estimated 8,007 fish at various life stages occurred from July 2005 to June 2007, based on actual intake flows during the two-year period. PSNH converted the 8,007 value to a three-year-old adult equivalent value of 1,033 fish.*

Adult equivalency estimates were based on age at first reproduction, not at age 3. Ages of first reproduction were estimated in Tables 2-6 through 2-14 of Normandeau (2007b).

Page 261, Section 11.2.2b3: USEPA States:

> *The impingement survival rates calculated by Merrimack Station are questionable in EPA's view, but even these rates are appreciably lower than rates obtained elsewhere during studies conducted by EPRI (2006). The loss of thousands of juvenile fish per year from an ecosystem already stressed by the plant's thermal effects and entrainment constitutes an adverse environmental impact.*

USEPA provides no basis for questioning the calculated impingement survival rates. USEPA provides no basis in this section for its assertion that the ecosystem is already stressed by thermal and entrainment impacts.

Page 269, Section 11.4.2c: USEPA States:

> *As rotating traveling screen panels emerge from the water, laden with fish and debris, a power spray wash system clears the material from the screens.*

Based on year 1 and year 2 impingement results reported in Section 11.2.2b2, impingement averaged 19 fish/day (less than one per hour) for year 1, and 3.5 fish/day in year 2. This does not support the statement that the screens were "laden with fish." Even assuming the high of 4,300 fish in June of

2006, that would only be about 6 fish/hr, hardly a rate that results in the screens being "laden" with fish.

Page 269, Section 11.4.2c: USEPA States:

> *The pressure of the spray wash system in Unit 1 is 85 pounds per square inch (psi), and 80-100 psi in the Unit 2 system (Normandeau 2007d). These are high pressure systems designed primarily for debris removal. It is evident that the Unit 1 and II spray wash systems are designed to remove debris from the traveling screens, not to safely remove fish and other soft-bodied aquatic organisms.*

The water pressure that contacts fish and debris is much lower than 85 psi or 80-100 psi. These pressures are measured in the spray header system, and pressure decreases greatly as the water leaves the header, passes through the traveling screen mesh and meets the debris and fish impinged on the traveling screen.

Page 269, Section 11.4.2c: USEPA States:

> *Occasionally, during winter months, one circulation pump and one traveling screen are shut down on Unit 2 due to the formation of frazil ice. By not operating both traveling screens, 100 percent of the screen wash flow is directed at the operating traveling screens. This concentrated flow further increases the spray wash pressure against the impinged fish.*

USEPA fails to note that with one pump operation, the through-screen velocity is significantly reduced. That fact was not noted either here or in Section 11.4.2a, where the trough screen velocity was discussed. If USEPA feels discussion of screen wash stress during this period is warranted, then discussion of the reduced velocity and fish stress should also be warranted.

Page 277, Section 11.6.1, USEPA States:

> *It is unclear whether adequate water depths exist in Hooksett Pool to accommodate an effective wedgewire screen installation.*

Recent empirical data indicates that depths in the vicinity of Merrimack Station's CWISs are about 4 m (13 feet). In May 2009, a bathymetric survey was conducted along a longitudinal transect near the CWISs. Locations L05 and L06 are closest to the CWIS for Unit 2, and location L10 is closest to the CWIS for Unit 1 (Figure 4-2). These data are the most detailed bathymetric data available for the area in the vicinity of the Station's CWISs.

Figure 4-3 is a screen capture of the raw bathymetric data and shows the depth of the water as the transect proceeds upstream. The x-axis of this screen capture corresponds to the locations plotted in the figure above. The second image shows that depths in the vicinity of locations L05 and L06 (Unit 2 intake structure) are slightly less than 4 m (13 feet), and depths in the vicinity of Location 10 are about 4 m (13 feet). Therefore, water depth also is not an adequate reason to reject wedgewire screens as an option for "best technology available" ("BTA") at Merrimack Station.

Figure 4-2. Data collection locations for bathymetric data collected in vicinity of Merrimack Station CWIS's.

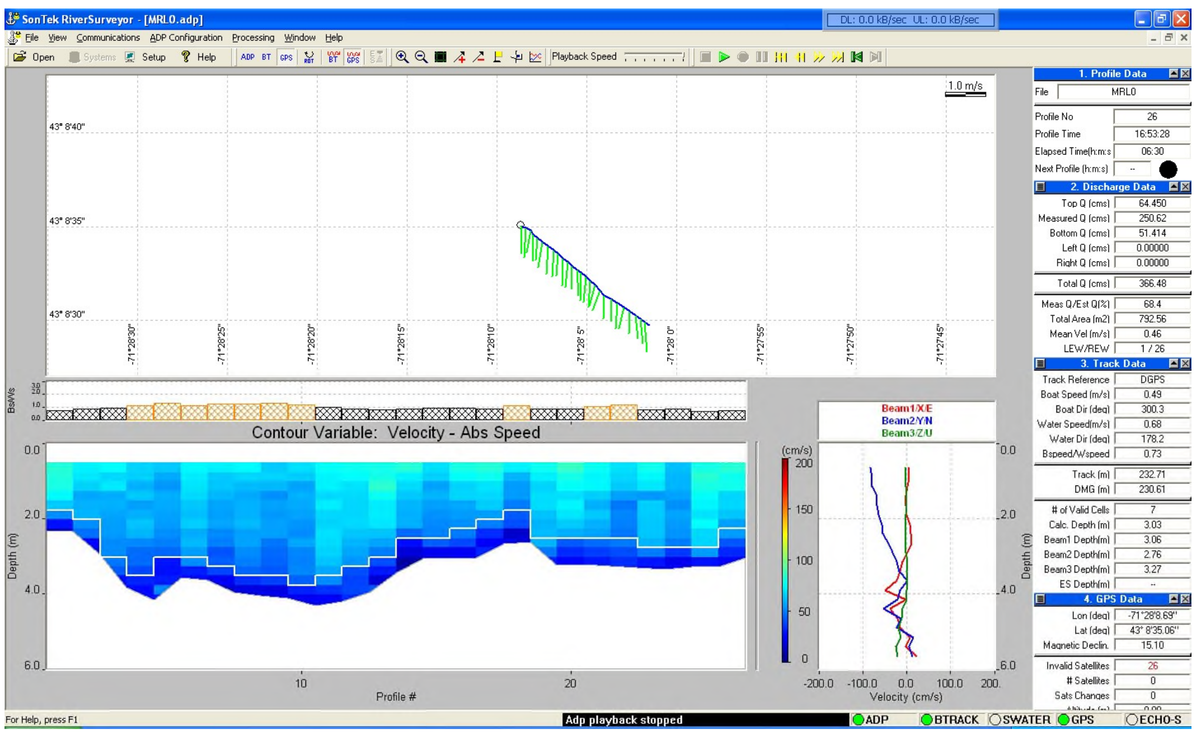

Figure 4-3. Screen capture of raw bathymetric data collected in vicinity of Merrimack Station CWIS's.

4.1.2 Detailed Comments on Section 11 of the §316 Determination Document

Page 314, Section 12.4.1. USEPA states:

> *It should also be noted that were it not for the depleted state of fish populations in the Hooksett Pool, these numbers would likely be even higher.*

See Normandeau's comments on Section 5 of the §316 Determination Document regarding the current state of fisheries resources in Hooksett Pool. A comparison of fish abundance collected by electrofishing from consistent sampling stations from the years 1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010 and 2011 does not indicate any clear trend in total abundance of fish, as estimated by electrofish CPUE in Hooksett Pool during these years. Normandeau does not consider the resources to be depleted, but the result of improved water quality in the Merrimack River since 1972.

Page 314, Section 12.4.1a. USEPA states:

> *The fraction of the river that runs through the plant, and the corresponding plankton community that is entrained with it, varies with the river flow.*
>
> *For example, EPA calculated that on July 7, 1995, Merrimack Station had withdrawn approximately 75 percent of the river flow. This represents a sizable fraction of the river flow and, by extension, a sizable fraction of the larva community during peak larval abundance.*

There is no quantitative evidence that entrainment at Merrimack Station is related to the fraction of the river withdrawn. Normandeau's comments on Section 11 show that there is a negative relationship between fraction of water withdrawn and entrainment. The largest fractions of the river withdrawal occur in the summer when ichthyoplankton densities are lowest, resulting in low entrainment.

Page 314, Section 12.4.1a. USEPA states:

White sucker and yellow perch were the numerically dominant indigenous species in the 2007 entrainment sampling, representing 46 and 18 percent, respectively, of all species sampled. Both species have larval stages that are particularly prone to entrainment. The abundance of these two species has declined over the years as water quality and habitat in the river have degraded. In the 1960s, the relative abundance of yellow perch and white sucker was 26 percent and 16 percent, respectively. By the 2000s, those numbers had both dropped to 2 percent.

USEPA provides no justification as to why white sucker and yellow perch " have larval stages that are particularly prone to entrainment".

Water quality and habitat in Hooksett Pool have improved since the 1960s, primarily due to the enactment and implementation of the Clean Water Act which resulted in the cessation of discharges of raw sewage to the Merrimack River. USEPA surely cannot be suggesting that water quality was better in the 1960s prior to the enactment of the Clean Water Act. The cessation of the discharge of nutrient enriched waters likely resulted in significant changes to the fish community in the Hooksett Pool.

As detailed in the most recent assessment of fisheries abundance trends in Hooksett Pool (Normandeau 2011a) there is no detectable trend in the abundance of white sucker whereas the abundance of yellow perch has decreased over time. The fact that CPUE of one RIS coolwater fish increased over time (white sucker) yet CPUE of another RIS coolwater fish (yellow perch) decreased is not a clear indication that thermal discharges are responsible for the changes.

Page 315, Section 12.4.1a. USEPA states:

> *Another species particularly vulnerable to entrainment is American shad.*

USEPA provides no justification as to why larvae of American shad are "particularly vulnerable to entrainment".

Page 315, Section 12.4.1.a. USEPA states:

> *The portion of the ichthyoplankton community entrained could be large given the large proportion of available river flow that Merrimack Station withdraws during some periods. In addition, entrainment rates may also reflect the compromised state of fish populations in Hooksett Pool, with fewer adult fish available to contribute to the ichthyoplankton community In light of the above factors, EPA deems entrainment at Merrimack Station to represent a significant adverse impact to the Hooksett Pool.*

As shown earlier (in response to Section 11 of the §316 Determination Document), there is not a positive relationship between water withdrawal and entrainment because the greatest water withdrawals occur in months when ichthyoplankton densities are low. Furthermore, Normandeau does not accept USEPA's unjustified assertion that the current state of the fish community in Hooksett Pool is compromised, especially when compared to the upstream Garvins Pool.

Page 316, Section 12.4.1b: USEPA states:

> *Merrimack Station's CWISs have several features that are likely to cause impingement mortality. First, the approach velocities of the CWISs for Units I and II are 1.5 ft/sec and 1.8 ft/sec, respectively. These rates are three to over three and a half (3.64) times greater than the 0.5 ft.sec intake velocity that EPA has identified to be low enough to allow many fish species to swim away from an intake velocity and avoid becoming impinged.*

Avoidance of fish entrainment and impingement problems at water intakes is related to fish size and swimming performance (Castro-Santos and Haro 2005). A literature review of swim speed information for fish species that inhabit Hooksett Pool is provided here. The purpose was to provide a basic comparison of available swim performance data for Merrimack River fish species to the calculated CWIS approach velocities of 1.5 fts/s (U1) and 1.8 ft/s (U2).

Three swim speed modes are generally recognized for fishes. Sustained swim speed is that maximum speed sustainable indefinitely, or for at least 200 min (Beamish 1978). Prolonged swim speed represents continuous, faster swimming that ultimately results in fatigue after at least 20 seconds. Laboratory testing of prolonged swim speeds for specific time intervals, frequently related to an expected or required time required to pass through fishways or culverts, results in estimates of critical swim speed (U), accompanied by a time stamp (e.g., Ucrit2 = maximum prolonged speed for 2 min). Burst, or sprint swim speeds, results in fatigue after no more than 15-20 seconds or less (Beamish 1978; Bell 1991). Burst or sprint swim speeds (also startle, fast-start, or dart) are the fastest attainable, and are also those generally associated with fish well-being or survival (Beamish 1978; Wardle 1980), as they are also related to a fish's ability to capture prey, avoid predators, or in the present case, avoid water intake velocities or structural elements. Among the three swim speed modes, burst swim speed is harder to quantify in a laboratory, and, thus, fewer burst swim speed studies with adequate sample sizes are available (Castro-Santos and Haro 2005).

Utilization of burst swim speed to avoid water intakes also implies the ability to use additional sensory mechanisms to properly detect and orient to the intake. Available stimuli near an intake, in addition to the physical structure, include turbulence, flow acceleration, pressure changes, sound, etc. (Castro-Santos and Haro 2005). The ability to utilize available cues to avoid intake structures or flow fields may be compromised by darkness or turbidity, for example, or reduced swimming ability as water temperatures approach or exceed cold water tolerances.

Swim speeds determined in the laboratory are typically measured by a distance rate, e.g., feet/sec, for a given fish length range or measure of length central tendency (mean, median). However, in recognition of the role of fish size in swim performance, much information on burst swim speed may also be expressed as fish body lengths/sec (L/sec), termed "relative burst speed". Smaller sized fish typically have a higher relative swim speed (more body lengths per second) than larger fish, even though the absolute swim speed of larger fish is faster.

The data listed in Table 4-4 include studies specifically designed to measure one or more component of swim speed or performance, as well as other studies, typically more recent, that measure swim speed in relation to one or more variables, such as temperature changes, dissolved oxygen levels, etc. Where a temperature range or specific test temperature is provided, these are indicated. For others with a range provided, the maximum swim speed attained was listed along with the appropriate temperature. Where other conditions were tested, such as physically-conditioned fish versus non-conditioned fish, the data from non-conditioned fish were used as they best represent wild fish (Young and Cech 1993). Few studies were noted that tested fish with an objective of developing a water intake design, or tested vs intake design criteria (e.g., Tatham 1970; Hocutt 1973). In general, the comments or clarifications provided in Table 4-4 identify any information deemed useful to assist interpretation of the test result.

A review of swim speed values in Table 4-4 identifies two trends for any given species. First, the swimming speed of larger juveniles or adult fish is faster than smaller juveniles. Second, water temperature also plays a role, and swim speed for several species appears maximized at approximately 20-30°C, typical late spring to fall ambient water body conditions. A reduction in swimming ability of 50% may occur at water temperatures outside a preferred range (ASCE 1995). Typically, reduced swimming ability only becomes a concern at water intakes in temperate latitudes as winter approaches. A review of available burst or sprint swim speeds (those generally associated with fish well-being or survival) show values greater than approach velocities for juvenile and adult alewife, adult American shad, adult bluegill, and Atlantic salmon adults and smolts. Within a species, the reported range of critical swim speeds varies, and some estimates are near or greater than Merrimack Station approach velocities for larger individuals of each of the six species where data is available.

Table 4-4. Available reported swimming speeds for nine Hooksett Pool fish species.

Species	Life Stage	Fish Size	SWIM SPEED-feet per second-ft/s Max. Sustained	Prolonged or Critical	Burst or Startle	Literature Source-Comments-Clarification
Alewife	juv	2.5-3 in			~3.0	est. from Bell 1991; dart speed maintained for 7.5 sec;
	adult	250mm TL			11.5-16.4	range of burst swim speed in fishway; Dow 1962 cited in Beamish 1978.
	adult	235mm FL			11.2*	Haro et al. 2004; @ 11.2C; able eto enter fishway at this V (max tested)
American shad	adult	unknown			11.5-13.2	Weaver (1965) in Beamish; adult timed over distance in fishway
Bluegill	juv	25-40 mm FL	0.3-0.75			Schuler 1968; S/max = minimal swim speed in natural environment; most tests ≥ 60F.
	juv	39-44 mm FL	0.48-0.52			King 1969; S/max = minimal swim speed in natural environment; 79-85F.
	juv	51-54 mm		0.92		tested at 21C; Beamish 1978
	adult	203 mm TL	1			Deng et al. 2004
	adult	unknown	0.98			Drucker and Lauder 1999
	adult	100-150 mm TL		1.22		Critical swim speed for 10-min; Gardner et al. 2006
	adult	153 mm TL			4.3	Webb 1978; final velocity measured after 9-sec burst over short distance
Black crappie	juv	78 mm TL	0.5L/sec***			Assumed foraging swim speed, slower than sustained (Chick and Van Den Avyle 2000)
Landlocked/ Atlantic salmon	juv	N/A	1.78			Mean; Beamish 1978
	juv	N/A	1.44-2.26			Range; Beamish 1978
	Parr	2-5 in	2.82			Peak and McKinley 1998
	smolt	4.9-8.3 in	4.13	5.4	6.4	Prolonged speed maintained for 2-10 minutes; Peak and McKinley 1998
	lg juv	13.8 in			11.4	Beamish 1978
	N/A	N/A			9.8	Beamish 1978
	adult	21-34 in	3.4			Maximum; Beamish 1978
	adult	29.5-33.5 in			14.1-19.7	Beamish 1978
	adult	N/A			26.4	Presumed adult timed over distance in fishway; Beamish 1978

(continued)

Table 4.4 (Continued).

Species	Life Stage	Fish Size	SWIM SPEED-feet per second-ft/s Max. Sustained	Prolonged or Critical	Burst or Startle	Literature Source-Comments-Clarification
Largemouth bass	juv	150mm	0.79 @ 10C			Beamish 1970 in Carlander 1977
	juv	150mm	1.57 @ 30C			
	juv	250 mm	1.51 @ 10C			
	juv	250mm	2.07 @30C			
	juv	75-85mm	1.21-1.34			Dahlberg et al. 1968 in Carlander 1977
	juv	52-64mm TL	0.50 @ 30C	1.63		Hocutt 1973; at 30C;--critical speed was max of tests from 15-35C.
	juv	52-64mm TL		8.08L/sec		Hocutt 1973; at 30C; same study--relative swim speed.
	juv	93-128mm		1.6		U-crit 2 min = 3.5-3.8 BL/s; 15-19C; Kolok 1991
	juv	93-128mm		0.92		U-crit 2 min = 2.2 BL/s; 5C; Kolok 1991
	juv	52-64 mm		1.64		Farlinger and Beamish 1977 (cited in Beamish 1978); critical @ 25C
	juv	102 mm		1.5		Farlinger and Beamish 1977 (cited in Beamish 1978); critical @ 25C
	juv	100 mm		1.15		Otto and Rice 1974 (cited in Beamish 1978); critical @ 10C
	fry	20-22mm		0.78-1.02		Larimore and Deuver 1968 (cited in Beamish 1978); prolonged @10-30C.
	juv	57mm		1.01		Larimore and Deuver 1968 (cited in Beamish 1978); prolonged @20C
	lg juv	150-270 mm		1.80-2.17		Beamish 1970 (cited in Beamish 1978); prolonged at 10-30C.
Smallmouth bass	fry	20-25mm		≤0.89		Larimore and Deuver (1968) cited in Carlander 1977 & Houde 1969
	fry	14mm		13-19L/sec		relative prolonged speed; Larimore and Deuver (1968)
	fry	14mm		0.60-0.87		range of prolonged speed; Larimore and Deuver (1968)
	juv	91-93mm		1.3-1.8		Critical swim speed, 2-min U-crit @ 13-23C range; Webb 1998.
	adult	262-378mmTL		1.6-3.9		Critical swim speed, U-crit-10 min @ 15-20C; Bunt et al. 1999.
Yellow perch	juv	unknown		1.1		Otto and Rice 1974; acclimated at 20°C
	juv	unknown		0.7		Otto and Rice 1974; acclimated at 10°C
	juv	unknown		0.6-1.5		Nelson 1989
White sucker	juv	170-370 mm		1.6-2.4		Range; Beamish 1978; 12-19°C

* Values cited represent measured current velocities (V) that fish were able to negotiate at a fishway entrance.

** Estimated from HSI curve in source literature.

***Assumed swim speed, not from laboratory test.

BL = Body Length

Page 317, Section 12.4.1b: USEPA states:

> *Comprehensive year-round impingement sampling appears to have been conducted only once before at Merrimack Station, based on EPA's review of the plant's permit file. According to PSNH's Merrimack River Monitoring Program 1978 Report (Normandeau 1979a), annual "entrapment" (now commonly referred to as "impingement") was estimated to be 2,504 fish during 1976 and 1977. PSNH's estimated annual impingement rate (4,903 fish) for the 2005-2007 study period is nearly twice the reported impingement rate for 1976-1977. Increased impingement rates combined with evidence of declining populations suggests that the facility's level of impingement may represent significant harm as a cumulative stress to fish populations already struggling to maintain themselves.*

It is unclear where USEPA obtained the estimate of 4,903 fish impinged for the 2005-2007 period. The correct estimate of Merrimack Station impingement for the 25-month period of June 2005 – June 2007 based on the product of 14-hour sample density and CWIS volumes is 5,032 fish (Normandeau 2007b). However data from Table 4-5 of that report illustrates the inherent variability in impingement estimates. During the two-year period, the impingement estimates ranged from 4,137 fish in Year 1 to 895 in Year 2. The nearly five-fold decrease in impingement over two consecutive years during a period when fish populations in Hooksett Pool were relatively stable shows that impingement estimates are not a good indicator of fish population abundance. Therefore, the two-fold decrease in impingement estimates between 1976-1977 and 2005-2007 are not indicative of a decrease in fish populations in Hooksett Pool. Furthermore, the impingement estimate for Year 1 of 5,032 is more than double the 1976-1977 estimate of 2,504, which by USEPA's logic would indicate a larger fish population in Hooksett Pool in 2005.

4.2 Discussion of de minimis 316(b) "adverse environmental impacts"

Losses due to entrainment (passage of eggs and larvae through the cooling water system) and impingement (entrapment of juvenile and adult fish on intake screens) and at a power plant can seem to be enormous in terms of sheer numbers. Annual estimated losses, which can range into the millions for entrainment, at first appear to be astronomical until the equally large natural mortality of early lifestages of fishes is considered. Equally important are the enormous reproductive capacity of fish. For example, a single 10-inch female yellow perch can produce 109,000 eggs in a season (Scott and Crossman 1973). If the natural mortality of fish eggs was also not extremely high, yellow perch would crowd the waterways. For example, USEPA estimates that only 6.4% of the yellow perch eggs will survive to the yolk-sac larval stage, and for every 1,890 newly hatched yellow perch larvae, only one (0.05%) will survive to reproductive age (age 4). This section will attempt to put the losses due to entrainment and impingement in context with natural mortality and to show that these losses due to operation of Merrimack Station are *de minimis*. This will be done through comparisons of entrainment and impingement estimates at Merrimack Station to the results of biological models that estimate (1) the number of adults that would have resulted if the impingement and entrainment did not occur (adult equivalency or AE) and (2) the amount of biological production in terms of biomass that would have occurred if the impingement and entrainment did not occur (production foregone or PF) and the economic value of these losses. Also, the losses due to impingement and entrainment will be compared to the trends in the abundance of fishes in Hooksett Pool since 1972.

4.2.1 Entrainment

Table 5-7 in Normandeau (2007a) provides estimates of entrainment of eggs and larvae of the four taxonomic groups that made up 90% of the entrainment at Merrimack Station in 2006 and 2007. These estimates were made with the conservative assumptions of design intake flow through the year, and as such represent the maximum entrainment that could have occurred in 2006 and 2007, because the Station did not operate at design flow each day of the year. Estimates of the number of eggs entrained were 0 for most fish and 11,246 eggs for the carp and minnow family in 2006. An estimate of 0 egg entrainment in freshwater is not surprising since most freshwater eggs are adhesive and stick to the substrate, and therefore are not likely to be in the water column and subject to entrainment. Estimates of larval entrainment ranged from to 53,556 yellow perch larvae entrained in 2006 to 1.381 million white sucker larvae in 2006.

These estimates of entrainment are large in the normal usage of numbers. However, the enormous natural mortality and reproductive capacity of fish need to be considered. The loss of 53,556 yellow perch larvae over the course of a year is not large when one considers that a single female yellow perch can produce 109,000 eggs in a spawning season. Adult equivalency (AE) is a process whereby the losses of early lifestages can be scaled to the equivalent number of an older lifestage, usually adult, which is defined by the age of first reproduction. AE estimates for egg entrainment at Merrimack Station in 2006 and 2007 ranged from 0 for all taxa except the carp and minnow family in 2007, for which the estimate was six equivalent adults. AE estimates for entrainment of larvae were larger and ranged from 23 adult yellow perch in 2006 to 8,735 adult white sucker in 2007.

The entrainment of eggs and larvae of the fish that made up 90% of the impingement estimates in 2006 and 2007 was equivalent to the loss of between 15,500 and 16,000 adult fish annually. A complete census of the number of fish in Hooksett Pool would be necessary to determine if this is a substantial component of the fish community. Unfortunately this does not exist. However, trends in the abundance of fish in Hooksett Poll were made for the period 1972 through 2011 in Normandeau (2011a). If entrainment substantially affected fish populations, it would be reasonable to expect that the abundance of fish with the greatest AE losses would be declining. White sucker had the largest EA estimate derived from all lifestages, with 8,354 adults in 2006 and 11,774 adults in 2007. However, there was no significant trend in the abundance of white sucker between 1972 and 2011, which is not consistent with the hypothesis that entrainment losses have affected the white sucker population in Hooksett Pool. In comparison, an estimated 23 equivalent adult yellow perch were lost due to entrainment in 2007 and 238 in 2006. By any reasonable evaluation, these are *de minimis* losses and would be expected to have no impact on yellow perch populations in Hooksett Pool. However, yellow perch abundance decreased significantly between 1972 and 2011 in Hooksett Pool indicating that natural annual variation in the abundance of yellow perch is a greater influence on the yellow perch population than losses due to entrainment.

4.2.2 Impingement

Similar to entrainment, impingement estimates were made for the six fish that made up 90% of the fish impinged in 2006 and 2007 based on design flows. These impingement estimates ranged from 43 yellow perch in 2007 to 5,156 bluegill in 2007. The same adult equivalent procedure used for the entrainment estimates was applied to the impingement estimates, and the estimated annual adult equivalent losses ranged from two black crappie to 550 spottail shiner. By any reasonable estimate, losses of adult fish of these magnitudes should be considered *de minimis*.

4.2.3 Production Foregone and Economic Value

The adult equivalent process estimates the impacts of the direct losses due to entrainment and impingement of eggs, larvae, or fish in terms of equivalent adult fish. In addition to these direct losses, entrainment and impingement can have ecosystem ramifications in that the biomass lost due to entrainment and impingement, or biological production, is no longer available as prey items to other trophic levels. These losses can be estimated through the production foregone (PF) procedure as developed by Rago (1984). Production foregone modeling has been conducted by EPRI for Merrimack Station using the entrainment and impingement data collected in 2006 and 2007. Using actual flow data for this sampling period, the estimated production foregone was estimated for the losses of 11 species that contributed to economic benefit including recreational fishing and the forage base. An estimated 2,382 lbs (1,080 kg) in production foregone was lost with an estimated economic value of $1,421. These are losses that should be considered *de minimis*.

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