Final Third-Party Review of Entergy Nuclear Vermont Yankee's Hydrothermal Modeling Report and 316(a) Demonstration in Support of a Request for Increased Discharge Temperature Limits at Vermont Yankee Nuclear Power Station During May through October

Prepared for:
Vermont Agency for Natural Resources,
Department of Environmental Conservation

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PREFACE

On April 4, 2003, Versar, Inc. distributed to VANR, the EAC and ENVY a draft of our review of ENVY's Hydrothermal Modeling Report and 316(a) Demonstration that were submitted to VANR in support of a request for increased discharge temperature limits at the Vermont Yankee Nuclear Power Station during May through October. Subsequently, we received comments from EAC members, on both the 316a Demonstration and on our review. These comments are attached as Appendix A (numbered A1 to A6) and include:

- Comments on Versar's draft review from New Hampshire Fish & Game Department (Gabe Gries), U. S. Fish & Wildlife Service (Melissa Grader), and Vermont Fish & Wildlife Department (Ken Cox), dated 4/24/03 **(A1)**
- Memo from Gabe Gries, Fisheries Biologist, New Hampshire Fish and Game Region 4 (undated but received 4/1/03) **(A2)**;
- Letter from Janice N. Rowan, Connecticut River Coordinator, U.S. Fish and Wildlife Service, dated 4/23/03 (which incorporates input from Stephen D. McCormick and Alex Haro, Research Scientists, USGS, Conte Lab, Turners Falls, MA) **(A3)**
- McCormick and Haro in a memo that was undated but received by VANR on 4/9) **(A4)**;
- Memo Robert H. Estabrook, Chief Aquatic Biologist, State of New Hampshire, dated March 25, 2003 **(A5)**
- Memo from Ken Cox, (dated 4/3/03) **(A6)**.

Versar also received from ENVY via e-mail on April 29 a document entitled "ENVY Response to Versar Draft Review of 316(a) Demonstration, 29 April 2003 – DRAFT." That document is attached here as Appendix B.

Versar met with VANR, the EAC and ENVY and their consultants on April 30, 2003, to discuss the comments received by Versar from EAC members and to discuss ENVY's reponses to our review. Based on the comments received and the discussions on April 30, we have made some changes to our draft review, taking into account additional information and clarifications provided in the April 30 discussions. In order to provide good documentation of the basis for any changes we have made in our draft review, and also to respond to the comments received, we have adopted for this final review the following protocols:

- We have retained, for reference, all of the original text of the April 4, 2003 draft review;
- We have used Word red-line and strike-out to indicate any changes made in our review; in cases where we did not change our draft comments, we so indicate. We also provide the basis for changes to or retention of our prior comments; where appropriate, we refer to specific comments from the EAC or ENVY to which we have responded.

We have replaced Section 6, Overall Conclusions, entirely, since this is the section in which we summarize changes in the review and also our conclusions on the Demonstration, which reflects any and all changes made from the draft review.

1.0 Introduction

1.1 Background (No changes were made to this section of the draft review)

Entergy Nuclear Vermont Yankee, LLC. (ENVY) is seeking an amendment to the NPDES Permit VT0000264, No. 3-1199 from the Vermont Agency of Natural Resources (VANR) for the Vermont Yankee Nuclear Power Station (VYNPS). The permit governs discharges to the Connecticut River from VYNPS, and specifies certain monitoring requirements intended to ensure compliance with applicable limitations, including those related to thermal discharges. The amendment requested is for modification of the use of cooling towers at the facility and a change in the magnitude of thermal discharge into the river. Entergy has submitted to VANR a report on thermal modeling performed to support the permit amendment request, and a 316a Demonstration that presents the data and information believed necessary for an informed decision regarding the permit amendment requested. The Demonstration was prepared to comply with Section 316a of the Clean Water Act, which allows a variance to thermal discharge permit limits to be granted if it can be shown that it will ".... assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on that body of water." VANR determined that, in order to expedite the processing of the application and facilitate its decision-making process on the application for the amendment, it would be expedient to work with a third party consultant with technical expertise in 316a reviews.

Versar, Inc. was selected by the VANR, working with the Environmental Advisory Committee (EAC)[1] to provide technical expertise for review of Entergy's 316(a) Demonstration, including both the hydrothermal and biological aspects of the Demonstration. The objective of the review was to determine if the studies performed provide the information necessary for making an informed 316a variance decision, and to determine if the findings of those studies indicate that the facility will comply with state and federal thermal discharge variance requirements if the amendment is approved. As a third-party contractor, Versar has worked under the direct supervision of VANR but under contract to ENVY.

Under this third-party contract, technical reviews were conducted of two documents:

- Hydrothermal Modeling of the Cooling Water Discharge from the Vermont Yankee Power Plant to the Connecticut River (February 2003), prepared by Applied Science Associates, Inc. (ASA), for Normandeau Associates, (ASA 2003) and
- 316(a) Demonstration in Support of a Request for Increased Discharge Temperature Limits at Vermont Yankee Nuclear Power Station During May through October (February 2003), prepared for Entergy Nuclear Vermont Yankee, LLC. by Normandeau Associates (Normandeau 2003)

1.2 Summary of Vermont Yankee's Permit Amendment Request (No changes were made to this section of the draft review)

[1] The EAC is comprised of representatives of the Vermont Department of Environmental Conservation, Vermont Department of Fish and Wildlife, New Hampshire Fish and Game Department, New Hampshire Department of Environmental Services, Massachusetts Office of Watershed Management, Massachusetts Division of Fisheries and Wildlife, and Coordinator of the Connecticut River anadromous Fish Program, U.S. Fish and Wildlife Service.

Normandeau (2003) presents detailed background on the permitting history of VYNPS that we do not repeat here. The focus of this review is on the summer (May 16 to October 14) thermal discharge limits that were established with issuance of the NPDES permit by VANR on August 29, 2001 and the changes in those limits that are being requested by VYNPS. The current and requested limits are as shown in Table 1-1. As is explained in Normandeau (2003), the calculated temperature at Station 3 is established using Equation 1-1 (pg. 4 of Normandeau 2003), with three different data inputs: the recorded ambient temperature at upstream monitoring station 7; the Connecticut River flow rate at Vernon Dam; and, the heat rejection rate to the River, which is controlled by VYNPS plant operators by varying the amount of water diverted to the station's cooling towers.

Table 1-1. Current and requested summer thermal discharge limits for VYNPS (from Normandeau 2003)

Upstream Station 7 Ambient Temperature	Calculated Temperature Increase Above Ambient at Downstream Station 3	
	Current Limits	Requested Limits
>78°F	2°F	2°F
>63°F to 78°F	2°F	3°F
>59°F to 63°F	3°F	4°F
55°F to 59°F	4°F	5°F
<55°F	5°F	5°F

The request that is being supported by the Demonstration and the thermal modeling report is for an increase of 1°F in the allowable temperature increase when ambient temperatures are between 55°F and 78°F.

1.3 Basis for the Review (No changes were made to this section of the draft review)

Our review of the 316a Demonstration was conducted from two perspectives. First, we evaluated whether the structure and content of the Demonstration were adequate to meet the federal and state regulatory requirements pertaining to thermal discharges and thermal variance requests. Section 2, below, presents a summary of the applicable regulations on which we based our adequacy assessment. Secondly, we evaluated whether the data and information included in the Demonstration provided a sound scientific basis for making a decision on whether the facility will be in compliance if the permit amendment is granted. Our review of the thermal modeling report (ASA 2003) was solely technical in nature, as is elaborated upon in Section 4, below. At issue was whether the modeling accurately predicted the changes in the thermal regime that would occur if VYNPS were operated in accordance with the permit amendment requested. In addition to technical review comments, we also present in this document other comments that are more editorial in nature, such as typographical errors, or suggestions for elaboration of detail. We felt that these comments might contribute to making the report more readable, although they don't relate to regulatory or technical adequacy.

2.0 Regulatory Adequacy (No changes were made to this section of the draft review)

As noted in Section 1.3, our review included an evaluation of whether the contents and scope of the Demonstration met all applicable state and federal regulations. To ensure that we had consensus on those regulations and their requirements with VANR and the EAC, we prepared a summary of Vermont and New Hampshire discharge permit regulations pertaining to thermal discharges and variances, and also included an overview of pertinent federal regulations that apply to the VYNPS permit amendment request. We then used this overview of applicable regulations to assess the adequacy of the VYNPS 316a Demonstration.

2.1 State of Vermont Thermal Discharge Regulations (No changes were made to this section of the review)

Pertinent Vermont regulations can be found in: Vermont Water Quality Standards, (adopted June 10, 1999, effective July 2, 2000), Chapter 3 DETERMINATION OF CRITERIA, Section 3, 01 Water Quality Criteria and Indices. The regulations are as follows:

B. General Criteria - The following water quality criteria shall be achieved in all waters, regardless of their classification:

1. Temperature

a. General

The change or rate of change in temperature, either upward or downward, shall be controlled to ensure full support of aquatic biota, wildlife, and aquatic habitat uses. For the purpose of applying this criterion, ambient temperature shall mean the water temperature measured at a control point determined by the Secretary to be outside the influence of a discharge or activity.

b. Cold Water Fish Habitat[2]

The total increase from the ambient temperature due to all discharges and activities shall not exceed 1.0°F except as provided for in paragraph (d) below.

c. Warm Water Fish Habitat

The total increase from the ambient temperature due to all discharges and activities shall not exceed the temperature criteria derived from tables 1 or 2 except as provided for in paragraph (d) below.

Table 1. Lakes, Ponds, and Reservoirs not including Riverine Impoundments; Total allowable increase Ambient temperature above ambient temperature	
>60°F	1°F
50°F to 60°F	2°F
>50°F	3°F

[2] The portion of the Connecticut River on which VYNPS is located is currently designated as cold water fish habitat.

Table 2. All Other Waters; Ambient temperature	Total allowable increase above ambient temperature
>66°F	1°F
63°F to 66°F	2°F
59°F to 62°F	3°F
55°F to 58°F	4°F
<55 °F	5°F

d. Assimilation of Thermal Wastes

The Secretary may, by permit condition, specify temperature limits that exceed the values specified above in order to authorize discharges of thermal wastes when it is shown that:

(1) The discharge will comply with all other applicable provisions of these rules;

(2) A mixing zone of 200 feet in length is not adequate to provide for assimilation of the thermal waste; and

(3) After taking into account the interaction of thermal effects and other wastes, that the change or rate of change in temperature will not result in thermal shock or prevent the full support of uses of the receiving waters.

2.2 State of New Hampshire Thermal Discharge Regulations (On pg. 23 of ENVY's Draft responses to Versar's draft review (Appendix B), ENVY suggests that Versar's summary of applicable New Hampshire regulations be stricken from this review because VY is not subject to New Hampshire regulation. Versar notes that a review of New Hampshire regulations was specified in our Scope of Work for this project at the request of VANR. Thus, that section of this review was not stricken in this final review and no changes have been made from the draft review.)

Pertinent New Hampshire regulations are found in: NEW HAMPSHIRE SURFACE WATER QUALITY REGULATIONS, CHAPTER 1700 PART Env-Ws 1708 ANTIDEGRADATION

(e) In those cases where potential water quality impairment is associated with a thermal discharge, the antidegradation provisions shall ensure that the requirements of section 316 of the Clean Water Act are met.

TITLE L - WATER MANAGEMENT AND PROTECTION
CHAPTER 485-A, WATER POLLUTION AND WASTE DISPOSAL
Classification of Waters, Section 485-A: 8

VIII. In prescribing minimum treatment provisions for thermal wastes discharged to interstate waters, the department shall adhere to the water quality requirements and recommendations of the New Hampshire fish and game department, the New England Interstate Water Pollution Control Commission, or the United States Environmental

Protection Agency, whichever requirements and recommendations provide the most effective level of thermal pollution control.

2.3 Federal Regulations Relating to Thermal Discharge Variances (No changes were made to this section of the draft review)

Within the federal Clean Water Act (CWA), Section 316(a) specifically addresses the matter of obtaining a variance from thermal discharge criteria. The text of Section 316(a) is as follows:

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

USEPA developed and issued draft guidelines for how Section 316(a) should be implemented, first in 1974 (DRAFT 316(a) TECHNICAL GUIDANCE—THERMAL DISCHARGES, September 30, 1974, Water Planning Division, Office of Water and Hazardous Materials, Environmental Protection Agency), and then again in 1977 (DRAFT INTERAGENCY 316(A) TECHNICAL GUIDANCE MANUAL AND GUIDE FOR THERMAL EFFECTS SECTIONS OF NUCLEAR FACILITIES ENVIRONMENTAL IMPACT STATEMENTS, U.S. Environmental Protection Agency, Office of Water Enforcement, Permits Division, Industrial Permits Branch, Washington, D.C., May 1, 1977).

The 1974 document described three types of demonstrations. Type I, Absence of Prior Appreciable Harm, is an approach used for facilities that have been in operation and are now seeking a thermal discharge variance. A Type I demonstration uses data from past ecological monitoring programs to show that existing thermal discharges from an operating facility have not adversely affected the "...protection and propagation of a balanced indigenous population...." Type II and Type III demonstrations are predictive. Type II is based primarily on predictions of potential impacts derived from laboratory and literature information for several species (Representative Important Species, or RIS) considered to be representative of the ecosystem of the receiving water body. Type III is a non-specific category of demonstration, under which the approach for predicting that the balanced indigenous population will not be adversely impacted is developed in consultation between the applicant and the regulatory

agency, taking into account the guidelines and criteria specified for the other types of Demonstrations.

The 1977 Guidance Document superceded the 1974 Draft, although it remained a Draft and was never re-issued as final to date. This document addresses only Type II and Type III demonstrations, refines the data and information requirements for a demonstration, and also refines the criteria to be used in evaluating whether the requirements for a variance approval have been met. For a Type II demonstration, it is recommended that the applicant select Representative Important Species in consultation with the Director or State at the time the plan for completing the demonstration is presented for approval. For a Type III demonstration, it is recommended that the applicant consult with the Director or State on the approach and data/information that will be used in the demonstration. Section 3.7 of the 1977 guidance document states, "...A type III demonstration provides for the submittal of any information which the Regional Administrator/Director believes may be necessary or appropriate to facilitate evaluation of a particular discharge.....[and]....also provides for submittal of any additional information which the applicant may wish to have considered."

2.4 Summary of Regulatory Requirements Applicable to the VYNPS 316a Demonstration **(No changes were made to this section of the draft review)**

Our review of New Hampshire regulations (Chapter 1700 Part Env-Ws 1708 Antidegradation) indicates that they defer to Section 316a of the CWA with regard to thermal discharge permit variances. Vermont regulations (Section 3-01 [Water Quality Criteria and Indices] B.1.d) do not specifically refer to CWA Section 316a, but the wording captures the intent of Section 316a. It indicates that the Secretary may specify temperature limits that exceed the water quality criteria values when it is shown, A.... after taking into account the interaction of thermal effects and other wastes, that the change or rate of change in temperature will not result in thermal shock or prevent the full support of uses of the receiving waters. @ In the case of VYNPS, the water use of the Connecticut River where the plant is located was designated as Cold Water Fish Habitat in 1985, based on the use of that portion of the river as a migration corridor for Atlantic salmon (i.e., not as spawning or rearing habitat for other coldwater species) (Normandeau 2003). We interpret the wording of this section of Vermont=s regulations to be consistent with that of Section 316a: AWith respect to any point source... whenever the owner or operator of any such source... can demonstrate... that any effluent limitation proposed for the control of the thermal component of any discharge from such source will require effluent limitations more stringent than necessary...the Administrator (or, if appropriate, the State) may impose an effluent limitation ... that will assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on that body of water.@

Neither Vermont nor New Hampshire regulations provide specific guidance on methods or procedures to be used to indicate compliance with these regulations. In the absence of State guidance, we consider procedures presented in EPA=s 1977 316a Technical Guidance document to be appropriate for use in Vermont Yankee=s request for an amendment to their thermal discharge variance. While that document is 26 years old, to our knowledge the procedural guidance presented there has been and is still being followed in all of the thermal variance

projects and requests of which we are aware throughout the country. It should be noted that the 1977 document presents guidance, and clearly states that whether this guidance should be followed or whether alternative approaches to meeting the regulatory objectives are employed is at the discretion of the Director or State. Thus, the Director or State has wide discretion in deciding how the regulatory requirements of Section 316a of the CWA must be met.

2.5 Summary of the Approach Used in the VYNPS 316a Demonstration (Normandeau 2003) (No changes were made to this section of the draft review)

A plan of study to support VYNPS' request for a NPDES permit amendment was submitted to VANR in June 2002. That plan described biological and hydrothermal assessment studies that would be performed to support the request for a permit amendment but did not specifically indicate the type of demonstration that would be submitted. The revised study plan, submitted in March 2003, while also not specifying the type of demonstration intended, does provide the rational for the demonstration: ".... The biological assessment will use site-specific data on relative abundance and distribution of fish and macroinvertebrates collected over 30 years, known behavioral reactions of fish to thermal plumes, and literature information to make the 316(a) demonstration. The hydrothermal assessment will characterize the frequency and duration of critical periods relevant to fish and macroinvertebrates of the Connecticut River, and model changes in the thermal plume configuration under various flow and temperature conditions. Finally, the two assessments will be integrated to evaluate the magnitude of potential effects, if any, of modified operation of the VY Station on the biota of the Connecticut River (from pg. 1, 1.0 Introduction)."

The Executive Summary of the 316a Demonstration (Normandeau 2003) states that ".... This Demonstration Report details a Type III assessment of the potential effects of the proposed nominal increase in the thermal-discharge limitation, as it relates to seven (7) species of fish identified as Representative Important Species (RIS).... This Demonstration Report is considered a Type III demonstration because a combination of predictive and retrospective studies is used to interpret the biological effects (if any) of the predicted river thermal regime and habitat changes under the proposed new limits compared to the existing (baseline) conditions. Predictive studies were used to forecast the changes in the river thermal regime and associated fish habitats under the existing and proposed new summer Delta T limits......Retrospective studies involved an examination of the recent (1990-2001) biological monitoring data from lower Vernon Pool and from the Connecticut River downstream from Vernon Dam for evidence of prior appreciable harm to the benthic macroinverebrate and fish communities."

2.6 Versar's Conclusions Regarding Regulatory Adequacy of the VYNPS 316(a) Demonstration (Normandeau 2003) (No changes were made to this section of the draft review, but a response to ENVY comments has been added)

The text of the Executive Summary presents the only discussion of the type of 316(a) demonstration that is intended and the elements of that demonstration. Our understanding of the approach taken is as follows: use the conclusions drawn from the prior 316a demonstrations (1978 and 1990), and analysis of the data collected through 2001 to show that the

existing plant operations have not adversely affected the balanced indigenous population, as represented by the fish and invertebrate communities sampled in the continuing monitoring program; use the thermal modeling to predict the changes that will occur in the thermal regime of the Vernon Pool (magnitude, location and changes in volume and area) if the requested changes in thermal limits are implemented; use temperature monitoring data from Stations 7 and 3, and predicted temperature increases using Equation 1.1, to predict changes in the thermal regime at Station 3 and in the Vernon fishway if the requested changes in thermal limits are implemented; and, use an RIS-based approach and literature data to show that those predicted changes in the thermal regime will not adversely affect the balanced indigenous population, as represented by the RIS identified.

Given the nature of the permit amendment that is being requested and the past and on-going thermal and biological monitoring programs in the vicinity of the plant, we conclude that the approach taken in this demonstration to predict potential biological impacts is consistent with 316(a) Type III demonstration requirements as presented and discussed in the EPA's 1977 guidance document.

While we believe the approach taken is adequate with regard to applicable regulations, we noted in progress reports on our review that the demonstration document lacks a good "road map" to the approach. Reorganization of the document would be very helpful to readers in understanding the purpose of the different types of data presented, the reasons the different analyses and data presentations were done, and how they are all integrated together to make the intended argument.

On page 1 of ENVY's draft reponse to Versar's draft review (Appendix B), they provide a response to this section of our draft review, clarifying the basis for and type of Demonstration intended and explaining that the Demonstration document contains all of the information required for such a demonstration. We have no disagreement with the information presented in this response. However, we have not changed our comments presented above. As we noted in those comments, the Demonstration document is not organized in a manner clearly consistent with the elements of the demonstration that is being made; that is, as noted on page 2 of ENVY's draft response, the sequence of presentation of the appropriate information is: Chapter 3, Chapter 5, Chapter 4, Chapters 2 and 6, etc. Thus, our point is that the demonstration document itself should be reorganized to reflect the appropriate sequence of information that is presented to support the arguments being made. We believe that a final demonstration document should be a "stand alone" document that would not require a reader to refer to clarifications and explanations presented in other documents to understand what is being presented and why it is being presented. This is not a regulatory requirement, but certainly would make it easier for any reader of the demonstration to understand the basis for the demonstration.

3.0 Review of Historical Biological Studies

3.1 Findings of Past 316(a) Demonstrations (No changes were made to this section of the draft review)

We were provided copies of the two prior 316(a) Demonstrations conducted for VYNPS:

- Binkerd, Roger C., William D. Countryman, R. Mason McNeer and Daniel J. Marx. 1978. 316 Demonstration, Vermont Yankee Nuclear Power Station, Environmental Impact Assessment. Aquatec, Inc., South Burlington, Vermont.
- Downey, P.C., R. C. Binkerd, and D. J. Marx. 1990. 316 Demonstration, Vermont Yankee Nuclear Power Stations, Connecticut River, Vernon, Vermont; Biological, Hydrological and Engineering Information, and Environmental Impact Assessment (For the period 16 May to 14 October). Vermont Yankee Nuclear Power Corporation.

We reviewed these documents in order to familiarize ourselves with the biological and physical characteristics of the Connecticut River in the vicinity of the power station and also to become knowledgeable about past studies performed and on-going monitoring programs. In addition, we also used our reviews to determine if the findings of those earlier demonstrations were accurately summarized and cited in the current demonstration report.

Our understanding is that these demonstration reports were submitted to VANR to support prior NPDES permit and thermal variance requests and served as a basis for the issuance of those permits and variances. It is also our understanding that under past and current permits, VYNPS staff and consultants meet annually with VANR and the EAC to review and evaluate results of the ongoing monitoring programs and modify those programs as appropriate based on the reviews of findings. We found that changes to the monitoring program have been implemented over the years, such that some ecosystem elements that showed no adverse impacts since the inception of the monitoring programs are no longer monitored (e.g., phytoplankton, zooplankton, ichthyoplankton), and some changes in sampling methods and locations have been made (e.g., benthic macroinvertebrates as no longer sampled in Vernon Pool). Summaries of these two demonstrations are presented in Section 6 (pg 40) of the current demonstration document (Normandeau 2003).

One comment that pertains to the organization of material presented in this document is that in Section 6.2.2 (pg. 44) of the current demonstration, in a summary of the biological assessment presented in the 1990 demonstration, reference is made to findings of more recent studies (Finck et al, 1995, and Normandeau, 1999a, 2000a and 2001a). The findings of these studies should be presented in the discussion of more current monitoring findings (Section 5.2 of the current demonstration) and not included in the summary of prior demonstration findings.

Versar Conclusions: The summaries of the 1978 and 1990 demonstrations presented in Section 6 of the current demonstration are not totally comprehensive, but the information that is presented accurately reflects the information presented in those earlier documents. However, because the approach in the current demonstration relies on these earlier demonstrations to support the conclusion of no prior appreciable harm, it would be helpful to have the summaries focus on and provide more detail on presentations and analyses that supported the finding of no

appreciable harm, including presentation of data on the fish and invertebrate communities as well as assessment of impacts to the RIS.

Our review of these earlier demonstrations was for informational purposes, and we thus offer no detailed judgment on their regulatory or technical adequacy. Since the studies were done in consultation with VANR and the EAC, annual meetings for review of findings were held with the agencies, and the demonstrations served as the basis for approval of the NPDES permits and variances, we presume that the findings in those demonstrations were agreed to by the agencies. The studies described and summarized in those two demonstrations appear to cover all appropriate ecosystem elements and all modes of potential thermal impact. The decision to terminate long-term monitoring of plankton communities appear valid and is consistent with many other monitoring programs of which we are aware, since these communities are only in rare instances impacted by regulated thermal discharges. The long time series of data available on the fish and benthic invertebrate communities are ideal for evaluating trends and long term impacts, and thus provides a sound basis for detecting adverse impacts. The manner in which those demonstrations and the monitoring programs were developed and executed are in accord with the USEPA 1977 316a guidance document procedures.

3.2 Review of Findings of Monitoring Studies Conducted From 1990-2001 (Demonstration Section 5.2) (The text of this section has not been changed, but we include a response to ENVY's comment on analytical bulletins and on statistical analysis of the historical data)

This section of the demonstration presents monitoring program findings from 1990 to 2001 that were not reported in previous demonstrations. On page 33, it is stated that "...These results comprise the foundation for evaluation of the potential for adverse effects due to the proposed implementation of a small (1°F) incremental increase in thermal loading to the Connecticut River...." Section 5.2.1 presents findings of the benthic macroinvertebrate studies, and Section 5.2.2 presents findings of the fish community studies.

Our comments on this section of the demonstration are as follows:

- The sampling program design and methods are described adequately.
- The methods used (Ponar grab and "rock basket" colonization for macroinvertebrates and electrofishing and trapnetting for fish) are appropriate sampling methods for these biota in the local aquatic environment.
- The study area, as defined by sampling station locations, is adequate for addressing potential plant impacts.
- The statement made on pg. 32, Section 5.2 (4th line) that "...These previous Demonstrations also indicated that additional small increases in thermal loading would not endanger the community...." is not valid; those demonstrations did not address additional small increases in thermal loading.
- While extensive amounts of data are presented from these monitoring studies (e.g., Tables 5-10 through 5-29), the conclusions drawn from the data are based on descriptive narrative (e.g., Section 5.2.1.2 on page 35 includes statements like ".... There is no discernable relationship between station locations and total

numbers of macroinvertebrates collected.", and on page 38, "The data confirm a general similarity in community composition, although several relatively minor differences are evident....") While a visual inspection of the data suggests such statements may be true, statistical analysis of these data are necessary to provide a scientifically rigorous basis for the conclusions. Standard analytical approaches for these types of studies include comparison of biotic communities at affected and unaffected stations, and long term changes in community composition or abundance that could be indicative of effects. In the case of Vermont Yankee, the significant differences in habitat types at the affected and unaffected stations would seem to preclude station comparisons. So the focus of analyses should probably be examining long-term trends, and assessing if any significant trends found could be attributed to the plant's thermal discharge. For the benthic invertebrate data, we would expect to see some characterization of long- term trends in benthic communities using standard biological indices, such as Hilsenhoff. Trend analysis in "sensitive" taxa such as Ephemeroptera and Trichopter would also be appropriate for demonstrating no prior appreciable harm. Similar approaches could be used on the fish data (e.g., analyses to confirm the absence of statistical differences in fish community composition in different time periods presented in Table 5-23).

The 4th paragraph on page 33 states that "...this Report demonstrates that a balanced indigenous community of aquatic biota has been maintained in the vicinity of VYNPS during the many years of plant operation and will be maintained under the Request...." This "report" (we presume this refers to Section 5.2) does not provide a technical basis for concluding that the community "...will be maintained...", since the findings are not predictive in nature. The remainder of this paragraph presents conclusions prior to the study findings being presented, so there is no basis for judging the validity of those conclusions. As a matter of organization, it would be preferable to have a conclusions section at the end of the section that draws upon the specific technical results and discussions sections for both macroinvertebrates and fish sections (Sections 5.2.1.2 and 5.2.2.2).

Appendix 1 presents a list of analytical bulletins produced as a result of the implementation of Part II "goal oriented" studies. The results of many of these studies were not covered in earlier demonstrations and only a few are cited in this section of the demonstration. To the extent that results in any of the bulletins are relevant to issues relating to the requested permit amendment, those results should be incorporated into this section. On page 2 of ENVY's responses to Versar's draft review, they indicate that the Demonstration presents findings of all of the analytical bulletins that addressed issues relevant to the Demonstration, which is a sufficient response to this comment. It does suggest, however, that the EAC may want to reassess priorities for the goal oriented studies to be performed in the future, to target more specifically a number of issues raised in the review of this Demonstration document.

Versar Conclusions: The benthic macroinvertebrate and fish community data presented in this section provide a good foundation for demonstrating that there has been no prior appreciable harm from VYNPS operating under its current permit conditions. However, the lack of statistical analysis of the data places in question the interpretation of the data and conclusions that are drawn. Such analyses should be done to provide a rigorous

scientific basis for any conclusions about prior appreciable harm. The analyses should examine changes in abundance or community structure over time, and, if there were any negative changes, an explanation of potential causes and an assessment of whether the plant thermal discharge may be a contributing factor. These analyses could also employ the longer term data sets that were analyzed and addressed in the two prior demonstrations. Our visual inspection of the data does not suggest that there are negative trends or obvious adverse impacts, but that is a subjective judgment. Also, these monitoring study results, while very valuable for addressing no prior appreciable harm, do not provide a basis for prediction of impacts of the requested increase in thermal loading. The fact that no harm was caused by prior small increases in thermal loadings does not, a priori, mean that no harm will be caused by additional small increases.

ENVY suggests on page 3 of their draft responses to Versar's draft review that statistical analysis of data is not required to satisfy criteria for a 316(a) demonstration. We note that EPA's 1977 guidance document provides great latitude to the Director (i.e., Delegated State) in determining what information is or is not sufficient to meet regulatory requirements, particularly in a Type III demonstration. Versar has been contracted to provide to VANR our technical opinion on the Demonstration, and, in our opinion, conclusions based on visual inspection rather than appropriate statistical analysis of data are not scientifically sound. Given that the Demonstration in support of the permit amendment relies heavily on a conclusion that existing plant operations have caused no prior appreciable harm to the balanced indigenous populations, we believe it is essential to rigorously support that contention through appropriate statistical analysis of the long- term data sets that are available. ENVY suggests that "confirmatory statistical analysis" be conducted, in essence treating the permit amendment as an experiment, and comparing statistically the post-amendment communities to the pre-amendment communities. We believe that such analysis would be appropriate if the amendment is approved, to confirm predictions of no adverse impact, and the EAC and ENVY should certainly consider that suggestion in future monitoring plans. However, we remain firm in our contention that statistical analysis of the long-term monitoring data is necessary to support the request for approval of the amendment. The analysis methods suggested on pages 3 through 5 of the ENVY draft responses are reasonable and appropriate for the purpose of establishing if there have been any adverse impacts. EAC members suggested during the April 30 meeting that as part of this analysis the power of the tests be evaluated to establish the level of change that may be detectable based on the design of the monitoring studies and the nature of the data that has been collected, and that is an appropriate request. The results of such an assessment may provide guidance for future modifications to the ongoing monitoring programs. Note that our comments and the analyses we address here relate only to the resident benthic invertebrate and fish communities. Discussions regarding the anadromous fish populations are presented below. We also emphasize a caveat on our statement in our draft review that, "Our visual inspection of the data does not suggest that there are negative trends or obvious adverse impacts, but that is a subjective judgment." We clearly present that observation as a subjective judgment and not a firm scientific conclusion. We cannot draw a firm conclusion without the appropriate statistical analysis having been performed.

4.0 Review of Prediction of Effects of Requested Permit Changes on RIS (Demonstration Sections 2 and 5.1) (No changes were made to this section of the draft review)

The prediction in this demonstration of effects on RIS in the Vernon Pool is done by using the hydrothermal model to predict how the temperature regime in the Vernon Pool would change under the requested increase in thermal loadings, and then relating that change to temperature levels that are of biological significance to the RIS. We have structured our review of these elements of the demonstration by first considering the RIS selected, secondly examining the thermal criteria used for impact prediction, thirdly reviewing the technical adequacy of the hydrothermal modeling, and finally evaluating how the modeling results were combined with the thermal criteria to predict impacts.

4.1 Selection of RIS (No changes were made to this section of the draft review, but responses to ENVY and EAC comments have been added)

Section 2 indicates that seven of the RIS species addressed in this demonstration are the same RIS used in prior demonstrations. These species were selected in consultation with VANR and the EAC, a process consistent with procedures presented in the USEPA 1977 guidance document. Thus, there is strong precedent for their use in this demonstration. The species selected adequately cover the criteria for RIS selection specified in 1977 guidance document (Section 3.5.1, pg. 35). American shad and salmon are anadromous species of commercial and recreational importance and presently the subject of extensive restoration efforts. Spottail shiner is a common resident species that occupies a middle trophic level in the local ecosystem, is of forage value to major predator species, and is dependent on lower trophic levels (e.g., zooplankton populations) for sustenance. White perch, smallmouth bass, yellow perch and walleye are all resident species of recreational importance which comprise the major predators in the local ecosystem. Any plant impacts to lower trophic levels would, over the long term, be reflected in changes in the populations and population characteristics of these higher trophic level species. Except for all being important recreational species, having all four of these species as RIS would generally not be necessary to ensure adequate coverage of the ecosystem in the Demonstration.

Additional RIS species were suggested by some members of the EAC for inclusion in the demonstration to provide a more complete assemblage of fish species representative of guilds inhabiting the impoundment above Vernon dam and the tailwater below the dam. These species included sea lamprey, largemouth bass, black crappie, white sucker, gizzard shad, and American eel. We assume gizzard shad was included as a potential nuisance species whose abundance could be enhanced as a result of the requested permit change. Gizzard shad and sea lamprey have only been able to access the Vernon pool since fish passage was constructed and would not have been appropriate as RIS for the earlier demonstrations or for "no prior appreciable harm" assessments. American eel populations have been in decline throughout North America, so could be a species of concern. The other species are considered to represent additional guilds within the local fish community. Of these additional species, only three (gizzard shad, sea lamprey and American eel) are addressed in this demonstration.

Versar Conclusion: Because selection of RIS is based on consultation between the agencies and the applicant, the process followed to date in their designation has been appropriate and consistent with procedures presented in the USEPA 1977 guidance document. The species that are addressed in the demonstration and those additional species suggested by EAC members cover all of the categories specified for RIS selection in the 1977 guidance document. It appears to us that there may be more species than necessary to adequately represent the potentially affected aquatic community, since several species appear to be redundant in terms of their ecosystem role. However, the Regional Administrator/Director (i.e., VANR) has the authority to designate the RIS, (although that selection can be challenged by the applicant ; see Section 3.5.2.1, pg. 36, of the guidance document), so the final decision on how many RIS and which species are to be addressed is up to VANR. One factor that is to be taken into account in selection of RIS is availability of data and information. So that may be a topic for discussion with VYNPS in resolving the RIS species list.

On page 5 of ENVY's responses to Versar's draft review, they question the value of expanding the number of RIS species incorporated into the Demonstration. On page 2 of the EAC fisheries biologists' comments on Versar's draft review (A1), they disagree with Versar's statement that there may be more species than necessary to adequately represent the fish community. During the April 30 meeting, EAC members reemphasized their desire to have all fish community guilds represented by RIS (See page 1 of the memo from Ken Cox, A6). EPA's 1977 guidance document emphasizes that the intent of use of RIS is to simplify demonstrations and reduce the amount of data and information that must be included. However, they also provide a range of 1 to 15 as an appropriate number of RIS to be considered, which would encompass all of the species suggested by the EAC. We reiterate what we stated in our draft review, that the selection of RIS is the responsibility of the Director, and thus VANR has the final say in how many and which species should be addressed. We defer to the judgment of local fisheries scientists (i.e., EAC members) in that regard, acknowledging their intimate knowledge of the fish communities present in the receiving waters. We thus provide no specific recommendation on how many or which species should be addressed, having confirmed that the process being followed in RIS selection is consistent with EPA guidance. However, we do suggest to EAC members that they give some weight to EPA's intention of simplifying demonstrations, and select as few species as possible to achieve the guild coverage they desire.

4.2 Thermal Effects Parameters used for Prediction of Thermal Impact to RIS (Section 5.1) (We have augmented some portions of the conclusion we present of this section)

The demonstration identifies four thermal effects parameters that are used to predict potential impacts of the requested increase in thermal loadings: maximum temperature for summer survival and/or upper incipient lethal temperature; optimum temperature for growth; avoidance temperature; and, preferred temperature. These effects parameters are among those suggested for use in the 1977 guidance document and encompass nearly all of the life history aspects of a species that might be affected by a change in the thermal regime. The one life history aspect not specifically addressed relates to spawning and egg/larvae development,

Versar Conclusion: The thermal effect parameters selected for use in prediction of effects on RIS are appropriate for that purpose. However, they do not include a parameter that would specifically address potential for effects on spawning and eggs or larvae. While this segment of the life history of many of the RIS may not be relevant (e.g., species that would spawn before May 15, or species for which no spawning habitat exists in the Vernon Pool), this issue should be addressed in this section of the demonstration.

On page 2 of the EAC fisheries biologists' comments on Versar's draft review (A1), they concur with our conclusion that the parameters selected do not adequately account for potential effects on spawning and eggs or larvae. Ken Cox, in his review of the demonstration (A6), also addresses this issue, and questions (his item 8) whether habitat availability for RIS in the vicinity of VY has been identified and evaluated. On page 6 of ENVY's responses to Versar's draft review, they state that "...no location within this potentially affected habitat [i.e., the lower Vernon Pool] has been identified as an important spawning habitat for any RIS or the additional species." This statement is not supported by any citations and does not provide a detailed description of habitats present in that portion of the lower pool affected by the thermal plume and the potential importance of those habitats for RIS. The discussions of individual species that follow on pages 7 and 8 do provide more details that relate to this issue. However, an addition to the Demonstration that described or mapped habitats in the lower pool in detail (e.g., substrate types, depths, velocities, together with suitability of those areas as various types of habitat for the RIS) would be a concise and efficient way of establishing the potential importance of the areas affected by the plum as spawning and nursery habitat for RIS. In addition, given concerns of EAC members about the potential thermal effects on fish habitats between the dam and Station 3, the Demonstration should also include some description of the habitats present in that portion of the river and their use by RIS.

ENVY, on page 6, points out that the portion of the Vernon pool affected by the thermal plume is 324 acres in size, or 12.7% of the total pool. We concur with that statement. They also note that plume modeling confirms that during the summer permit period, the plume would be a surface plume and result in the greatest elevated temperatures primarily along the western bank south of the plant. We agree with this statement, and confirm that it is supported by modeling as well as prior thermal plume studies. The net effect of these two factors is that the portion of the Vernon pool subject to changes in temperature as a result of the requested permit amendment is very small, particularly when viewed from the perspective of the entire Vernon pool, which can reasonably be considered the river reach occupied by resident fish stocks potentially affected by the plume. As a consequence, the temperature changes predicted to occur under the requested amendment would only be of potential significance to species for which the lower, western pool contained habitat of particular importance for that species. We elaborate further on this issue in Section 4.5, below, where we evaluate ENVY's specific response on spawning and nursery areas within Vernon Pool for RIS (pgs. 7 and 8 of their responses).
The issues just discussed relate to RIS use of habitats within Vernon Pool. Other issues raised by EAC members (A3 and A4 in Appendix A) relate to additional thermal effects parameters of potential significance to migrations of shad and salmon through the pool, including temperatures at which salmon smolts cease feeding, temperatures at which shad eggs may develop abnormalities, and temperatures at which shad upstream migration may cease. During our April

30 discussions, EAC members provided information suggesting that salmon smolts may interrupt their downstream migration when they encounter barriers, such as dams, and remain in the immediate area of the barrier for some time before passing the barrier and continuing their downstream migration. Under such circumstances, migrating smolts could be exposed to elevated temperatures from the VY thermal plume for an extended period and thus be subject to cessation of feeding. Given the high level of importance accorded Atlantic salmon in the Connecticut River, we recommend that this thermal effects parameter be added for Atlantic salmon and addressed in the Demonstration. The thermal modeling results relevant to such an assessment are identified and discussed in our comments in section 4.3.4, below. Regarding shad larval development, we think that this issue can be adequately addressed in the text of the Demonstration, in conjunction with the optimal spawning temperatures. Temperature effects on shad migration are addressed specifically in Section 4.6, below.

4.3 Review of Hydrothermal Modeling (ASA 2003) (In this section, we have included many responses to the detailed responses to our draft review included in ENVY's April 29 draft, from page 9 through page 23; we have also made a number of grammatical corrections and changes; none of the comments or clarifications provided by the EAC or ENVY has resulted in any change in our conclusions that the hydrothermal modeling is technically sound)

ASA (2003) is a stand-alone report that describes the modeling done to predict thermal changes in the Vernon Pool and the results of model runs that are then used in predictions of impacts to RIS presented in the demonstration. Because this is a stand-alone report, our review comments are organized in a different manner than for our review of the demonstration itself. A later subsection, below, provides comments on those portions of the demonstration that relate directly to the modeling work. Other sections below present page-by-page comments on ASA (2003) as well as on those sections of the demonstration that relate to the thermal modeling. Some of these comments are editorial in nature, but the majority indicate where further detail or clarifications are necessary. The intent of this review of the hydrothermal modeling report and the relevant sections of the demonstration was to assess whether, if the requested permit amendment is implemented, the predictions of temperature change in Vernon Pool are valid.

4.3.1 Overview of the Adequacy of the Model Construct (No changes were made to this section of the draft review)

The purpose of the hydrothermal model was to simulate flow and temperature conditions in Vernon pool as it responds to cooling water discharge from VY and the natural heating and cooling processes that occur within the impoundment. The model was calibrated and confirmed (i.e., validated) to existing measured conditions. Scenarios were then simulated to provide information on the thermal regime which would occur with VY's proposed increase in thermal loading. Model results were used in the demonstration to calculate changes in total volume and bottom area of specific temperature values, which are then related to the biologically critical

thermal criteria discussed above. The model may also be used to evaluate changes in the temperature pattern which could occur, across or along the pool or vertically.

Our review indicates that the model construct is appropriate for simulating the details of thermal conditions within Vernon pool, including natural thermal and flow conditions and the VY discharge. The lower boundary of the model is at the Vernon Dam, so it does not simulate thermal conditions below the dam. The fully 3-dimensional aspect is well suited for looking at the thermal variability longitudinally, laterally and vertically within the pool. The grid cell spacing is more than adequate to simulate the spatial variability within the pool for considering thermal exposure of biota. The grid cell size close to the VY discharge is about 20 meters square with 24 cells across the pool and 11 vertical layers. Although a near-field model such as CORMIX could provide greater detail of the behavior of the discharge plume as it enters the pool, this does not seem warranted or necessary given the large size of the pool relative to the discharge plume.

Versar Conclusion: The model is an appropriate tool for predicting how the change in permit conditions would affect the thermal regime within the Vernon Pool, in magnitude, area and volume, and location, including temperatures in the discharge through the fishway. Additional specific comments on various sections of the model report are provided below. The additional information or clarifications requested are intended to provide further documentation of the model. We do not anticipate that the answers would change our conclusion that the model is appropriate and well-constructed for the 316a demonstration in support of a thermal limit increase.

4.3.2 Boundary Conditions (We did not modify the original text but provide additional discussion based on comments and discussion at the April 30 meeting)

The upstream boundary is the river at Bellows Falls, well upstream of the influence of the VY discharge and thus appropriate as an upper boundary. The downstream boundary is at Vernon Dam, which is an appropriate boundary for modeling thermal regimes within the Vernon Pool. However, with this downstream boundary the model cannot be used to assess changes in thermal patterns downstream of the dam. The model can appropriately be used to predict temperatures at the Vernon Dam fishway. Upstream temperature input to the model is data from Station 7. These data are from a single sensor, located near the bottom of the river at that location. Since there is only one measurement location at this station and thermal stratification and lateral differences may occur at times (see paragraph 2 on pg. 5 of the demonstration), there is increased uncertainty in model precision, particularly at the upstream end, because the thermal variability in the river at Station 7 does not appear to have been specifically addressed in the model input.

Versar Conclusion: The boundary conditions established for this model are appropriate for predicting thermal regimes in Vernon Pool and in the fishway. An outstanding issue is the extent to which unrepresentative temperatures at Station 7 may result in an inaccurate representation of the magnitude of temperature changes under the permit amendment. Further information should be provided on the significance of the uncertainty of this input variable to

model output. We do not expect that it will have a significant effect on the overall model results, since the calibration adjusts for this factor along with many others (i.e., the uncertainty associated with temperatures recorded at Station 7 are accounted for during calibration).

Based on ENVY's response to draft comments of April 29, our understanding of the Station 7 input data has been clarified. Station 7 is about 23 km downstream of Bellows Falls dam and is about 18 feet deep (diagrams of sampling locations at stations 3 and 7 are included in Appendix B). Temperature values at this location are used as the upstream boundary condition just below the dam, even though there may be thermal stratification in the pool at Station 7. This is acceptable since the Station 7 sample location is near the bottom and much less affected by thermal processes occurring in the pool near the water surface. A uniform temperature is used as an upstream boundary condition under the assumption of complete mixing just below the Bellows Falls dam. Natural thermal heating and cooling processes in the Vernon pool are then simulated in the model from that point downstream. Since the simulated and measured Station 7 data are very similar and since there is very little diurnal temperature change, this shows that little change in temperature occurs deeper in the water column and the assumptions listed above are reasonable.
The model is not capable of predicting temperature regimes below the Vernon Dam, an issue of concern to some EAC members. Additional monitoring in this area is probably the most reasonable way to address this issue, since the complexity of flows through and over the dam would be very challenging and difficult to model.

EAC members have expressed considerable concern that the effects of the proposed permit amendment on thermal regime between Vernon Dam and Station 3 has not been adequately addressed in the Demonstration. In Item 4 in Ken Cox's memo (A6) and Item 1 in Gabe Bries' memo (A2), they suggest that the assumption of complete mixing below the dam has not been verified since many modifications have been made to the dam and to the manner in which it is operated. The concern is that significant thermal gradients that could occur if mixing is not complete could influence fish behavior as they move into the area below the dam to spawn (e.g., walleye) or approach the fishway to move upstream (e.g., shad). Additional discussions with the EAC and ENVY at the April 30, 2003 meeting leads us to provide to the following additional comments and observations: The Vernon Dam hydraulic capacity is 13,280 cfs. The fish ladder passes 105 cfs, including attraction flow. Downstream passage provides a 350 cfs bypass flow. Median flow during May and June is 11305 and 7663 cfs, respectively (Table 3-1 of the Demonstration document), indicating that the flow is going through the hydro units substantially more than half the time and not over the spillway during these months. Since total upstream and downstream passage flow of 455 cfs is about 3.4% of Vernon station capacity, it seems unlikely that there would be much variation in temperature in the region below the dam and that an assumption of complete mixing below the dam is reasonable. However, because of the concern expressed by EAC members about this issue, and the fact that the demonstration does not specifically address it, ENVY should provide additional information and discussion of this issue in the Demonstration.

4.3.3 Adequacy of Calibration and Confirmation (No changes were made to this section of the draft review)

The calibration period in August had relatively low flows and high temperatures and the independent confirmation period in June had higher flows and lower temperatures, representing a good range of conditions for checking the model validity. Of interest is that the confirmation against the June data appears to be more precise than the calibration using the August data, which is the inverse of what would normally be expected. This may be due to a more uniform thermal pattern with higher flows in the June period, resulting in less variability overall.

Versar Conclusion: Calibration and confirmation of the model are very good and provide a reasonable indication of the uncertainty that can be expected from the model results (Table 4-1). However, additional explanation of the differences in the model results as compared with the measured data should be provided.

Table 4-1. Vernon Pool hydrothermal model calibration and confirmation evaluation in comparison with EPA guidance (McCutcheon at al., 1990)

Error Measure	Property	Guidance Value	Calibration	Confirmation
Relative Mean Error, RME	Flow	30%	3.0	2.5
	Temperature (avg)	25%	1.1	1.9
Error Coefficient of Variation, ECV	Flow	10%	0	3.6
	Temperature (avg)	45%	2.2	4.2
Squared Correlation Coefficient, r^2	Flow	0.88	0.92	0.98
	Temperature (avg)	0.71	0.74	0.82

4.3.4 Appropriateness of Model Scenarios (We did not modify the original text but provide additional discussion based on comments and discussion at the April 30 meeting)

The model scenarios that were selected seem well suited to simulate worst-case (1 percentile) and average (50 percentile) flow and temperature conditions during August (worst-case month) and June-July (worst-case period for upstream fish passage). The worst-case scenario documents the extent to which the most extreme temperatures would be further exacerbated by the requested increase in thermal loading, which provide the most conservative basis for determining if biological impacts may occur. As will be discussed further below, the worst-case and average

values for flow and temperature were derived from the flow and temperature records for the period 1998 to 2002 (Discussed in 3.2.1 and 3.2.2 of the demonstration). However, only a few of the scenario results are presented in visual form (most findings are presented in tables). Because the visual presentations can aid in interpretation of the potential biological significance of the thermal distributions, presentation of the thermal plume figures for additional scenarios are warranted. Suggestions for additional results to be presented are: 1) plots showing plan-view worst-case (1%) results of the pool temperatures at top, mid-level and bottom during the passage season (June-July); 2) plots showing the worst-case results of the difference between existing and proposed thermal criteria; and 3) area and volume calculation differences for the worst-case condition during mid-day high temperature rather than over a 24-hour average period.

ENVY's response seems to indicate that they misunderstood our comment. Additional results which need to be presented are from scenarios already simulated. Items 1 and 2 above simply request plots of plan-views for the existing fish-passage season worst-case scenario, to provide another perspective of the results. This scenario will be useful for evaluating thermal exposure of downstream migrant fish which could be delayed just above the dam. Specifically, the fine detail of the model cells just above the dam can show the amount of potential change in thermal habitat at that location, where the EAC is concerned about thermal exposure of outmigrating smolts which could be delayed at that location.

Item 3 is requested as another way to confirm that the area and volume differences are relatively minor for the requested thermal variance increase, for a peak heating period during the day]

Versar Conclusion: The scenarios selected, in particular the worst-case, provide a good basis for assessing the potential for adverse biological impacts during the most extreme temperature period. We note that EAC members have expressed concerns about the potential for the increase in temperatures as a result of additional thermal loading could adversely affect migration of anadromous fish, a topic we address in detail below. Given this concern, it may be desirable to run additional model scenarios with flow and temperature inputs representative of conditions during the migration period.

4.3.5 Detailed Comments ASA(2003)

- Exec. Summ., 5th paragraph, 4th line, symbol should be r-squared, not square root.

ENVY provided an adequate response to this comment.

- Exec. Summ., last paragraph, recommend not using the term 'insignificant' without statistical meaning.

ENVY provided an adequate response to this comment.

- Section 3.2. There is no description here or elsewhere, that describes the details of the field data collection, including how the stations were selected, the types of thermistors, their accuracy and precision, how often they were downloaded, etc. This information is important to understanding the uncertainty in the field data measurements, relative to uncertainty in the model.

ENVY provided an adequate response to this comment.

- Section 3.2.1.1. Provide further details on processing with a 3-hour low-pass filter, e.g., a 3-hour moving average?

ENVY provided an adequate response to this comment

- Section 3.2.1.4. Provide more details on processing with cubic splines and a 3-hour low-pass filter.

ENVY provided an adequate response to this comment.

- Section 3.2.2.1. Why was sensor C4 offline from 8/1 to 8/15?

ENVY provided an adequate response to this comment

Provide a plot of temperature profiles of the E stations, similar to those for C and D in this section.

ENVY misunderstood the original comment. What we are requesting is an additional plot showing the vertical thermal profile for the E stations, similar to those for the C and D stations. These plots will serve to illustrate the spatial extent of thermal stratification throughout the pool.

- Section 3.2.2.2. Explain or refer to a section of the main 316a report which explains about the nature and variability of upstream hydroelectric operations and how this affects flow entering Vernon pool. It is important to understand that flow entering Vernon pool is highly regulated by upstream hydroelectric projects.

ENVY misunderstood the original comment. The ASA report at this section just needs to refer to the appropriate section of the Demonstration, so the reader of the modeling report will be able to easily find the explanation of the hydrology in the study area.

- Section 4. Although a near-field model is not needed for the purposes of this modeling effort, describe the specific reason that the VYNPS discharge could not be simulated with CORMIX, to provide a more complete explanation for the report.

ENVY provided an adequate response to this comment.

- Section 4.3.2, 2nd paragraph, 2nd sentence, strike 'in' after 'used'; 3rd paragraph strike 's' in Figures 4-2.

ENVY provided an adequate response to this comment.

- Section 4.3.3. Explain how the 11-layer grid system varies with pool depth, i.e., are there always 11 layers regardless of local water depth, so that in shallow areas the layers are thinner, or are there fewer layers in the shallow areas? This will provide more complete explanation of how the model is constructed.

ENVY provided an adequate response to this comment.

- Since the upstream boundary condition for temperature is set using data from Station 7, and since that station may sometimes be stratified, is each cell in each layer set to the same temperature value? If so, explain how the model compensates for the periodic lack of stratification in the upstream conditions. It may be that this phenomenon is not explicitly included in the model but contributes to the inherent variability within the model which is minimized to the extent possible as part of the calibration process.

ENVY provided an adequate response to this comment. In addition, we provide further explanation above under comments on section 4.3.2.

- Section 4.3.3.1, 4th paragraph, clarify flow description. The <u>lowest</u> flow for the August period was about 50 m3/s (Fig. A35-36) and flows in June were mostly greater than 200 but in early July were often less than 200. Also compare these flows with the long-term average monthly flows, to put the calibration and confirmation flows in context with the longer term period of record.

ENVY provided an adequate response to this comment. The additional text provided by ENVY needs to be incorporated into the report.

- Section 4.3.3.2. Indicate the period of record upon which the 1% and 50% occurrences of low flow and high temperatures are based. If this is stated in another part of the 316a document, refer to the appropriate section of the document. Also indicate the period of record for the monthly mean values of atmospheric forcing functions and for the mean daily variations in air temperature and solar radiation. It is not clear from just this report if the period of record for temperature was just the last 5 years or a longer period based on monitoring at Station 7 or some other location.

ENVY provided an adequate response to this comment. However, the text in section 3.2.1.4 does not specifically state the dates used for the forcing functions and the figures referred to in the text do not provide the complete record. The text of the report should be revised to include the response provided.

- Section 4.4. Provide a table which includes a range of typical parameter values for those parameters which were adjusted as part of the calibration process. The purpose of this information is to show that the calibration process was performed by adjusting parameters within a reasonably expected range of values.

ENVY provided a partial response to this comment. Typical literature values for these parameters in this type of riverine environment with citations should also be provided in the table.

- Section 4.4.1, flow comparisons, provide additional explanation of the artificial oscillations which are illustrated in Figure 4-6, where the predicted flows decrease briefly to zero and then overshoot, on several days in August. Also indicate whether the water mass balance is correct over this period of time.

ENVY provided an adequate response to this comment.

- Provide an explanation as to the divergence between model and observed temperatures at the various stations. Overall, there seems to be a greater amplitude in the model in diurnal temperature patterns at the surface for all stations, as compared with the measured data. Could the lack of stratified thermal input data at the upstream station have contributed substantially to the differences?

ENVY provided an adequate response to this comment.

- Section 5. State what time period is shown in Figures 5-1 to 5-3; are these at the peak of the daily heating cycle or some other time or averaged over a day? Figures 5-5 and 5-6 show the mean bottom area and volume coverage for the various scenarios, calculated over a daily cycle. Clarify that this means the model temperatures were averaged over a 24-hour period. What are the calculated values for these coverages, using the daily peak values for each scenario? This will indicate the scenario results for each coverage, during the hottest part of the day, which should be similar to the results for the daily mean.

ENVY provided a partially adequate response to this comment. The bottom area and volume coverages for a near-peak time should also be calculated to show that the results are similar for even the warm period of the day. Understanding that the time of peak temperature varies with depth, a surface peak time could be chosen for this calculation. See also our comment under section 4.3.2.

- Provide greater detail on how the fishway temperatures were simulated. Are these flow weighted averages from layers 9-11 from all of the cells ending at the dam, or just those in the vicinity of the fishway?

ENVY provided an adequate response to this comment.

- Figure A2. Ending date should read 8/16/02.

ENVY misunderstood the comment. There is a simple typo on the horizontal scale on the right side of figure A2.

- Figure A34-39, B23-26, add cfs scale

ENVY provided an adequate response to this comment. This scale can be added to the appropriate figures.

4.3.6 Detailed Comments on the Hydrological and Thermal Sections of the Demonstration

- Section 3.1.4 - Station 7 information: a statement is made here that there can be as much as a 5F difference between surface and bottom at this station and that the assumption of a single ambient temperature is not always appropriate. Yet this data is used as an upstream boundary condition for the detail hydrothermal model as well as for the calculation of delta-T to the downstream station 3. The consequences of this assumption could be important and further consideration of this issue is warranted.

This comment is no longer relevant regarding the upstream boundary condition for the model; see our revised comment on section 4.3.2 above. Regarding calculation of delta-T to the downstream station 3, this is a compliance issue outside the scope of this review and our understanding is that ENVY and the EAC are addressing this issue separate from this review.

- Section 3.2.1.1. Provide more details of the flow transformation that was performed, including a report citation and a description of the USGS program that was used (if any) to do this transformation. For upstream input to the model, the Vernon flow was corrected by subtracting the estimated flow from the intervening contributing watershed. The language in this section is not clear however, on how and where flow is measured at the dam and why the flow at North Walpole was not used as an upstream input, with some adjustment for the watershed below that point. What is the source of the factor 4.32 which was multiplied by the West River at Jamaica flow? All of these questions serve to provide more complete documentation of the calculations that were done, and will aid in evaluating that they were done correctly.

ENVY provided an adequate response to this comment; the new information should be included in the revised Demonstration report.

- Section 3.2.2.3. Are the temperature duration curves and calculations based on hourly temperature values?

ENVY provided an adequate response to this comment.

- Next to last paragraph on pg. 13, strike 'that' from first sentence.

ENVY provided an adequate response to this comment.

- Pg. 14, first paragraph, percentages of occurrence of various temperatures are provided but a more meaningful number would include some measure of the frequency of occurrence in consecutive hours or days, rather than averaging over all of the summer months.

ENVY provided a partial response to this comment; we nevertheless believe that an analysis of consecutive hours of exceedance should provide a further indication of the likelihood of no additional exposure to excess temperature should the variance be granted.

- Section 4.3, how were the fishway temperatures extracted from the model (refer to the hydrothermal modeling report section)

ENVY did not adequately address this comment in their response. This section of the Demonstration attempts to describe how the hydrothermal model was used to predict changes in the fishway temperature due to the proposed new discharge limits. However, it is still not clear from the draft Demonstration or the response, exactly how the model was used for this purpose.

- Table 5-1, last column. It doesn't seem logical that the increase in percent time at 70F (8.8%) should be higher than at 65F (4.2%). Provide an explanation.

ENVY provided an adequate response to this comment.

- Figure 3-7d. Why is the fishway water temperature higher for most of the time than at Station 3 (for Figures 3-7a to e, except for d)? Presumably this is because it is withdrawing warmer water from the surface layers on the west side of the pond, while Station 3 is a mixture of all of the water flowing over the dam including the cooler water on the east side and in lower layers. Some explanation should be provided.

ENVY provided an adequate response to this comment.

4.4 Review of Prediction of Temperature Change at Station 3 (Section 3.2.2) (No changes were made to this section of the draft review, but some text has been added)

While the hydrothermal modeling provides the means of predicting changes in the Vernon Pool temperature regime and temperatures in the fishway, it is not used to predict changes in temperatures at Station 3, downstream of Vernon Dam. The methods used to make those predictions are presented in these sections of the demonstration. Section 3.2.2.1 presents the argument that summer temperatures in the most recent years of temperature monitoring (1998 to 2002) span a wide range of potential summer temperature regimes and are thus considered to encompass the range of summer temperatures that might occur in the future. Section 3.2.2.2 presents a discussion to support the conclusion that temperature differences between Station 7 and Station 3 during the summer are only partially (50%) controlled by thermal loadings from VYNPS and are significantly affected by atmospheric influences. Section 3.2.2.3 presents predictions of changes in Station 3 temperatures that would result if the requested increase in thermal loading were implemented, using probability of exceedance curves.

The use in Section 3.2.2.1 of a long-term historic record of air temperatures as a surrogate for long-term river temperature values is reasonable and acceptable. Those data (e.g., Figure 3-4) support the contention that average summer temperatures from 1998 to 2002 spanned a wide range of average summer temperatures, and thus provide a reasonable basis for predicting temperatures in the future. The data and information presented in Section 3.2.2.2 strongly supports the contention that thermal loadings from VYNPS account for only a portion of the temperature increase that exists between Station 7 and Station 3. A concern that arises in Section 3.2.2.3 relates to the basis for the probability of occurrence data that is presented in Tables 3-3 and 3-4, and in Figures 3-8 and 3-9.

On page 11, third paragraph, the text indicates that the probabilities were established using the entire 5 years of recent hourly temperature records (more than 17,000 data points). We assume then that the probabilities were calculated by totaling the number of hours in any and all of the 5 years in which temperatures exceeded a certain value and dividing that total by 17,000. Exceedance probabilities from these data summaries were subsequently used to define worst-case and average conditions for use in the thermal modeling, which appears appropriate and probably conservative. The predicted change in the exceedance probabilities at Station 3 is incorporated into the RIS thermal effects prediction tables in Section 5.1.1

The use of the total 5-year time record as the basis of the exceedance probabilities for the assessment of potential for biological impacts is somewhat misleading. Biota are affected by duration as well as magnitude of elevated temperatures. That is, if an extended period of time with high temperatures occurred in one of the five summers, its percentage occurrence within that specific summer would be much higher than the percentage calculated based on the summers of all five years pooled together. Another factor of biological importance is the continuity of the temperatures, i.e., whether there were 100 continuous hours of a particular biologically important

temperature or 100 total hours of that temperature occurring sporadically over an extended period of time.

Versar Conclusion: We agree that the summer temperature regimes during the period 1998 through 2002 are representative of temperature regimes that may occur in the future, and thus provide a sound basis for predicting future temperatures if increased thermal loadings are approved. We also agree that there is substantial thermal loading to Vernon Pool that is not attributable to VYNPS thermal discharges. In addition, we agree that the probability of exceedance curves based on the pooled data from all five years (1998 to 2002) provide a sound and conservative basis for identifying worst-case and average temperatures for use in hydrothermal modeling. However, we do not believe that changes in the probability of occurrence of biologically important temperatures at Station 3 can be based on the pooled 5-years of data for the reasons noted above. At a minimum, exceedance tables and curves should be developed for individual years (e.g., five annual figures replacing each of Figures 3-8 to 3-10). These exceedance probabilities should then serve as the basis for predicting changes that may occur if the requested increase in thermal loadings is approved. Such presentations would be more biologically meaningful.

The issue we address in this section of our review is of relevance to concerns raised by EAC members about the assumption that the river is well mixed between the dam and station 3; that is, in the Demonstration the prediction of temperature changes at Station 3 is assumed to be applicable to the entire dam tailrace, which would include the entrance to the fishway. We addressed that issue in our additional comments in Section 4.3.2, above.

4.5 Review of Prediction of Effects on RIS from the Requested Increase in Thermal Loadings (Section 5.1.1) (Text in this section has been revised based on comments from and discussions with EAC members on April 30)

Section 5.1.1 presents the detailed predictions of impacts on each of the RIS. These predictions, in tabular form, employ the thermal effects parameter temperatures for each of the RIS taken from the literature, and indicate the percentage change in the plume and bottom areas within which temperatures at those thermal effects levels occur. These tables also present the change in probability of occurrence at Station 3 of those biologically significant temperatures for each of the RIS.

We have not conducted an independent literature review to establish the validity of the references cited as sources for the thermal effects parameter values. Some of those citations are relatively old, but if studies were conducted properly, the fact that they may have been done many years ago does not in any way invalidate the findings. However, a number of potentially relevant citations were provided to Versar by EAC members in their comments (A3 and A4), and Ken Cox distributed at the April 30 meeting a table from a publication that included some thermal effects data for RIS that was not cited or discussed in the Demonstration. EAC members stressed the importance of ensuring that the Demonstration incorporate all relevant literature to date, and that there be a detailed explanation of how the single temperature entered into each of

the tables in Section 5.1.1 was selected from a range of temperatures that may be available in the literature. We concur with these EAC members' comments and recommend that the Demonstration be revised to include such information. We do believe that the manner in which the thermal effects information has been summarized (e.g., tabular presentations of the magnitude in change of probability of occurrence of critical temperatures if the permit amendment were approved) is a clear and concise way of presenting the assessment results.

In the presentation of habitat changes that would occur with the requested permit change (e.g., Table 5-1 for American shad), the specific portion of the total or lower Vernon Pool in which the temperature changes are predicted to occur, and the extent to which that part of the Pool may be of importance to each of the species should be more precisely addressed. That topic is addressed for some species but not for all. This could be done in a narrative in the text, making reference to the plume figures that should be taken from ASA (2003) and based on knowledge of how the RIS use the habitats present in the Vernon Pool. Also, in most of the discussions on RIS, some comment is made about changes in species abundance over time, but no specific plots or statistical analyses of those data are presented. The data for some years is in tables (e.g., 5-19, 5-20), but not presented separately in each of the RIS impact discussions and not analyzed for trends. If a "no prior appreciable harm" assessment is to be included here to support the arguments made, such plots and analyses should be presented.

This aspect of our response is closely related to our discussion of this issue in Section 4.2, above. There we indicated the need to clearly identify the habitat value for each of the RIS of areas within the lower pool that are affected by the thermal plume. The changes in the percentage of the lower pool at a particular temperature under the worst case and average condition if the permit amendment were approved are presented in Table 4-2 on page 18 of the demonstration. However, that presentation of findings, which is based on the hydrothermal modeling results and has a strong technical basis, is not further linked to the RIS impact assessment presented in Section 5.1. As we noted earlier, the percentage of the total pool within which temperature regimes will be changed if the permit amendment is approved would be even smaller than the values shown in Table 4-2. If the area affected is expressed as a percentage of the total pool or of the total habitat available within the pool for a given RIS, it is very likely in many cases that the percentage value will be smaller than the percentage change in plume volume or area that appear in the existing tables in Section 5.1.1, and thus be more favorable to approving the permit amendment. However, that is the most biologically meaningful way to present the assessment. It would also eliminate some misleading results that appear in the current presentation. For example, in Table 5-1 for American shad, the table correctly indicates that there is no change in the percentage of the plume or bottom area that would be unavailable for optimal growth or preferred temperature conditions. However, as can be seen in Table A2-1, the reason is that the entire plume exceeds optimal and preferred temperatures under existing conditions, for both average and worst case conditions. Thus any elevation in temperatures could not increase what is already 100% unavailability. That situation also occurs for a number of other species and effects parameters (Table A2-1). Placing the percentage change in availability of certain temperature regimes within the context of the lower or total pool area or volume (as appropriate) would eliminate that problem.

Versar Conclusion: The approach taken for predicting the impact of the requested in increase in thermal loadings on the RIS is sound and consistent with procedures suggested in USEPA's 1977 guidance document. The four thermal response parameters are comprehensive, but an additional parameter that addresses spawning and egg/larval survival should be included for any species that may use the plume area for spawning. Also, the literature serving as the basis for designation of the thermal effects parameter temperatures does not appear to be completely comprehensive and should be expanded to include all relevant information sources. In addition, the rationale for selection of one specific temperature from whatever temperatures are available in the literature to represent the temperature at which a biological effect is anticipated should be explained in the text. The additional RIS suggested by the EAC should be addressed in the same detail as the original RIS. Two additional issues must be addressed before final conclusions can be drawn about potential for impact to the RIS: where the predicted changes in temperatures may occur relative to use and availability of that habitat by the RIS; and, probability of exceedance temperatures that are based on summer temperature data from individual years rather than the pooled data from five years, as have already been discussed.

On pages 7 and 8 of their responses to our draft review, ENVY presents information responding to the issue of thermal effects on spawning and early life stages of RIS. These presentations address some but not all of our preceding comments on this issue. This material would have to be fully integrated with the revised presentation of changes in temperature regimes to be fully assessed for adequacy.

4.6 Review of Prediction of Effects on American Shad and Atlantic Salmon Migration and Fish Passage at Vernon Dam (Sections 5.1.1.1, 5.1.1.2, and 5.2.3) (We have revised our conclusions in this section as a result of comments from and discussions with the EAC at the April 30 meeting)

The potential for effects on the migration of these two anadromous species is addressed in the RIS impact discussion sections (5.1.1.1 and 5.1.1.2) as well as in a separate section on fish passage (5.2.3). These discussions rely heavily on findings of previous studies and of the prior demonstrations, but do present two data sets to support the assessment of potential for impact: Table 5-24 that shows the mean daily temperatures in the fishway and at Station 3, and the differences between the two, for the period 1997 to 2002; and, Tables 5-25 to 5-29, that present records of daily fish passage and mean daily temperatures for the years 1998 to 2002. Hourly fishway temperatures are also shown in Figures 3-7a to e.

Regarding upstream passage of adult American shad, it appears that the proposed increased thermal loading is unlikely to have any effect. Our position on this issue is based on our examination of the data presented in the demonstration. The temperatures that occur during the spring migration period for both shad and salmon (Tables 5-25 to 5-29) are within the preferred temperature range of shad and below the avoidance temperatures for both species (Tables 5-1 and 5-2). The temperatures are quite variable from day to day (as reflected in the data in Table 5-24), so that fish are not likely to encounter the kind of abrupt change from some steady-state condition that might cause a behavioral response. Because temperatures likely to

occur during the migratory period are not near any important thermal threshold, changes in the temperature of the magnitude predicted to occur in the fishway as a result of the requested variance (on the order of 1°F as shown in Figures 4-3 and 4-4 of the Demonstration) are unlikely to have any effect on successful migration through the fishway. EAC members strongly contested our position on this issue (e.g., page 4 of A1), suggesting that daily average temperatures are not an adequate basis for assessing this issue and that elevated temperatures may cause migration delays. One comment (A3 and A4) was that adult shad may discontinue upstream movement at temperatures above 68°F. These concerns are not supported by the information that is presented. Hourly fishway temperature data are presented in Figures 3-7a to e, and show that daily fluctuations in fishway temperature are often many degrees in magnitude. Substantial shad passage through the fishway has occurred in some periods when temperatures well exceeded 68°F (Table 5-26). We see nothing in the data and information available that would support the validity of the concerns expressed, and thus retain the conclusion stated above.

Regarding downstream migration of salmon smolts, the discussion in Section 5.1.1.2 cites Downey et al (1990) as confirming that smolts moved through the Vernon Pool without any discernable avoidance behavior in response to the thermal plume. In reviewing that report, we noted that this conclusion is based on tracking four smolts that moved through the pool, which is a very small sample size, and we would consider the findings of that study to be tentative at best, and not a definitive finding on this issue. In discussions with EAC members on April 30, we were informed that studies have documented that downstream migrating salmon smolts may interrupt their migration when they encounter migration barriers, such as dams, and may remain in the vicinity of those barriers for some time before continuing their migration. Such behavior may result in their having substantial exposure to elevated temperatures. Ken Cox also described the two downstream fish passage facilities located in the dam. They both have surface water intakes and are both located within areas of potential influence of the thermal plume. As we noted in Section 4.2, above, Atlantic salmon are a species of particular concern in the Connecticut River and warrant a more comprehensive and detailed assessment than that presented in the Demonstration. Several specific issues should be addressed, using the most current literature available, including: predicted changes in temperature regimes at the entrances to the downstream fish passage facilities; and, potential behavioral responses of salmon smolts (e.g., cessation of feeding, interruption of downstream migration) to the predicted temperature increases

Versar Conclusion: We agree with the conclusion that the requested increase in thermal loading will not adversely affect the migration of American shad past the VYNPS. Our discussions with EAC members leads us to conclude that the assessment of potential for impacts to Atlantic salmon, in particular to downstream migration of salmon smolts, has not been adequately addressed in the Demonstration. As a result, we cannot concur with the conclusion drawn in the Demonstration that no effects on Atlantic salmon will occur.

6.0 Overall Review Conclusions and Recommendations

In this revised Overall Review Conclusions and Recommendations section, we will summarize our major findings and conclusions, present a recommendation to VANR regarding this Demonstration, and then provide some additional commentary and opinion that we hope may be of some value to VANR, the EAC and ENVY in their further progress on this permit amendment request. However, we will preface this information with a clear statement of our role and responsibilities as a third-party reviewer of this Demonstration. While we have reviewed and assessed the adequacy of the Demonstration with regard to applicable regulations, we are not providing a legal opinion, but simply an assessment of adequacy from a technical perspective, based on our experience with other 316a demonstrations. Regarding the technical aspects of the demonstration, we are providing our own technical opinion, having taken in to account the verbal and written comments received from EAC members and from ENVY and their consultants since we distributed our draft review. For a number of issues (e.g., RIS), we have deferred to EAC members' opinions in acknowledgment of their detailed familiarity with the ecosystem of the receiving waters. However, we have not taken at face value the views of either EAC members or ENVY and their consultants, but have critically evaluated their views from a scientific perspective in order to come to our own conclusions. Finally, we are providing only technical support to VANR and offering our opinions on the technical adequacy of the Demonstration, not an opinion on whether the technical information warrants approval or disapproval of the permit amendment request.

Our major findings from this review include the following:

- The Demonstration meets all applicable state and federal regulatory requirements in its general content.
- The Demonstration is comprehensive and includes sections that address all of the potential impacts that are appropriate and necessary, consistent with 316(a) demonstration guidance provided in USEPA's 1977 guidance document. However, the demonstration is not organized in a manner consistent with the basis of the Type III demonstration being made, and the technical content of some elements of the Demonstration are deficient.
- The hydrothermal model used to predict the changes in the Vernon Pool thermal regime that would result from the requested increase in thermal loadings is an appropriate modeling tool for that purpose, and has been properly constructed, calibrated and validated. The model outputs thus represent reliable predictions of how temperatures within Vernon Pool would be changed in response to the increased thermal loadings. However, a number of details of the modeling effort require clarification (most of the required clarifications were presented in ENVY's response to our draft review, but should be incorporated into a revised thermal modeling report).
- The general impact assessment approach taken in the demonstration (demonstrate no prior appreciable harm to the balanced, indigenous populations through 2002 under current operating conditions; predict temperature changes in Vernon Pool and at Station 3; and, show that those predicted temperature will not impact RIS) is technically sound.
- While the general approach is sound, many of the details of its implementation are inadequate and require additional work. These inadequacies are described in detail in the

review sections above and will not be repeated here. The more significant of these are the lack of statistical analysis of historical data to confirm the absence of prior appreciable harm and the insufficient assessment of issues relating to salmon smolt migration.

- Some potentially significant issues that were of concern in our draft review have been explained and resolved in comments and discussion on April 30. For example, how potentially unrepresentative Station 7 temperatures were used as input to the modeling was adequately explained, such that we concluded that the modeling results are valid and not compromised by use of the Station 7 data. Other issues resolved are noted in our detailed review comments above.
- Because of the inadequacies in the Demonstration, we cannot provide to VANR at this time a technically sound opinion on whether approval of the requested permit amendment would threaten the "protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on that body of water." Such an opinion could only be reached after review of a revised Demonstration that addresses the inadequacies already described.

Based on these findings, we recommendation to VANR that ENVY should revise the Demonstration document as well as the thermal modeling report to address the inadequacies and/or need for clarifications we have identified in the review. The revisions should include a reorganization of the report so as to provide a clear road-map to the Type III demonstration being made, and should also include all of the applicable clarifications presented in ENVY's responses to our draft review.

While we cannot offer a final opinion on the potential biological consequences of approval of the requested permit amendment, we do believe it appropriate to discuss a number of factors that must be taken into account in developing such an opinion. As we described in Section 1.2, the permit amendment sought requests that the calculated delta T be increased by 1°F when ambient temperatures are between 55°F and 78°F, during the period May 16 through October 14. This is a very small change in thermal regime, as is noted repeatedly within the Demonstration, and it is not imposed when temperatures are at the minimum or maximum of the permitted temperature range. Thus, the changes in thermal regime that will occur will be, as is presented in the Demonstration, in the percentage of time that mid-level temperatures will occur during the permit period. The biological consequences of such small changes in thermal regime are likely to be equally small, and very difficult to both predict and measure. The approach taken in the Demonstration to predict the effects is an appropriate and rather innovative means of meeting this difficult challenge.

Many of the EAC concerns we have attempted to address in our review deal not so much with the approach taken in the Demonstration for predicting the impact of the requested change in the permit conditions, but with the effects of the existing thermal discharge of the plant, particularly on migratory species. We believe that these concerns are valid but are adequately captured in the Demonstration because it includes a combination of an evaluation of "prior appreciable harm" under the existing permit conditions and a

prediction of potential effects of the requested permit amendment. If this were a request for a new permit, then predictions of impacts of the total discharge would be necessary and might have substantial uncertainty associated with them. However, VY has been the object of biological study for decades, and large databases exist from which an evaluation of whether current plant operations have had an adverse effect can be made. Results of the statistical analyses we have suggested in Section 3.2, above, should provide a firm basis for establishing whether current plant operations have adversely affected the resident fish and benthic invertebrate communities. Making such a determination regarding the migratory species appears to be more problematic, since data to address specific EAC concerns (e.g., migration delays in response to elevated temperatures) appears to be inadequate or not available. In addition, there are numerous non-VY-related factors that may have adverse effects on these species, including hydroelectric facility operation, natural variations in river flows, and natural radiant heating of the Vernon Pool. Partitioning plant effects on fish migratory behavior from these other effects, whether through data analysis or through field study, poses significant additional challenges. The complexity of the impact issues is one reason that we relied on "gross" indicators of effects, such as the temporal pattern of shad passage up the Vernon Dam fishway as related to the temperatures observed during the migration, in our review. We believe that a conclusion on impacts can be reasonably based on such information without detailed knowledge of every factor contributing to the observed behavioral patterns.

One issue that has been mentioned in discussions with the EAC is a concern that there may be some undefinable maximum thermal loading to the system, beyond which significant impacts may begin to appear. This concern is based on the fact that individual requests for small changes in thermal loading might individually be acceptable, based on prediction of minimal impacts, but could cumulatively and eventually result in significant harm. While theoretical ecosystem modeling could be conducted to investigate such a phenomenon, such an effort would be very speculative, and would be unlikely to have any practical predictive value. Of greatest benefit to VANR and the EAC would be to rigorously review ongoing VY monitoring programs and special studies to ensure that work being performed targets the issues of greatest concern to the resource agencies. Such studies would ensure that evaluations and decisions made as part of future permit renewal processes can have a sound scientific basis.

Appendix A
Comments from EAC Committee Members on Versar's Review and on the 316a Demonstration

(A1)

Comments on the Draft Third-Party Review of Entergy Nuclear Vermont Yankee's Hydrothermal Modeling and 316(a) Demonstration Documents

On April 15, 2003, representatives of New Hampshire Fish & Game Department (Gabe Gries), U. S. Fish & Wildlife Service (Melissa Grader), and Vermont Fish & Wildlife Department (Ken Cox) met to review and discuss the draft report prepared by Versar, Inc., the Third-Party, which presents a review of reports submitted by Entergy Nuclear Vermont Yankee (Entergy) in support of their proposed new thermal effluent limits to the Connecticut River from the Vermont Yankee Nuclear Power Station (VYNPS) during the summer period, May 16-October 14. Versar, Inc. was selected by the Vermont Agency of Natural Resources, and under contract with Entergy, to provide third-party technical review of Entergy's 316(a) Demonstration, which includes both hydrothermal and biological assessments of thermal effects. The following comments represent a collaborative review by the agencies of Versar's draft report.

General Comments

The draft third-party review identifies substantial technical, analytical and presentation weaknesses in the demonstration documents which we believe are critical to evaluating the potential impacts of the proposed effluent limits on the aquatic biota of the Connecticut River. For example, data are interpreted and findings are drawn in the apparent absence of statistical analyses, and the demonstration document is organized in a manner which does not present a better "road map" of the process leading to Entergy's conclusion that the proposed thermal effluent limits will not result in "no prior appreciable harm." While we agree with Versar's review in many respects, we also find the review to be weakly worded for the most part and lacking in specific recommendations Entergy needs to take into consideration in making the demonstration document more "substantial" and in support of its case.

Furthermore, we also note that on several occasions Versar makes the point that the demonstration document frequently bases a conclusion of "no harm under the proposed conditions" on historical information that is not predictive in nature and yet basically comes to the same conclusions as the demonstration. This is perplexing. Historical information can be used to conclude "no prior appreciable harm" but then suitable, relevant literature, specific studies that address the proposed permit amendment, or predictive analyses are to be used to conclude to demonstrate the proposal will cause no harm. No predictive analyses were performed, and the literature that was used was not comprehensive.

We are disappointed in Versar's apparent lack of attention to the agencies' input regarding RIS and the thermal requirements of specific anadromous fishes. In light of these deficiencies we do not concur with Versar's preliminary conclusion that "it does not appear to us that approval of the requested permit amendment will threaten the 'protection and propagation of a balanced,

indigenous population of shellfish, fish, and wildlife in and on that body of water.'" More specific comments on information contained in the draft review are identified below.

Specific Comments

Section 3.1, Findings of Past 316(a) Demonstrations, Versar Conclusion, paragraph 1, last sentence: "...it would be helpful to have the summaries focus on and provide more detail on presentations and analyses...." While we agree with this statement, more detail and analyses are definitely needed and specific recommendations to Entergy should be made regarding particular statistical tests to use and/or trends to analyze.

Section 3.2, Review of Findings of Monitoring Studies Conducted from 1990-2001, paragraph 2, 4th bullet. We strongly agree that the conclusions reached in previous demonstrations are not necessarily applicable to the current proposed thermal limits.

Section 3.2, paragraph 2, 6th bullet. This is a salient point which deserves more emphasis and is more significant than "...a matter of organization...."

Section 3.2, Versar Conclusion. We agree with the findings that "the lack of statistical analysis of the data places in question the interpretation of the data and conclusions that are drawn" and "the fact that no harm was caused by prior small increases in thermal loading does not, a priori, mean no harm will be caused by additional small increases."

Section 4.1, Selection of RIS. We disagree with Versar's statement: "Except for being important recreational species, having all four of these species as RIS would generally not be necessary to ensure adequate coverage of the ecosystem in the Demonstration." While it is true that white perch, smallmouth bass, yellow perch and walleye are important from a recreational viewpoint, it is also significant to examine and consider that they do have different life histories, e.g. they use the area in and around Vernon pool and the tailrace below the dam to varying degrees, all spawn at slightly different times of the year and vary with respect to egg incubation and larval development. Furthermore, the selection of RIS, including those identified by the agencies but not considered in the demonstration document, was to establish guilds of fishes representative of communities inhabiting and/or which frequent two very different habitats or flow regimes under the influence of the thermal discharge from VYNPS (i.e., Vernon pool and tailrace). The agencies are open to recommendations Versar has to offer for the selection of RIS which provide for complete representation of these fish assemblages. Versar's assumption that gizzard shad was included because of the potential for the species to become a nuisance under a theoretically warmer thermal regime is correct.

Section 4.2, Thermal Effects Parameters Used for Prediction of Thermal Impacts to RIS, paragraph 1. We agree that the thermal effect parameters selection for use in predicting the effects on RIS do not include those that would specifically address potential effects on spawning, eggs and larval stages. This is a very important issue. Specific studies and a more complete

literature review need to be conducted. Additionally, the cues that the various RIS rely upon leading up to and including spawning need to be addressed.

Sections 4.3.1, Overview of the Adequacy of the Model Construct, and 4.3.2, Boundary Conditions. We fully agree that the model does not account for potential changes in the thermal conditions between Vernon dam and Station 3. Nonetheless, this is a critical reach of the river in terms of it being a migration corridor, access point for fish passage above the dam, and important habitat for several resident and anadromous RIS. As such, a detailed thermal study is needed downstream of the dam to Station 3, including a study of the outflow/attraction water plume exiting the fish ladder entrance.

Section 4.3.2, Versar Conclusion. We find it very disconcerting that the ambient river temperature is measured at a single location at Station 7 and that details of the specific location of the single thermistor within the water column is unknown. We too agree more information is needed to ascertain the potential uncertainty of this input variable to the model output.

Section 4.3.4, Appropriateness of Model Scenarios, Versar Conclusion. Versar acknowledges that the agencies have concerns about the potential for additional thermal loading affecting anadromous fish migrations. In addition to Versar's suggestion that additional model scenarios be generated with flow and temperature inputs representative of conditions during migratory periods, there may be a need to conduct specific studies of the behavior of salmon smolts and adult shad in response to these conditions.

Section 4.3.6, Detailed Comments on the Hydrological and Thermal Sections of the Demonstration, 2nd bullet. We agree that the description of how the flow transformation used in the model was calculated is not clearly stated and understandable.

Section 4.3.6, 8th bullet. In addition to the explanation offered by Versar which might possibly explain why fish ladder water temperatures may be higher than at Station 3, we further add that temperature is measured at the fish trap pool situated at the approximate midway point in the ladder. The upper length of the ladder is a vertical slot design with a channel having steep walls and covered by grating providing shading from the sun. In contrast, the ladder down from the trap pool is an ice harbor design where the flow passing through the upper portion of this section is largely exposed to the midday sun with the potential for gaining additional heat. Whether or not water temperatures measured at the trap pool are representative of temperatures exiting the ladder should be verified.

Section 4.4, Review of Prediction of Temperature Change at Station 3, Versar Conclusion. We concur with Versar's recommendation that "at a minimum, exceedance tables and curves should be developed for individual years...," and "these exceedance probabilities should then serve as the basis for predicting changes that may occur if the requested increase in thermal loading is approved."

Section 4.5, Review of Prediction of Effects on RIS from the Requested Increase in Thermal Loadings, paragraph 2. The agencies note that the lack of an independent literature review thoroughly identifying relevant and up-to-date literature sources is a significant deficiency in the demonstration document as well as the third-party review. Needless to say, we find this troubling. In that the third-party review acknowledges the demonstration relies on "relatively old" citations, and that it would be "nice to know" if more current sources are available for RIS is a gross understatement. There are many relevant studies that were not cited, including those identified by Steve McCormick and Alex Haro in their comments (see section 4.6 below), and which have potential bearing for the demonstration. Prediction effects on RIS must be based on as complete an understanding as possible gleaned from all relevant literature sources. This is needed.

Section 4.5, Versar Conclusion. We agree "an additional parameter that addresses spawning and egg/larval survival should be included for any species that may use the plume area for spawning." However, we also believe this needs to be applied to RIS spawning in the river between the dam and Station 3. Additionally, the cues that the various RIS use when spawning and prior to spawning need to be addressed.

Section 4.6, Review of Prediction of Effects on American Shad and Atlantic Salmon Migration and Fish Passage at Vernon Dam, paragraph 1. The data sets referred to are for the fish ladder and Station 3. In our opinion, predictions of temperature effects on upstream passage of migratory species cannot be based on daily mean temperatures. These data need to be re-analyzed using hourly temperatures. Further, as indicated under comments for section 4.3.6. above, fishway temperatures based on measuring point midway in the ladder may not representative of conditions throughout the ladder, therefore temperatures should be logged at multiple locations within the ladder as well as at the ladder entrance.

Section 4.6, paragraph 2. We do not agree with the statement "Regarding upstream passage, it appears that the proposed increased thermal loading is unlikely to have an effect." Comments regarding this subject submitted by Steve McCormick and Alex Haro of the Conte Anadromous Fish Research Center apparently were not considered by Versar. Their comments lend support to a different conclusion on this matter.

Section 4.6, paragraph 3. Regardless of past reviews and acceptance by the EAC of a previous study (Downey et al. 1990) detailing a lack of avoidance behavior response by salmon smolts to the thermal plume, we believe this subject must be revisited before additional thermal loading occurs. A thorough radio telemetry smolt study is needed with appropriate sample sizes using current technology to examine timing, transit time, movement, potential avoidance of the plume, and successful use of downstream fish passage routes/facilities. Further, while there is substantial literature from Connecticut Yankee Nuclear Power Station (CYNPS) showing a lack of thermal plume impact on adult shad migration (not included in the demonstration document), we do not agree that this literature is necessarily relevant to VYNPS. For example, the CYNPS is not associated with a dam and hydroelectric generating station and fishway, therefore opportunities exist for shad to avoid the plume. Instead of relying on literature that may not be

transferable, a study needs to be conducted at VYNPS examining upstream passage by shad. Such a study should take into consideration similar design and objectives as identified for a smolt telemetry study. Simply concluding that adult shad migrate past Vernon dam is not enough. The number of shad passed through the ladder relative to the number immediately below the dam is a more meaningful assessment of thermal impacts on adult shad migration drive and passage success. A telemetry study should also allow evaluating the movements of shad in Vernon pool relative to the plume and identify spawning areas.

Section 4.6, Versar Conclusion: We are left with a sense that the third-party does not fully understand the importance of the migratory RIS. These species for which there has been a decades-long interagency restoration effort are subjected to multiple stressors, including the possible VYNPS thermal effects. These effects, lethal and sublethal, could have a disproportionate impact on populations under the influence of the plant and are cumulative with impacts from other projects within the basin. Because of the importance of species, great deference should be given to comments from researchers involved in the restoration of these fishes, and greater caution should be used in arriving at a conclusion of project impacts.

24 April 2003

(A2)

Comments 316(A) Demonstration in support of a request for increased discharge temperature limits at Vermont Yankee's Nuclear Power Station during May through October

1) Despite the fact that the water below the Vernon Dam is considered fully mixed (thermally) when it reaches Station 3, I feel that a detailed thermal study needs to be conducted from Vernon Dam downstream to Station 3. If water is not fully mixed at any point downstream of the Vernon Dam, there is the chance for plumes of heated water to influence or negatively impact the spawning and survival of eggs of several resident fish species such as walleye, smallmouth bass, northern pike and chain pickerel and an anadromous species, American shad. Additionally, water in this area that is not fully mixed may influence the upstream migration of anadromous species (see below). Furthermore, the fish community up and downstream of the Vernon Dam is different and the effect of increased thermal discharge needs to be examined for both communities.
2) The water temperatures in the Vernon Dam fish way are described as being equal to or less than those at Station 3 during high river flows and at low flows are often 1 to 2 degrees F higher than at Station 3 and on occasion up to 3 to 4 degrees F higher. It is likely that these higher temperatures in the fish way lead to higher temperatures in areas below the fish way. While it has been documented that American shad and Atlantic salmon have successfully migrated past the Vernon Dam, more detailed studies are needed. For example, how far below the fish way does the influence of the fish way water temperature extend? Additionally, the question of whether the increased temperature in and below the fish way influences passage success is unanswered. I feel a temperature profile below the fish way (see above) and a tagging study of adult American shad below the dam examining transit time and passage success rate is needed.
3) Studies have been performed examining Atlantic salmon smolt downstream migration using radio telemetry. Are these studies scientifically sound and would it be worthwhile to re-examine this subject by using current (and likely far superior) radio telemetry/tags methodology to examine smolt transit time, passage success and thermal plume avoidance? Additionally, similar data is needed for juvenile and adult American shad.
4) I feel it is worthwhile to pursue a break from the proposed thermal limits in the fall and spring during times of diadromous fish migration and resident fish spawning. If this is acceptable to VY, they could instate the proposed thermal limits during the rest of the summer season.

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(A3)

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U.S. Fish and Wildlife Service
Connecticut River Coordinator's Office
103 East Plumtree Road
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April 23, 2003

Carol S. Carpenter
Wastewater Management Division
Vermont Department of Environmental Conservation
103 South Main Street
Waterbury, Vermont 05671-0405

Dear Ms. Carpenter,

I have reviewed the thermal discharge changes proposed by Entergy Nuclear for the Vermont Yankee Nuclear Power Station in Vernon, Vermont. Entergy Nuclear wishes to increase the thermal discharge limits at the Vermont Yankee plant by 1°F for ambient water temperatures between 55 and 78°F. My office has reviewed the proposal for its potential to adversely impact juvenile Atlantic salmon and adult and juvenile American shad and I offer the following comments:

Juvenile Atlantic salmon migrate downstream past the Vermont Nuclear Power Station from late April through early June. These smolts are known to feed in transit, which is important to smolt survival. The upper temperature for feeding is 72.5°F. Additionally, the fish are undergoing physiological changes during migration that will suit them to life in salt water. Salinity tolerance, and smolt survival, can be negatively impacted by exposure to increased temperatures.

Adult American shad spawn in the Connecticut River during May and June in a typical year, with larvae fully developed within a couple of weeks of egg fertilization. Shad eggs may develop abnormalities at temperatures over 71.6°F and eggs and larvae will not survive above 80°F. Adult shad may discontinue upstream movement at temperatures above 68°F.

Based on the above information (which has been pulled from existing literature), Entergy Nuclear's proposal has the potential to impact certain life stages of Atlantic salmon and American shad.

The documentation provided to date by Entergy Nuclear in support of their request does not adequately demonstrate that their proposal will assure the protection of salmon and

shad when ambient water temperatures are above 68°F. Instead, the report and data seem to indicate a need for further studies before any changes are initiated.

Sincerely,

/s/
Janice N. Rowan
Connecticut River Coordinator

References

Bradford, A.D., J.G. Miller, K. Buss. 1964. Progress report summary on phase B-2 to determine by bioassay techniques for inherent tolerance of shad during its egg and larval stages to specific environmental factors of the Susquehana River and its tributaries. Pennsylvania Fish Commission, Bresner Spring Fish Research Station (unpublished manuscript).

Carlson, F.T. 1968. Suitability of the Susquehana River for the restoration of shad. U.S. Department of the Interior, Maryland Board of Natural Resources, New York Conservation Department and Pennsylvania Fish Commission, Washington, DC. 60 pp.

Duston, J., R.L. Saunders, and D.E. Knox. Effects of increases in freshwater temperature on loss of smolt charactersistics in Atlantic salmon (*Salmo salar*). Can, J. Fish.Aquat. Sci. 48:164-169, 1991.

J.M. Elliot. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*,. Freshwater Biol. 25:61-70, 1991.

Kuzmeskus. 1977. D.M. 1977. Egg production and spawning site distribution of the American shad, Alosa sapidissima, in the Holyoke Pool, Connecticut River, Massachusetts. M.S. Thesis. University of Massachusetts, Amherst. 134 pp.

Liem, A.H. 1924. The life history of the shad (Alosa sapidissima) (Wilson) with special reference to the factors limiting its abundance. Biol. Board Can., Contrib. Can. Biol. 2: 163-284

B.C. Marcy, P.M. Jacobson, and R.L. Nankee. Observations on the reactions of young American shad to heated effluent. Trans.Amer. Fish. Soc. 101:740-743, 1972.

S.D. McCormick, R.A. Dempson, B. Cunjak, M.F. O'Dea, and J. Carey. Temperature-related loss of smolt characteristics in Atlantic salmon in the wild. Can.J.Fish.Aquat.Sci. 56:1649-1658, 1999.

Walberg and Nichols. 1967. Biology and management of the American shad and status of the fisheries, Atlantic coast of the United States, 1960, U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 550. 105 pp.

W.B. Wrenn. Effects of elevated temperature on growth and survival of smallmouth bass. Trans.Amer.Fis.Soc. 109:617-625, 1980.

(A4)

Review of Proposed Vermont Yankee Thermal Limits - Summer Period (May 16 to October 14) (from McCormick and Haro)

Higher thermal limits for discharge into the Connecticut River had been proposed for the period of May 16 to October 14. These changes have the potential to impact migrating juvenile salmon, migrating adult shad, juvenile shad and native warm water species. Migration of juvenile Atlantic salmon smolts in the mainstem of the Connecticut River occurs from April 20 to June 7. The upper thermal limit for survival of Atlantic salmon juveniles is 82.0 F (7 days exposure) and the upper limit for feeding is 72.5 F (Elliot, 1991). Migrating smolts are known to spend extended periods of time in the area in question (days), and feeding during migration has been strongly linked to smolt survival. Furthermore, laboratory studies indicate that increased temperature will increase the rate at which salinity tolerance is lost (Duston et al. 1991). This temperature-related loss of salinity tolerance, which is linked to reduced marine survival, has been shown to occur in the Connecticut River (McCormick et al. 1999). *For these reasons, artificial temperature increases of any kind should not be permitted until after the smolt migration (June 7).*

Adult American shad migrate upstream for spawning on the Connecticut River from May 15 to June 30. The upper temperature limits for spawning of American shad are not currently known. Upper limits for survival of shad eggs and larvae are 80 F (Bradford et al. 1964; Carlson 1968). Late in the spawning season, larval development of shad larvae is usually complete within 10 days of fertilization. *Thus, temperatures should not be allowed to rise above 80 F until after July 10.* Higher temperature water from the fish ladder during low flow has the potential to act as a thermal barrier to migration, and the possible influence of this barrier should be investigated.

Native warm water species in this area are likely to be harmed by increases in temperature when river temperatures are near their thermal limits. There is little published information on this aspect for most of our native warm water game species such as pike and pickerel. Smallmouth bass have a upper thermal tolerance of 95 F and an upper thermal growth tolerance of 90 F (Wrenn 1980). Juvenile shad have an upper thermal limit of 86 F (Marcy et al. 1972). *Therefore, increased thermal discharge should not be allowed when temperatures reach 86 F.*

Please contact us if you have any question or need further information.

Stephen D. McCormick and Alex Haro
Research Scientists
USGS, Conte Lab, Turners Falls, MA

References:

Bradford, A.D., J.G. Miller, K. Buss. 1964. Progress report summary on phase B-2 to determine by bioassay techniques the inherent tolerance of shad during its egg and larval stages to specific environemental factors of the Susquehana River and its tributaries. Pennsylvania Fish Commission, Bresnner Spring Fish Research Station, (unpublished manuscript).

Carlson, F.T. 1968. Suitability of the Susquehanna River for the restoration of shad. U.S. Department of the Interior, Maryland Board of Natural Resources, New York Conservation Department and Pennsylvania Fish Commission, Washington, DC. 60 pp.

Duston, J., R. L. Saunders, and D. E. Knox. Effects of increases in freshwater temperature on loss of smolt characteristics in Atlantic salmon (*Salmo salar*). *Can.J.Fish.Aquat.Sci.* 48:164-169, 1991.

J. M. Elliott. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*. *Freshwater Biol.* 25:61-70, 1991.

B. C. Marcy, P. M. Jacobson, and R. L. Nankee. Observations on the reactions of young American shad to heated effluent. *Trans.Amer.Fish.Soc.* 101:740-743, 1972.

S. D. McCormick, R. A. Dempson B. Cunjak, M. F. O'Dea, and J. Carey. Temperature-related loss of smolt characteristics in Atlântic salmon in the wild. *Can.J.Fish.Aquat.Sci.* 56:1649-1658, 1999.

W. B. Wrenn. Effects of elevated temperature on growth and survival of smallmouth bass. *Trans.Amer.Fish.Soc.* 109:617-625, 1980.

(A5)

STATE OF NEW HAMPSHIRE
INTER-DEPARTMENT COMMUNICATION

FROM Robert H. Estabrook
Chief Aquatic Biologist

Date March 25, 2003

SUBJECT Comments of 316a and hydrothermal modeling documents, Vermont Yankee

AT(OFFICE)
Dept. of Environmental Services
Water Division/Watershed
Management Bureau

TO Brian Kooiker
VT ANR Permits

I do not have specific comments on the two subject documents at this time. I am relying on Versar to do the detailed review and, because NH thermal criteria are based on the recommendations of the NH Fish and Game Department, I am relying on the fishery biologists to evaluate thermal impacts. I do, however, have a general comment about the process that may give some perspective to what has occurred in the past.

Through the years the EAC has addressed a number of issues related to the operation of VT Yankee and possible biological impacts. For example, there has been some feeling that the thermal effluent may play some role in the poor shad production in Vernon pool or that it may play a role in the early maturation and dropping of shad eggs prior to reaching Vernon dam. There was never a smoking gun. Conclusive data was not available to prove that the plant was the cause of such impacts and thus we did not require more restrictive thermal limits. However, that does not mean that all EAC members are completely comfortable with the existing conditions.

The company's position is that there are no documented adverse impacts from the effluent. Their reasoning follows that everything is fine now and they are only requesting a one degree F increase in the limit. While it may be true that there is no "documented" evidence of adverse impacts, it does not follow that everything is okay and everyone is satisfied with the existing limits.

It seems to me that the burden of proof to raise a temperature limit is much greater than the proof needed to continue existing limits. The fact that a certain procedure is used for compliance monitoring of existing conditions does not mean that it is sufficient to support increased limits. I was not real comfortable with some of the responses by

Normandeau at the March 6 meeting. For example, they didn't seem to know where in the water column the temperature probe was located nor any idea of the delta T from top to bottom. We need to know how representative the probe temperature is in relation to what is going on in the pool (presumably the hydrothermal model will do this). Another issue is the thermal plume study stops at the dam (for practical reasons), but the area below the dam is critical spawning habitat. More information on temperature conditions in this area (vertically and horizontally) than is currently provided by the probe at stn 3 is required to assess the thermal impacts on spawning fish.

In the 316a demonstration report from Normandeau (February, 2003), it appears that only expected changes between existing and new conditions are evaluated (e.g., sect 4.2 changes in fish habitat, and sect 5.1 changes in representative species). In other words, they don't evaluate the total impact, only the impact of an additional one degree F. Again, they are making the assumption that everything is fine now. While it may be interesting to know that the one-degree increase will only result in an X% loss in habitat, the critical question is what is the total loss of habitat over ambient or closed-cycle cooling conditions. I would encourage Versar to evaluate the total impact of the VT Yankee thermal discharge on the biota of the river, not just the change between existing and new conditions.

(A6)

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MEMORANDUM

TO: Brian Kooiker, Enviromental Analyst, Discharge Permits

FROM: Kenneth Cox, District Fisheries Biologist

DATE: April 3, 2003

SUBJECT: 316(a) Demonstration Report
Entergy Nuclear Vermont Yankee, LLC

The above-referenced document, dated February 2003, has been reviewed by me. I request that the following comments be passed along Bill Richkus of Versar for his consideration during their review of the same document and preparation of the draft analysis and response report.

1) In a January 31, 2003 memorandum to Carol Carpenter from me and subsequently provided by Carol to Lynn Dewald, additions to the list of RIS were identified. These species were identified by state and federal agencies as providing a more complete assemblage of fish species representative of guilds inhabiting the impoundment above Vernon dam and the tailwater below the dam. The added species include sea lamprey, largemouth bass, black crappie, and white sucker. The assessment of projected thermal impacts on RIS presented in the 316(a) does not include these fishes; nevertheless, these species should also be evaluated and included in the report.

2) The 316(a) uses as a measure of impact on the amount of habitat that would become unavailable should temperature criteria for each species be exceeded based on total volume (7,172 x 10^3 c.y.) and total bottom area (324 acres) affected by the thermal plume. This assumes that the entire plume volume or area is habitat for one or more life stages of each of the RIS. This is an unlikely assumption. A habitat specific analysis would in many of the cases indicate greater impacts.

3) Temperature effects on many of the RIS (e.g., spottail shiner, white and yellow perch, smallmouth bass, etc.) assumes all life stages have the same temperature criteria. Potential impacts on specific species may be more evident, if a finer scale

assessment was conducted. For example, water temperature increases to 73.5°F have been shown to result in smallmouth bass egg mortality in their final stages of development, and male bass have been observed to abandon nests when water temperatures suddenly drop below 60°F. Not only should increases in temperature be assessed but also fluctuations effects.

4) The temperature regime in the tailrace (dam to Station 3) has been assumed to be fully mixed and not to be an issue, albeit no verification of this has been made in light of several structural and operational changes to the hydropower station, such as replacement of flash boards with mechanical crest weirs, permanent retirement of two generators, operational modifications following power deregulation, and so on. The magnitude and distribution of temperatures in the tailrace reach, if not fully mixed, could have implications for fish behavior, attraction to the fish ladder discharge, etc. Three dimensional thermal monitoring and mapping in the tailrace is recommended.

5) Thermal discharge affects on fish passage through the ladder have not be adequately assessed in the past. Generally the conclusion reached has been if fish are using the ladder for upstream passage and in the absence of the data showing an obvious problem, then passage efficiency must be acceptable. However, passage (e.g., shad) has never been directly studied. One approach would be to release an adequate sample of radio tagged adult into the ladder discharge and monitoring their movement and timing up through the ladder in relation to temperature conditions and Vermont Yankee's plant operations. Such an assessment is needed to address this issue.

6) The affects of the proposed thermal discharge limits on the downstream smolt passage, behavior and timing that was addressed during the last 316(a) review may need to be re-examined using more current radiotelemetry technology and a large sample size.

7) The report characterizes the relative importance of RIS in terms of numbers of fish sampled measured against the numerical abundance of all other species. This may be misleading. Preferably the relative abundance of individual RIS would be better expressed as comparisons between and within similarly functioning species groups, i.e. top predators or piscivores (smallmouth and largemouth bass, walleye, pike, etc.), mid level predators (yellow and white perch, crappie, rock bass), insectivores (spottail shiner, fallfish), generalist or omnivores (suckers), etc. Weight of individual species is another preferable way to represent relative species within fish communities.

8) The report states there are no important spawning areas identified in the vicinity of Vermont Yankee and due to habitat preferences none would be expected. Has habitat availablity in the area been identified and evaluated for RIS species or is this conclusion based on speculation? It would appear that there is some spawning habitat in the tailrace between the dam and Station 3.

I encourage Bill or you to call me, if you have any questions about these comments or wish to discuss these further.

KMC

cc: C. Carpenter

Appendix B

ENVY Responses to Versar's Draft Third-Party Review

ENVY Response to Versar Draft Review of 316(a) Demonstration
29 April 2003 - DRAFT
1

Entergy Nuclear Vermont Yankee, LLC's (ENVY's) Responses to
Versar 4 Apr 03 Draft Review of 316a Demonstration
29 Apr 03 - Draft

In the paragraphs presented below, we quote Versar's original statement or comment in bold, with reference to the Section and page number(s), followed by ENVY's response in standard text.

Versar's Section 2.6, third paragraph on page 9 states:
"While we believe the approach taken is adequate with regard to applicable regulations, we noted in progress reports on our review that the demonstration document lacks a good "road map" to the approach. Reorganization of the document would be very helpful to readers in understanding the purpose of the different types of data presented, the reasons the different analyses and data presentations were done, and how they are all integrated together to make the intended argument."

ENVY's Response is:
In its comment, Versar suggested that, while not required, the § 316(a) Demonstration document would benefit from a "road map", detailing the basis for the approach taken in the Demonstration. By way of response, the U.S. Environmental Protection Agency's draft 1977 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements (the 1977 Technical Guidance), the operative guidance document (although it remains in draft), sets forth three types of demonstrations that a § 316(a) variance applicant may use to establish that a discharge is appropriately protective of the balanced indigenous population. *See generally* the 1977 Technical Guidance; *see also* April 18, 1974 USEPA Draft Proposal Guidelines for Administration of the 316(a) Regulations (April 1974 Draft Guidelines); September 1974, USEPA 316(a) Technical Guidance - Thermal Discharges (September 1974 Draft Guidance) (superceded by the 1977 Technical Guidance); USEPA/NRC/FWS (316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Power Plant Environmental Impact Statements) (1975 Draft Guidance), December 1975. Indeed, EPA suggests that state regulators, such as ANR, employ the 1977 Technical Guidance or confirm with EPA any deviations (1977 Technical Guidance, p. 9).

As these documents provide, a Type III demonstration, such as the Demonstration reviewed by Versar, is a combination of predictive and empirical assessment methods and data (April 1974 Draft Guidelines, pp. 34-35). More particularly, a Type III demonstration properly entails reasonably: (1) identifying the water-body segments occupied by the relevant aquatic biological communities; (2) identifying any critical function zone in that area; (3) identifying biotic categories potentially impacted by the thermal plume; (4) selecting representative important species ("RIS") within impacted biotic categories; and (5) evaluation of the potential impacts, if any, of the identified thermal plume to the selected RIS.

As Versar is aware, the Demonstration tracks EPA's suggested decision train above, all in a manner consistent with EPA's guidance for Type III demonstrations, particularly the 1977 Technical Guidance. In particular, Chapter 3 of the Demonstration identifies the Connecticut River ("River") segment relevant to the Demonstration, and Chapter 5 presents the aquatic communities relevant in that segment of the River. Chapter 4 identifies the critical function zone, equating the area with the locations subject to thermal influence. Chapter 2 details the identified RIS and supports the selection criteria, based upon the extensive biological data set developed over the last several decades (Chapter 6). Chapters 3 through 5, as well as the accompanying hydrothermal assessment (Appendix 3), detail the absence of potential impacts on the relevant aquatic community, as determined by the identified RIS, attributable to the proposed thermal increase.

Versar's Section 3.2, last bullet on page 12 states:
"Appendix 1 presents a list of analytical bulletins produced as a result of the implementation of Part II "goal oriented" studies. The results of many of these studies were not covered in earlier demonstrations and only a few are cited in this section of the demonstration. To the extent that results in any of the bulletins are relevant to issues relating to the requested permit amendment, those results should be incorporated into this section."

ENVY's Response is:
In its comment, Versar suggested that those Analytical Bulletins, which played a critical role in the Demonstration, be described in detail in the Demonstration. We did not rely extensively on the Analytical Bulletins. However, in the few instances where the results of a specific Bulletin were relevant, we believe that we appropriately detailed the relevant information and provided a citation for the source Bulletin. We also included the Appendix I list of all of the Bulletins as a convenience for the reader. As such, this comment is resolved.

Versar Concludes in Section 3.2 on the bottom of page 12, and continuing on to the top of page 13 that:
"The benthic macroinvertebrate and fish community data presented in this section provide a good foundation for demonstrating that there has been no prior appreciable harm from VYNPS operating under its current permit conditions. However, the lack of statistical analysis of the data places in question the interpretation of the data and conclusions that are drawn. Such analyses should be done to provide a rigorous scientific basis for any conclusions about prior appreciable harm. The analyses should examine changes in abundance or community structure over time, and, if there were any negative changes, an explanation of potential causes and an assessment of whether the plant thermal discharge may be a contributing factor. These analyses could also employ the longer term data sets that were analyzed and addressed in the two prior demonstrations. Our visual inspection of the data does not suggest that there are negative trends or obvious adverse impacts, but that is a subjective judgement. Also, these monitoring study results, while very valuable for addressing no prior appreciable harm, do not

provide a basis for prediction of impacts of the requested increase in thermal loading. The fact that no harm was caused by prior small increases in thermal loadings does not, a priori, mean that no harm will be caused by additional small increases."

ENVY's Response is:
In its comment, Versar indicates that visual inspection of the extensive volume of data collected during ENVY's environmental monitoring program suggest that the conclusions drawn appear to be valid. Versar also suggests additional statistical analysis, with a focus on long-term trends, to further demonstrate no prior appreciable harm. By way of response, the EPA's 1977 Technical Guidance, again the operative guidance document (although it remains in draft), which sets forth the necessary level of analysis, does not provide for, and certainly does not require, statistical analyses in support of 316(a) demonstrations. Further, the US EPA routinely issues 316(a) variances without the benefit of a comprehensive statistical analysis, in fact often without any long-term biological study program on the order of ENVY's (e.g. Cromby, Barbadoes, and Schuylkill Generating Stations, Aluminum Company of America and Appleton Papers). This is confirmed by our experience that few of the 316(a) demonstrations in which our office has participated have involved statistical analyses of the sort Versar suggests. As such, we interpret Versar's comment as being among its helpful suggestions, but not required for satisfaction of the applicable standards and criteria for 316(a) demonstration, including the current Demonstration.

To that end, we have proposed confirmatory work to be addressed as part of the subsequent monitoring relating to the Demonstration or ENVY Station operations under the new permit limits, as follows:

A confirmatory statistical analysis is proposed to determine the relationship between fish populations or macroinvertebrate community stability and the influence (if any) of the proposed new summer period thermal regime in Lower Vernon Pool of the Connecticut River. The proposed format for presentation of the results of these analyses will be in expanded fisheries and macroinvertebrate sections of the annual NPDES report, beginning with the first year in which the new summer limits become effective. The following two paragraphs provide a description of a proposed approach for the confirmatory statistical analysis. If desired, the final statistical design will be subjected to review and approval of the EAC prior to implementation.

The existing fish population relative abundance data derived from NPDES permit monitoring will be examined for each of the selected RIS to establish the baseline condition. A separate analysis will be performed for the fisheries data obtained by electrofishing and by trap netting. These two fisheries sampling gear and their deployment practices have been consistent across years providing catch per unit of effort (CPUE, log-transformed) as an appropriate response variable for application to a statistical model based on multiple linear regression and analysis of variance (ANOVA) techniques or similar non-parametric methods. The statistical model will consider station and year as blocking variables and initially test the hypothesis that no inter-annual trend

was apparent among sampling stations for the period from 1990 until the new limits became effective. Then, as fish population monitoring continues under the proposed new summer thermal limits, each subsequent year's fisheries CPUE data will be added to the statistical model and tested to determine if there is a change in each RIS fish population from the trend established prior to implementing the new summer limits. Segmented regression may also be required to help identify statistically significant nodes that occur at times that do not coincide with the onset of the new thermal limits. The proposed approach is robust in that it allows for the possibility that a linear trend of increasing or decreasing relative abundance may already exist in the fish populations of lower Vernon Pool due to existing agency management practices and the ongoing Connecticut River anadromous fish restoration efforts.

The proposed confirmatory analysis for benthic macroinvertebrates will be based on rock basket sampling that has been, and is presently, a permit-required monitoring program. Rock basket substrate samplers have been used to sample the benthic macroinvertebrate community in the Connecticut River downstream below Vernon Dam at stations 2 and 3 during the summer periods of each year 1990-present. Ponar grab sampling throughout the study area, and rock basket sampling upstream from Vernon Dam were both discontinued as benthic macroinvertebrate sampling programs in August 2001 pursuant with issuance of a new NPDES permit that no longer required these efforts. The statistical analysis will examine benthic macroinvertebrate community structure and function using metrics for evaluating aquatic community relationships to water quality (temperature) conditions (Barbour et al. 1999). The metrics initially selected for evaluation include: taxa richness, epemeroptera-plecoptera-tricoptera (EPT) richness, EP richness, Diptera richness, Tricoptera richness, Shannon-Wiener Diversity Index, ratio of scrapers to filterers, ratio of EPT to Chironomidae abundance, percent dominant taxa, community loss index, modified Hilsenhoff biotic index, and Bray-Curtis similarity index. All, or an appropriate non-redundant subset, of these metrics will be compared among the stations across years to measure the change (if any) in the macroinvertebrate community before and after implementation of the proposed new summer limits. The proposed statistical test will be based on either non-parametric multivariate analysis (Clarke 1993) or numerical classification (cluster analysis) and multivariate analysis of variance (MANOVA). Selection of the appropriate statistical methods will be determined at the time of analysis based on the ability of the metrics to meet the requirements (assumptions) of the methods. As mentioned above, the EAC will be consulted and their approval will be sought prior to performing the analysis. The proposed statistical model will consider station and year as blocking variables and initially test the hypothesis that no inter-annual trend was apparent among sampling stations for the period 1990 until the new limits became effective. Then, as benthic macroinvertebrate community monitoring continues under the proposed new summer thermal limits, each year's benthic macroinvertebrate community metrics will be added to the statistical model and tested to determine if there is a change in the community relative to the trend established prior to implementing the new summer limits.

References:

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment

Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Clarke, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18: 117-142.

Versar Concludes in Section 4.1 on page 14 that:
"Because selection of RIS is based on consultation between the agencies and the applicant, the process followed to date in their designation has been appropriate and consistent with procedures presented in the USEPA 1977 guidance document. The species that are addressed in the demonstration and those additional species suggested by EAC members cover all of the categories specified for RIS selection in the 1977 guidance document. It appears to us that there may be more species than necessary to adequately represent the potentially affected aquatic community, since several species appear to be redundant in terms of their ecosystem role. However, the Regional Administrator/Director (i.e., VANR) has the authority to designate the RIS, (although that selection can be challenged by the applicant; see Section 3.5.2.1, pg. 36, of the guidance document), so the final decision on how many RIS and which species are to be addressed is up to VANR. One factor that is to be taken into account in selection of RIS is availability of data and information. So that may be a topic for discussion with VYNPS in resolving the RIS species list."

ENVY's Response is:
In its comment, Versar affirms the selection of RIS, noting that there appears to be redundancies providing additional levels of assurances regarding the selection. However, we appreciate Versar's comment. The rationale employed in the selection of RIS for the current Demonstration, as Versar notes, fulfills the intent of the concept of RIS specified in the USEPA 1977 guidance document in that the seven species selected provide adequate coverage for all of the categories specified by EPA. The seven RIS selected for this demonstration (Atlantic salmon, American shad, smallmouth bass, white perch, walleye, yellow perch and spottail shiner) had been previously agreed upon in consultation with the resource agencies represented by the Environmental Advisory Committee (EAC) for inclusion in two earlier 316(a) Demonstrations (1978 and 1990). Three additional species of interest (gizzard shad, American eel and sea lamprey) were suggested for inclusion in the demonstration and, although we did not agree that they were necessarily appropriate as RIS, we included them because some members of the EAC expressed an interest in them. Therefore, we do not see the value added by including more RIS fish species (largemouth bass, black crappie, and white sucker) as identified in a 5 February 2003 memorandum from Carol Carpenter (ANR) to Lynn DeWald, Environmental Specialist (ENVY). The seven primary and three additional RIS already examined adequately represent the potentially affected fish community within the ecosystem. The protection of these ten fish species will reasonably assure the protection of other fish species at the site. However, keeping with our approach of addressing seven primary and three additional RIS, the discussion below with respect to spawning and early life stages will address these ten fish species.

Versar Concludes in Section 4.2 on page 14 that:
"The thermal effect parameters selected for use in prediction of effects on RIS are appropriate for that purpose. However, they do not include a parameter that would specifically address potential for effects on spawning and eggs or larvae. While this segment of the life history of many of the RIS may not be relevant (e.g., species that would spawn before May 15, or species for which no spawning habitat exists in the Vernon Pool), this issue should be addressed in this section of the demonstration."

ENVY's Response is:
Versar's comment confirms the appropriateness of the selected thermal effects parameters for the RIS and this Demonstration. Versar also suggests that consideration of spawning and early life stages may, where relevant, be useful. We agree, and already had included specific temperature information related to the early life stages for RIS and for the additional fish species considered in the Demonstration. Indeed, one of the thermal effects parameters included in Table 5-1 and discussed for American shad (Section 5.1.1.1) was the optimum growth temperature (70 °F selected from a range of 60 – 80°F given in the literature) for eggs and larvae. Below, we further discuss the contents of the Demonstration and conclusions to be drawn from this information.

Several general considerations are warranted, however. Of the 2,550 acres of water retained at a full-pond elevation behind Vernon Dam, potential adverse thermal effects may impact only the waters in the lower pool between the ENVY Station discharge and Vernon Dam, represented by 324 acres or 12.7% of the total impoundment. Also, and importantly, no location within this potentially affected habitat has been identified as an important spawning habitat for any RIS or the additional species. Further, as described in Section 4.2 of the Demonstration, only slight changes are predicted to occur in the potentially affected 12.7% of Vernon Pool. Such slight changes are not reasonably expected to adversely impact spawning and early life stages of the RIS and the additional species. This conclusion is further supported by predictions describing the behavior of the thermal plume.

The modeling shows the highest temperatures of the thermal plume occur at the surface and also along the western (NH) shore south of the ENVY Station. The affected littoral habitat along the western bank south of the Station is only a small fraction of similar habitat in the lower Vernon Pool. Therefore, the analysis confirms the absence of potential adverse effects on identified RIS and the additional species, as more fully discussed with respect to individual fish species below:

Representative Important Species

American shad: As indicated in the Demonstration, the scientific literature confirms that spawning occurs over a temperature range of 57 to 70 °F, which implies fairly broad thermal tolerance for the egg and larval stages. We also reported that the fertilized eggs settle out of the water column. Settling removes these life stages from the highest plume temperatures, which occur at or near the surface. Thus, the Demonstration confirms the absence of an adverse impact to American Shad in their spawning and early life stages.

Atlantic salmon: Not applicable, since no suitable spawning or nursery habitat exists in lower Vernon Pool, therefore eggs and larvae do not occur there.

Spottail shiner: Thermal effects information is not available in the scientific literature for spawning and early life stages. However, We reported that this fish has been one of the most abundant species in Vernon Pool since the monitoring studies have been underway, including the 1990 – 2001 review period during which the present discharge limits were in effect. The recent ichthyoplankton collection data indicates that this species has an extended spawning period and spawns over a fairly broad range of temperatures, as follows:

Daily average Connecticut River temperature on the earliest and latest dates when spottal shiner larvae were collected near the VYNPS intake.

Year	Earliest Capture	Station 7 Temperature	Latest Capture	Station 7 Temperature
1998	2-Jun	65	13-Jul	68
1999	4-Jun	68	2-Jul	75
2000	29-May	60	11-Jul	75
2001	4-Jun	56	18-Jul	72

We also noted that the broad geographical distribution of this fish (including the southern U.S.), as well as thermal effects information for other life history stages of this species, indicate it thrives in relatively warm waters. Thus, it is reasonable to conclude that a 1 °F increase in the temperature limit will not be detrimental to the continued success of this species in the Connecticut River near Vernon Pool.

White perch: The available scientific literature shows that white perch is distributed along the Atlantic coast from South Carolina to the St. Lawrence River, and that it thrives over a broad temperature range. The available scientific literature further indicates that, after spawning, white perch eggs most frequently settle to the bottom and adhere to the substrate, where they are less likely to be affected by the thermal plume. As reported in the 1990 Demonstration, white perch have an extended spawning and larval recruitment period which further indicates that spawning and early life stage development occur over a fairly wide temperature range. After spawning, the eggs most frequently attach to the substrate where they are less affected by the plume than they would be if they were floating up in the water column. As shown in Table 5-4 of the Demonstration, neither the plume volume nor the plume bottom area relevant to white perch will exceed the optimum temperature for growth under any of the modeled scenarios. Accordingly, a small increase in plume temperature due to the ENVY Station discharge will not have a substantial effect on the distribution or abundance of this species in lower Vernon Pool of the Connecticut River.

Smallmouth bass: This fish species spawns in nests built in the bottom substrate in locations protected from the main River currents. Spawning occurs over a temperature range of 55 – 68 °F, with egg deposition occurring mostly at 61 – 65 °F. As presented in

Section 4 of the Demonstration (see Figures 4-1 and 4-2), the hydrothermal modeling shows at these spawning temperatures that there is no difference in mean plume volume and mean bottom area for the existing and proposed new permit limits. Thus, neither spawning nor early life stages have the potential to be affected by the thermal plume.

Yellow perch: There is little potential for the thermal plume to adversely affect the early life stages of this species since it spawns in early to late May when water temperatures are low and River flows are generally high. Further, the eggs are deposited on the River bottom and become attached to the substrate, another factor removing them from potential impact.

Walleye: Walleye will have completed spawning prior to the summer compliance period for the ENVY Station (May 16), and therefore, would not be affected by the proposed change in thermal limits. Walleye also deposits its eggs on the substrate, like yellow perch, thus the early life stages are removed from the influence of the highest plume temperatures.

Additional Species

Sea lamprey: Lower Vernon Pool does not appear to contain spawning or nursery habitat preferred by this species. While the young may live in soft sediments, found primarily along shore, they will not be subjected to the highest temperatures of the thermal plume.

American eel: The American eel spawns in the Atlantic Ocean and the young migrate into rivers such as the Connecticut River where they reside for several years. The very broad geographic distribution of this species, from Greenland to Venezuela, indicates this species' ability to thrive in a wide range of temperatures.

Gizzard shad: The potential effects of the thermal discharge on the spawning success and growth of this species is indicated by life history information provided in the Demonstration (Section 5.1.2.3). This species has a broad tolerance to temperature during spawning, which has been reported to occur over a temperature range of 50 – 70 •F. Since the eggs are usually deposited in shallow water and are demersal, they will not be subjected to the highest temperatures of the thermal plume. In addition, an optimum growth temperature of 80 •F indicates that the young are thermally tolerant.

Versar Concludes in Section 4.3.2 on page 16 that:
"The boundary conditions established for this model are appropriate for predicting thermal regimes in Vernon Pool and in the fishway. An outstanding issue is the extent to which unrepresentative temperatures at Station 7 may result in an inaccurate representation of the magnitude of temperature changes under the permit amendment. Further information should be provided on the significance of the uncertainty of this input variable to model output. We do not expect that it will have a significant effect on the overall model results, since the calibration adjusts for this factor along with many others (i.e., the uncertainty associated with temperatures recorded at Station 7 are accounted for during calibration). The

model is not capable of predicting temperature regimes below the Vernon Dam, an issue of concern to some EAC members. Additional monitoring in this area is probably the most reasonable way to address this issue, since the complexity of flows through and over the dam would be very challenging and difficult to model."

ENVY's Response is:
This is actually a two-part conclusion. The first part addresses boundary conditions for the model and is addressed here. The second part pertains to Station 7, and is discussed in more detail below with respect to the Demonstration (see ENVY's Response to Versar's Detailed Comments on Hydrological Thermal Sections of the Demonstration, Section 4.3.6, first Bullet on page 20) and in independent correspondence regarding compliance.

The Station 7 temperature was used as the upstream boundary temperature at Bellows Falls Dam. This decision was made because there appeared to be minimal longitudinal temperature variation in the upper pool away from any thermal effects from the discharge. The correctness of this decision is shown graphically in Figure 4-10 on page 41 of the ASA Hydrothermal Modeling report. The upper panel of the figure shows the model predictions compared to observations at Station 7 and clearly indicates that the model reproduces the correct temperature response even though the atmospheric heat transfer was occurring in the surface layers along the length of the river downstream from the Bellows Falls Dam.
Although a separate river model could be applied to the reach from the Vernon Dam discharge to Station 3, based on our understanding of the short travel time and significant mixing, we assumed that the model-predicted vertically averaged temperature at the Vernon Dam discharge would be representative of observed Station 3 temperature. This assumption was confirmed by comparing time series of these temperatures as shown in the middle panel of Figure 4-10.

Versar concluded that the boundary conditions established for the model are appropriate for predicting thermal regimes in Vernon Pool and in the fishway. Figure 4-10 bears out the correctness of their conclusion.

Versar States in Section 4.3.4, first paragraph on page 17 that:
"Because the visual presentations can aid in interpretation of the potential biological significance of the thermal distributions, presentation of the thermal plume figures for additional scenarios are warranted. Suggestions for additional results to be presented are: 1) plots showing plan-view worst-case (1%) results of the pool temperatures at top, mid-level and bottom during the passage season (June-July); 2) plots showing the worst-case results of the difference between existing and proposed thermal criteria; and 3) area and volume calculation differences for the worst-case condition during mid-day high temperature rather than over a 24-hour average period."

ENVY's Response is:
Versar's comment confirms that the scenarios selected provide a sound basis for the Demonstration. Indeed, Versar concludes (on page 23 of their comments) that "We agree

with the conclusion that the requested increase in thermal loading will not adversely affect the migration of American shad and Atlantic salmon past the VYNPS". We understand, however, that certain members of the EAC have questioned whether the scenarios fully address potential effects on the migration of anadromous fish. As noted in Section 4.3 of the Demonstration and in Section 4.3.3.2 the ASA Hydrothermal Modeling report, worst-case and average modeling scenarios encompassing fishway operation time periods were developed and evaluated. Based upon these scenarios, no adverse affect on the migration of anadromous fish is expected. Consequently, the Demonstration adequately confirms the absence of any potential adverse impact to anadromous fish with respect to their migratory use of the Vernon Dam fishway.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, first bullet on page 18:
"Exec. Summ., 5th paragraph, 4th line, symbol should be r-squared, not square root."

ENVY's Response is:
A square root sign instead of the letter "r" is a typographic error. It should be r^2 as noted.
Versar's Detailed Comments (ASA 2003) in Section 4.3.5, second bullet on page 18:
"Exec. Summ., last paragraph, recommend not using the term 'insignificant' without statistical meaning."

ENVY's Response is:
We will replace "insignificant" with "de minimus".

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, third bullet on page 18:
"Section 3.2. There is no description here or elsewhere, that describes the details of the field data collection, including how the stations were selected, the types of thermistors, their accuracy and precision, how often they were downloaded, etc. This information is important to understanding the uncertainty in the field data measurements, relative to uncertainty in the model."

ENVY's Response is:
Versar's comment provides the opportunity to describe the state-of-the-art temperature monitoring system deployed during 2002 to obtain thermal data for calibration of the hydrothermal model. Onset StowAway. TidbiT. 32K, temperature data loggers were deployed to measure the thermal regime of lower Vernon Pool of the Connecticut River during June through November 2002. These temperature loggers have a manufacturer's reported measurement range of -4°C to +37°C, and a reported accuracy of +0.4°C. All of the temperature loggers were set to record data at simultaneous five-minute intervals. Two strings of temperature data loggers were deployed in close proximity to each other at each of 11 stations in Lower Vernon Pool. Three temperature data loggers were attached to each string and arrayed from surface to bottom. One temperature data logger was deployed at the surface depth (1 foot below the surface, referred to as surface or "S" when used as a suffix to Station number), a second logger was deployed at mid-depth (half way between the surface and bottom = "M"), and a third logger was deployed at one foot above the river bottom (bottom or "B") at each station. Therefore, a total of 66 temperature data loggers were deployed for this study (2 pairs per station x 11 stations x

3 depths). All depth measurements were relative to the total water column depth observed at a station at the time of deployment, and all station locations were marked with GPS latitude and longitude coordinates.

Nine of the 11 stations were established along three bank-to-bank transects in the Lower Vernon Pool at locations representing the expected exposure to the thermal gradient from the ENVY discharge. One transect was perpendicular to the river flow, located immediately downstream of the discharge weir, and had samplers deployed at quarter points along this transect (25%, 50% and 75% of the distance from the Vermont shore). The second transect was also perpendicular to the river flow, located downstream from the discharge weir one-third of the distance towards Vernon Dam, and had samplers deployed at quarter points along the transect (25%, 50% and 75% of the distance from the Vermont shore). The third transect was also perpendicular to the river flow, located downstream from the discharge weir two-thirds of the distance towards Vernon Dam, and had samplers deployed at quarter points along the transect (25%, 50% and 75% of the distance from the Vermont shore).

The remaining two of the 11 stations were established as upstream control stations (Figure 1). The two upstream stations were located within the Vernon Pool upstream from the influence of the thermal gradient along a transect perpendicular to the river flow, with samplers deployed at 25% and 50% of the distance from the Vermont shore. Stations are referred to by transect (F was the most upstream; C, D, E were the most downstream, respectively) and by station number (1-6). Station numbers were also assigned systematically, with stations 1 and 2 being the pairs of temperature loggers located proximate to the Vermont shore, stations 3 and 4 were in the center of the channel, and stations 5 and 6 were proximate to the New Hampshire shore. Upstream control stations (F1,F2 and F3,F4) were located upstream from the influence of the discharge, while the remaining transects were at or downstream of the ENVY discharge. For example, Station E5 and E6 were the pair of temperature strings located on transect E proximate to the New Hampshire shore on the most downstream transect below the discharge.

<u>Versar's Detailed Comments (ASA 2003) in Section 4.3.5, fourth bullet on page 18:</u>
"Section 3.2.1.1. Provide further details on processing with a 3-hour low-pass filter, e.g., a 3-hour moving average?"

<u>ENVY's Response is:</u>
In its comment, Versar sought confirmation that the 3-hour low-pass filter represents a three-hour moving average. Versar is correct. The 3-hour low-pass filter was a centered 3-hour moving average. This is an appropriate data conditioning step because the model input data is on an one-hour timestep and the model therefore cannot simulate processes that occur at frequencies less than one hour. The model-data comparison is thus more accurate, further supporting the conclusion of the demonstration.

<u>Versar's Detailed Comments (ASA 2003) in Section 4.3.5, fifth bullet on page 18:</u>
"Section 3.2.1.4. Provide more details on processing with cubic splines and a 3-hour

low-pass filter."

ENVY's Response is:
Since the meteorological data was not reported exactly on the hour, a cubic spline curve fit was applied to the observations (passing exactly through the surrounding four data points) to generate one-hour estimates. These data were then filtered with a centered 3-hour moving average. (See also the response in the preceding paragraph to bullet 4 on page 18.)

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, sixth bullet on page 18:
"Section 3.2.2.1. Why was sensor C4 offline from 8/1 to 8/15? Provide a plot of temperature profiles of the E stations, similar to those for C and D in this section."

ENVY's Response is:
Versar's comment asks about the data for the period between 1-15 August 2002 for the thermistor located at the surface at Station C4 in lower Vernon Pool. Data loggers were downloaded on 14 and 15 August 2002, during which 3 files were irretrievable. The loggers were sent to Onset to have the data retrieved. Data sets from two of the loggers were retrieved by the instrument manufacturer. The data from the station C4S logger could not be retrieved due to instrument failure, resulting in a loss of data for that point from 31 July to 15 August 2002. Station C3S, the duplicate of C4S, was downloaded without data loss during that period. Because all thermistor loggers were deployed in redundant pairs, there was no effective loss of relevant data. Even though the C4S temperature data logger failed out of the 66 deployed, the success rate of 65/66 or 98.5% is, in the experience of the consultant team (ASA and Normandeau), exceptionally good. Losses of data are fairly routine when loggers are deployed *in situ*, and, because of redundant deployment design, this loss did not affect conclusions in the Demonstration. Profile plots were provided in Section 3.2 of ASA's report as examples to illustrate times with and without thermal stratification. The D stations were chosen at three different times and presented in Figures 3-4 through 3-6. Figure 3-6 was incorrectly captioned as a profile from the C stations but the figure itself correctly indicates D stations were used. The same information at the three times for the C stations and E stations can be seen in the time series plots of Figure 3-7.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, seventh bullet on page 18:
"Section 3.2.2.2. Explain or refer to a section of the main 316a report which explains about the nature and variability of upstream hydroelectric operations and how this affects flow entering Vernon pool. It is important to understand that flow entering Vernon pool is highly regulated by upstream hydroelectric projects."

ENVY's Response is:
In its comment, Versar seeks an understanding about hydroelectric flow regulation in Vernon Pool. Section 3.1.2 of the Demonstration details the nature of flow regulation at Vernon Dam. As discussed therein, Connecticut River flow is highly regulated by numerous upstream storage and hydroelectric stations. Although storage in the Vernon headpond provides some flexibility of flow release from Vernon Dam, independent of

inflow, the upriver hydro stations and Vernon Station are generally operated more or less in unison to maximize power output during times of peak power demand. The hourly flow record for Vernon Dam provides direct evidence of the highly regulated nature of the whole River.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, eighth bullet on page 18:
"Section 4. Although a near-field model is not needed for the purposes of this modeling effort, describe the specific reason that the VYNPS discharge could not be simulated with CORMIX, to provide a more complete explanation for the report."

ENVY's Response is:
As Versar recognized in its comment, CORMIX3 was not an appropriate methodology for the Demonstration. However, Versar requests that a statement to this effect be included in the Demonstration, which follows. The near field effects of the discharge plume were minor compared to the large size of the pool, and therefore a near-field model such as CORMIX3 is not appropriate. The CORMIX3 model could not directly simulate the plant discharge geometry, in any event, since there is a built-in model limitation that the discharge depth to width ratio be at least 0.05. The plant discharge geometry is actually about 0.005 (depth of 0.54 ft, width of 100 ft), 10 times less than the minimum, making CORMIX3 an inappropriate model.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, ninth bullet on page 18:
"Section 4.3.2, 2nd paragraph, 2nd sentence, strike 'in' after 'used'; 3rd paragraph strike 's' in Figures 4-2."

ENVY's Response is:
In Section 4.3.2, 2nd paragraph, 2nd sentence, the word "in" was incorrectly inserted after "used". In Section 4.3.2, 3rd paragraph, 1st sentence, the word "Figures" was incorrectly used instead of "Figure".

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, tenth bullet on page 19:
"Section 4.3.3. Explain how the 11-layer grid system varies with pool depth, i.e., are there always 11 layers regardless of local water depth, so that in shallow areas the layers are thinner, or are there fewer layers in the shallow areas? This will provide more complete explanation of how the model is constructed."

ENVY's Response is:
As Versar has anticipated in its comment, the 11-layer grid covers the entire modeled area, regardless of the pool depth. In shallow areas, the local cell thicknesses are smaller (thinner), while in deeper areas the local cell thicknesses are larger (thicker). The local cell thickness is always 1/11 of the local water depth. Given he relatively shallow depth of the River in Vernon Pool, the advantage of this type of approach is that, regardless of the water depth, the model effectively resolves the vertical structure finely with 11 layers. This can be contrasted with models that are limited to constant local cell thicknesses (i.e., 3 ft everywhere) resulting in lower resolution in shallow areas.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, eleventh bullet on page

19: "Since the upstream boundary condition for temperature is set using data from Station 7, and since that station may sometimes be stratified, is each cell in each layer set to the same temperature value? If so, explain how the model compensates for the periodic lack of stratification in the upstream conditions. It may be that this phenomenon is not explicitly included in the model but contributes to the inherent variability within the model which is minimized to the extent possible as part of the calibration process. "

ENVY's Response is:
As Versar has anticipated in its comment, modeled conditions appropriately reflect expected conditions. By way of further clarification, and as discussed above, ASA assumed that the discharge from the Bellows Falls Dam is well-mixed, as is confirmed by the Vernon Dam tailrace temperature data, an appropriate assumption given that water passing through hydroelectric facilities is well mixed. Thus the upstream boundary condition should have no significant vertical structure, except that atmospheric heat transfer can and does cause periodic stratification of the water column as the water moves downstream through the Vernon Pool. The Station 7 temperature is indicative of the well-mixed Bellows Fall Dam discharge, since it is less affected by diel atmospheric effects due to its depth. These assumptions were corroborated during the model calibration process.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet twelve on page 19:
"Section 4.3.3.1, 4th paragraph, clarify flow description. The lowest flow for the August period was about 50 m3/s (Fig. A35-36) and flows in June were mostly greater than 200 but in early July were often less than 200. Also compare these flows with the long-term average monthly flows, to put the calibration and confirmation flows in context with the longer-term period of record."

ENVY's Response is:
The August period flows ranged from a low of approximately 50 m^3/s to a high of 200 m^3/s with a mean of 66 m^3/s. The June-July period flows ranged from a low of approximately 80 m^3/s to a high of 530 m^3/s with mean flow of 266 m^3/s.

Based on information presented in the Demonstration (Table 3-1, page 7), August median flow at North Walpole is about 3,735 cfs or about 106 m^3/s while the 95th percentile flow (August flow that exceeds this flow 95% of the time) is 1,797 cfs or about 51 m^3/s. Flows during the August modeling period were therefore substantial below "normal", but well within the historic range. We estimate that the average flow during the August modeling period has an exceedance value of about 85% and that lowest flow (50 m^3/s) would be expected to be exceeded more than 95% of the time.

Based on Table 3-1, we estimate the median flow during the June/July modeling to be about 5,900 cfs or about 167 m^3/s. The 95th percentile flow is expected to be about 2,800 cfs or 79 m^3/s during the same period. This means that average flow during the modeling period was considerably higher than historic median flow (~25% exceedance value), but still well within historic ranges. The minimum flow during this period was very low,

exceeded nearly 95% of the time.

Thus, it is concluded that flows that occurred during the time periods used for model calibration and verification were often well below historic median flows, but all were well within recorded ranges.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet thirteen on page 19: "Section 4.3.3.2. Indicate the period of record upon which the 1% and 50% occurrences of low flow and high temperatures are based. If this is stated in another part of the 316a document, refer to the appropriate section of the document. Also indicate the period of record for the monthly mean values of atmospheric forcing functions and for the mean daily variations in air temperature and solar radiation. It is not clear from just this report if the period of record for temperature was just the last 5 years or a longer period based on monitoring at Station 7 or some other location."

ENVY's Response is:
In its comment, Versar requests clarification of the period of record for selected modeling scenarios. As discussed in the Demonstration (Section 4.1), the period of record from which 1% and 50% occurrences of low flow and high temperature were derived for both the July-August and mid-May-mid-July periods of evaluation was the most recent five year period, 1998 – 2002. All monthly mean values of the atmospheric forcing functions, as well as the mean daily variations in air temperature and solar radiation used for the modeling scenarios were based on actual data from the 1-30 August and 15 June – 15 July periods of 2002, consistent with the calibration and confirmation periods. This is discussed in Section 3.2.1.4 of ASA's report.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet fourteen on page 19: "Section 4.4. Provide a table which includes a range of typical parameter values for those parameters which were adjusted as part of the calibration process. The purpose of this information is to show that the calibration process was performed by adjusting parameters within a reasonably expected range of values."

ENVY's Response is:

Parameter	Units	Value Used	Low Value Tested	High Value Tested
Quadratic bottom friction coefficient	n/a	0.005	0.0025	0.03
Vertical eddy viscosity	m2/s	0.005	0.001	0.01
Horizontal eddy diffusivity	m2/s	1.0	0.5	2.0
Vertical eddy diffusivity	m2/s	0.00007	0.00005	0.01

The calibration process tested values over a range from at least one half to at least twice the ultimate value used. This extensive testing provided confidence that the calibration process used the optimum set of parameters.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet fifteen on page 19: "Section 4.4.1, flow comparisons, provide additional explanation of the artificial oscillations which are illustrated in Figure 4-6, where the predicted flows decrease briefly to zero and then overshoot, on several days in August. Also indicate whether the water mass balance is correct over this period of time."

ENVY's Response is:
The overshoots and artificial oscillations in the modeled flow predictions are typical for an under-damped system responding to step inputs. The step inputs are due to the regulated flow in the River attributable to the hydroelectric project operations, as discussed above and in Section 3.1.2 of the Demonstration. The large, almost instantaneous change in flow, often by a factor of four from 1760 to 7060 cfs, is sufficient to generate an overshoot response followed by a damped oscillation. The period of oscillation is approximately 5 hrs, which corresponds to the natural frequency of the Vernon Pool. Conservation of water mass is preserved during these transient events. These small variations have no appreciable effects on temperature predictions, as is discussed in Section 4.4.1 of ASA's report. Also, in response to Versar's question, the water mass balance is correct over the time period in question.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet sixteen on page 19: "Provide an explanation as to the divergence between model and observed temperatures at the various stations. Overall, there seems to be a greater amplitude in the model in diurnal temperature patterns at the surface for all stations, as compared with the measured data. Could the lack of stratified thermal input data at the upstream station have contributed substantially to the differences?"

ENVY's Response is:
In its comment, Versar indicates a perceived divergence between modeled and observed temperatures, at certain temperature increments, and questions whether this perceived divergence is attributable to Station 7. It is not. Rather, as indicated in the Demonstration, the source of diel temperature data was the weather station at the Orange Municipal Airport in Orange, MA, which is 35 km southeast of the ENVY Station. Although some meteorological parameters were available at the ENVY Station, the surface heat transfer submodel of the hydrothermal model required additional meteorological parameters not measured at the ENVY Station, so the data from Orange were used. Some differences exist in parameters from the two stations. For instance, the daily air temperature variation at Orange has an amplitude 1 to 3°C larger than at the ENVY Station. From previous model applications, the surface water temperature variation is typically one-half of the air temperature variation which would result in a amplitude 0.5 to 1.5°C larger than the observations. Thus the model calibration would have been even better using the local ENVY Station temperatures. In any event, the model was shown to be well calibrated, indicating the Orange data was suitable for use, and that none of those variations between ENVY and Orange affect the conclusions of the Demonstration.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet seventeen on page 19 and the top of page 20:
"Section 5. State what time period is shown in Figures 5-1 to 5-3; are these at the peak of the daily heating cycle or some other time or averaged over a day? Figures 5-5 and 5-6 show the mean bottom area and volume coverage for the various scenarios, calculated over a daily cycle. Clarify that this means the model temperatures were averaged over a 24-hour period. What are the calculated values for these coverages, using the daily peak values for each scenario? This will indicate the scenario results for each coverage, during the hottest part of the day, which should be similar to the results for the daily mean."

ENVY's Response is:
Figures 5-1 through 5-3 show the model-predicted plume at different layers taken at 11:30 AM to illustrate the horizontal and vertical distribution of temperature. The data presented in Figures 5-5 and 5-6 represent averages computed over a 24-hr period. The peak temperature values in each layer occur at different times during the day, with deeper layers in the water column lagging behind the surface layers by several hours. Thus calculating coverages using peak values would present a distorted picture. Therefore, presenting peak conditions would not foster informed decision-making.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet eighteen on page 20:

"Provide greater detail on how the fishway temperatures were simulated. Are these flow weighted averages from layers 9-11 from all of the cells ending at the dam, or just those in the vicinity of the fishway?"

ENVY's Response is:
The fishway temperatures were calculated by flow weighting the top three layers of the western-most cell, which most closely approximates the geometry of the fishway.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet nineteen on page 20: "Figure A2. Ending date should read 8/16/02."

ENVY's Response is:
Figures A1-A33 and B1 – B22 in the appendices are labeled with the end date being midnight of the following day so that there is a continuous time series among subsequent figures. Thus Figure A2 ends on midnight of 8/17 which is consistent with the start date of midnight of 8/17 for Figure A3.

Versar's Detailed Comments (ASA 2003) in Section 4.3.5, bullet twenty on page 20:
"Figure A34-39, B23-26, add cfs scale"

ENVY's Response is:
It would be needlessly time-consuming to resubmit the figures with an alternative (cfs)

scale added. For ease of reading these figures, a conversion between m3/s and cfs is provided below:

Figures	m3/s	cfs	Figures	m3/s	cfs
A34-A36	50	1766	A37-A39	5	177
	100	3531		10	353
	150	5297		15	530
	200	7063		20	706
	250	8829			
B23-B24	100	3531	B25-B26	5	177
	200	7063		10	353
	300	10594		15	530
	400	14126		20	706
	500	17657		25	883
				30	1059

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, first bullet on page 20:
"Section 3.1.4 - Station 7 information: a statement is made here that there can be as much as a 5F difference between surface and bottom at this station and that the assumption of a single ambient temperature is not always appropriate. Yet this data is used as an upstream boundary condition for the detail hydrothermal model as well as for the calculation of delta-T to the downstream station 3. The consequences of this assumption could be important and further consideration of this issue is warranted."

ENVY's Response is:
In its comment, Versar identifies thermal stratification at Station 7 and notes that the Demonstration and permit compliance both assume a single ambient temperature. Versar asks for further input on the consequences of this assumption relative to the Demonstration. We provide further discussion of its effect on the hydrothermal modeling portion of the Demonstration on p. 9 of this response. We will be providing additional information regarding compliance in a separate document to ANR in the near future, after clarification of Versar's and ANR's compliance concerns at the 30 April 2003 meeting. Below, we provide additional discussion on the potential effects of this assumption on other aspects of the Demonstration.
First, as noted above, temperature measurements at Station 7 accurately reflect the anticipated complete-mix temperature below Bellows Falls Dam, which is the appropriate location to establish upstream boundary conditions. ASA's modeling consequently predicted diurnal heating and cooling of the entire Vernon dam headpond, including the Station 7 location, and presents an accurate representation of anticipated headpond thermal conditions under the worst-case and average conditions modeled. Also see the response above to Versar's conclusions in Section 4.3.2 on page 16 for further discussion.

Second, monitoring at Station 3 provides actual, complete-mix temperature data that is

representative of both the influence of discharge from the Station and headpond atmospheric conditions, irrespective of temperature measurements at Station 7. Our predictions of downstream temperatures that would have resulted if the Station were discharging at their proposed delta T were conservative based on actual measured Station 3 temperature and an assumed permit increase of 1 °F under most summer conditions, again irrespective of measured Station 7 temperatures.

Finally, the biological assessments were based on the headpond thermal modeling and predictions of Station 3 temperature, both of which conservatively and accurately estimate anticipated temperatures under worst-case conditions and under proposed increased thermal discharge from the Station. Consequently, the conclusions presented in this Demonstration are not affected by existing Station 7 temperature measurements.

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, second bullet on page 20:
"Section 3.2.1.1. Provide more details of the flow transformation that was performed, including a report citation and a description of the USGS program that was used (if any) to do this transformation. For upstream input to the model, the Vernon flow was corrected by subtracting the estimated flow from the intervening contributing watershed. The language in this section is not clear however, on how and where flow is measured at the dam and why the flow at North Walpole was not used as an upstream input, with some adjustment for the watershed below that point. What is the source of the factor 4.32 which was multiplied by the West River at Jamaica flow? All of these questions serve to provide more complete documentation of the calculations that were done, and will aid in evaluating that they were done correctly."

<u>ENVY's Response is:</u>
Section 3.2.1.1 compares the recent flow record at Vernon Dam to the historic flow record. Because a long-term flow record at Vernon Dam is not readily available, the upstream USGS station at North Walpole was used to document the historic flow record. Average daily flow data for the North Walpole station was transformed assuming a log Pearson Type III distribution, because USGS typically uses log Pearson Type III statistics to describe statistical characteristics of stream flow data, an established methodology. As noted, only post-1972 data were used, because of changes in minimum flow management practices that occurred after 1972. Use of the North Walpole Station is appropriate given the historical coordination of River flows due to hydroelectric generation activities, as discussed above.

Vernon flow data was then compiled to allow comparison with the North Walpole data. Hourly flow data were averaged to produce daily flow. These data were then corrected based on differences in watershed area between North Walpole and Vernon (5493 and 6266 sq. mi., respectively, for a difference of 773 sq. mi.). Again, since the Connecticut River is heavily regulated, particularly during low flow periods, we decided not to simply prorate flow based on the ratio 5493/6266. Instead, we took that portion of the 773 sq. mi. that is gaged by USGS (West River at Jamaica, VT, which accounts for 179 sq. mi.) and

prorated this flow to estimate flow differences between North Walpole and Vernon (773/179 = 4.32; and Vernon Flow – (4.32 X West River Flow) = North Walpole Flow. It is expected that, on a daily basis, differences between North Walpole and Vernon would be small, and that on a monthly and seasonal basis, differences would be negligible. Consequently, the methods of comparing recent Vernon Dam flow to historic North Walpole flow are appropriate for this Demonstration.

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, third bullet on page 20:
"Section 3.2.2.3. Are the temperature duration curves and calculations based on hourly temperature values?"

ENVY's Response is:
Temperature duration curves and calculations presented in Section 3.2.2.3 are based on average hourly River temperatures for the summer seasons of 1998 – 2002. The ENVY Station demonstrates compliance with their wastewater discharge permit by presenting hourly discharge and monitoring data. Consequently, an hourly timeframe is the appropriate time period for evaluating thermal conditions in the river.

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, fourth bullet on page 20:
"Next to last paragraph on pg. 13, strike 'that' from first sentence."

ENVY's Response is:
The word "that" will be removed and first sentence in the first paragraph of page 13 will be revised to read "Thus, the thermal discharge ...".

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, fifth bullet on page 20, continued to the top of page 21:

"Pg. 14, first paragraph, percentages of occurrence of various temperatures are provided but a more meaningful number would include some measure of the frequency of occurrence in consecutive hours or days, rather than averaging over all of the summer months."

ENVY's Response is:
In its comment, Versar seeks clarification regarding the scope of the worst-case scenario. Our approach to determining probability of exceedance of selected River temperatures was based on pooling hourly data for all five years in our data set. Consequently, exceedance probabilities are based on the number of hours that temperature was greater than a particular value, irrespective of what month or year the occurrence(s) was and without regard to whether hours were consecutive or not. If we were to impose "consecutiveness" on our evaluation (e.g. consecutive hours that temperature exceeds a certain value), the probabilities of exceedance for particular temperatures would be lower than the data used in our existing analysis in the Demonstration. Thus, the analysis

presented in the Demonstration is highly conservative, representing a heightened or worst-case scenario. While we agree that, as a theoretical matter, consecutive hours or days may present a condition of biological relevance, our "worst-case" analysis confirms that the proposed action would result in no appreciable harm to resident and migratory biological communities. Analysis of a "less than worst-case" condition will not change these conclusions.

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, sixth bullet on page 21:
"Section 4.3, how were the fishway temperatures extracted from the model (refer to the hydrothermal modeling report section)"

<u>ENVY's Response is:</u>
In its comment, Versar seeks clarification on fishway temperatures, implying that the hydrothermal model generated such temperatures. Except for the projections to future conditions under the proposed new thermal limits, fishway temperatures were not modelgenerated. Fishway temperatures were based on actual monitoring during the times when the fishway is operational; *i.e.* typically mid-May through early July of each year. Actual fishway water temperatures were observed using a WaDaR *in situ* continuous recording thermistor that was deployed at mid-depth in the fish ladder during the entire period when water was supplied to the ladder from Vernon Pool in each year. The WaDaR logs ambient temperature continuously at 15 minute intervals with an instrument precision of + 0.1°F.

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, seventh bullet on page 21:
"Table 5-1, last column. It doesn't seem logical that the increase in percent time at 70F (8.8%) should be higher than at 65F (4.2%). Provide an explanation."

<u>ENVY's Response is:</u>
Table 5-1 does contain an error. However, the correction does not change the finding that the percent change for 65 °F is still less than for 70 °F. The last column in Table 5-1 indicates the *increase* in the percent of the time that the selected temperature will be equaled or exceeded under the proposed summer temperature limits as compared to the current limits. If the selected temperature is already exceeded quite frequently, as is the case with 65 °F in this table, the change associated with the proposed discharge limit can be smaller than is the case with a higher temperature that currently is not exceeded very often. In Table 5-1, 65 °F is exceeded 72.7% of the time for the existing limits case and 79.5% for the proposed new summer limits case, an increase of 6.8% in the amount of time that Station 3 is at or above 65 °F. The 70 °F temperature is exceeded 54.5% of the time for existing limits and 63.3% for proposed limits, an increase of 8.8%. Note that the probability of a temperature being exceeded at Station 3 is computed based on the Station 7 temperature plus the calculated temperature increase allowed during operation of the ENVY Station at the existing and proposed Permit limitation during the summer period. The exceedance values are taken from the third columns in Tables 3-3 and 3-4, labeled upstream station 7 plus existing delta T in Table 3-3 and labeled monitor 7 plus proposed

delta T in Table 3-4.

Please note that Table 5-8 contains a similar computational error. The increase in time that 68 °F is exceeded at Station 3 is 5.8%, not 3.6%. These corrections do not change the conclusion of the Demonstration.

Please also note that the two columns shown under the super-heading "Change in % Plume Area Available" should read "Change in % Plume Volume Available" in Tables 5-1 through 5-9.

Versar's Detailed Comments on Hydrological and Thermal Sections of the Demonstration in Section 4.3.6, eighth bullet on page 21:
"Figure 3-7d. Why is the fishway water temperature higher for most of the time than at Station 3? Presumably this is because it is withdrawing warmer water from the surface layers on the west side of the pond, while Station 3 is a mixture of all of the water flowing over the dam including the cooler water on the east side and in lower layers. Some explanation should be provided."

ENVY's Response is:
We discuss in Section 3.2.2.2 of the Demonstration that fishway temperatures are frequently higher than Station 3 temperatures, particularly during daylight hours. We attribute these differences to diurnal heating of the surface waters of the Vernon headpond and to the fact that the fishway's source of water is primarily surface water. Station 3 temperatures are representative of complete-mix temperatures in the Vernon headpond and are therefore substantially cooler than fishway temperatures, at least during times when thermal stratification exists in the headpond. During 2001, as presented in Figure 3-7d, Station 3 temperatures were higher than fishway temperatures for most of period that the fishway was operated. This is inconsistent with other years, but it was confirmed by duplicate monitoring. We have no explanation for this inconsistency. Consequently, we simply presented the data as collected and without discussion.

Finally, we have several additional clarifications, specifically with respect to references to applicable law in Sections 2.2 and 2.3, pages 5 and 6 of Versar's comments.

First, the EAC is an advisory body that derives its right of comment from the NPDES Permit, Part I.11. Second, New Hampshire law and regulations are not applicable to this discharge as a matter of law. *See* R.S.A. 485-A:3 (New Hampshire law applies only to sources of pollution located within the State of New Hampshire). The Station discharge is located within the State of Vermont, and discharges into Vermont State waters. As such, Section 2.2 of the Versar Report should be eliminated, as should all other references to New Hampshire law, e.g., in Section 2.4. Versar's references to federal law in Section 2.3 are likewise appropriate.

STATION NO. 7

Station No. 7 is located 100 feet northerly of the upstream Automatic Water Quality Monitor site. The station crosses the Connecticut River on a magnetic bearing of S 85°30' E.

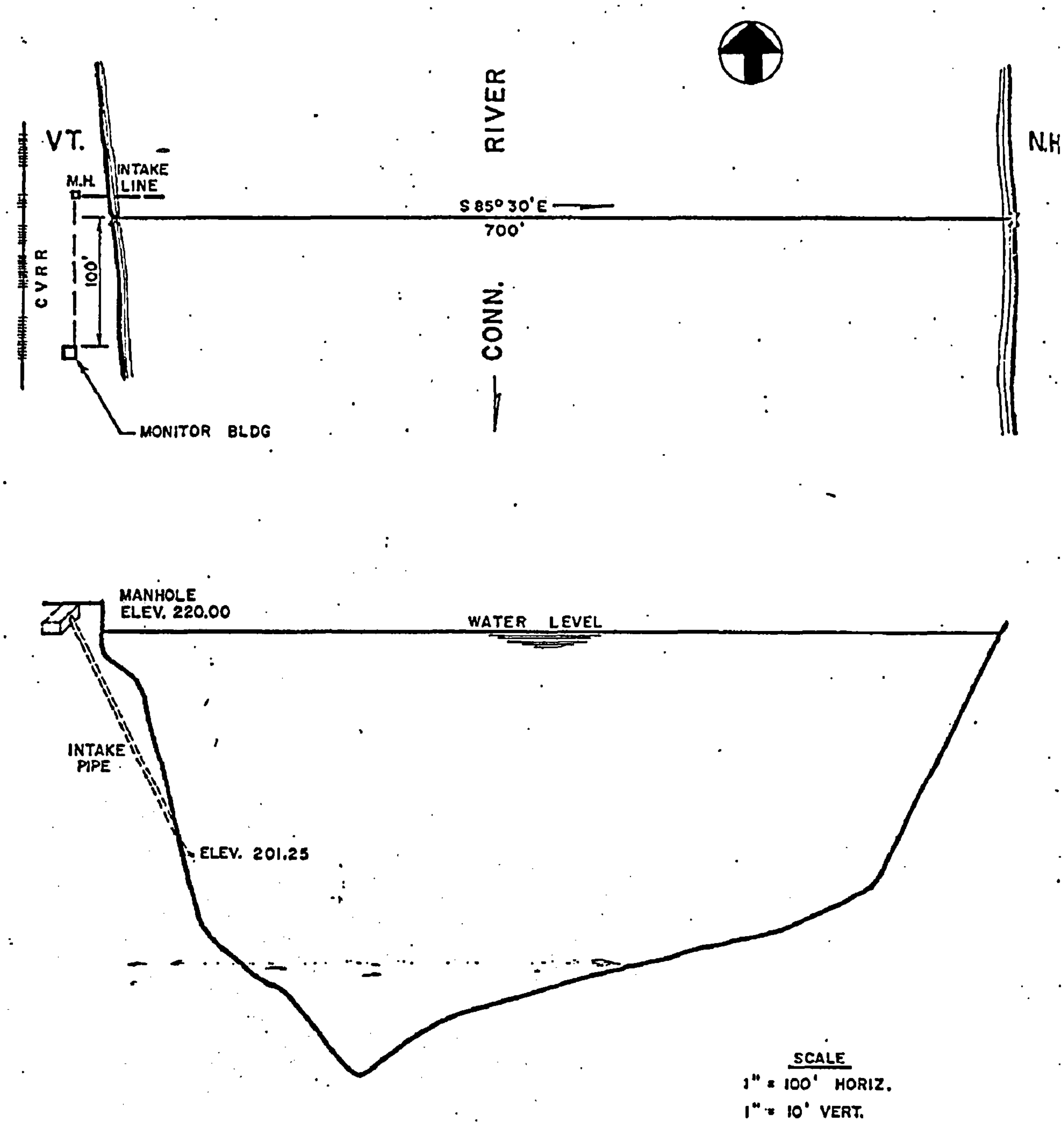

FIGURE B.8

STATION NO. 3

Station No. 3 is located at the downstream Automatic Water Quality Monitor site. Details and location of the concrete monuments are shown below.

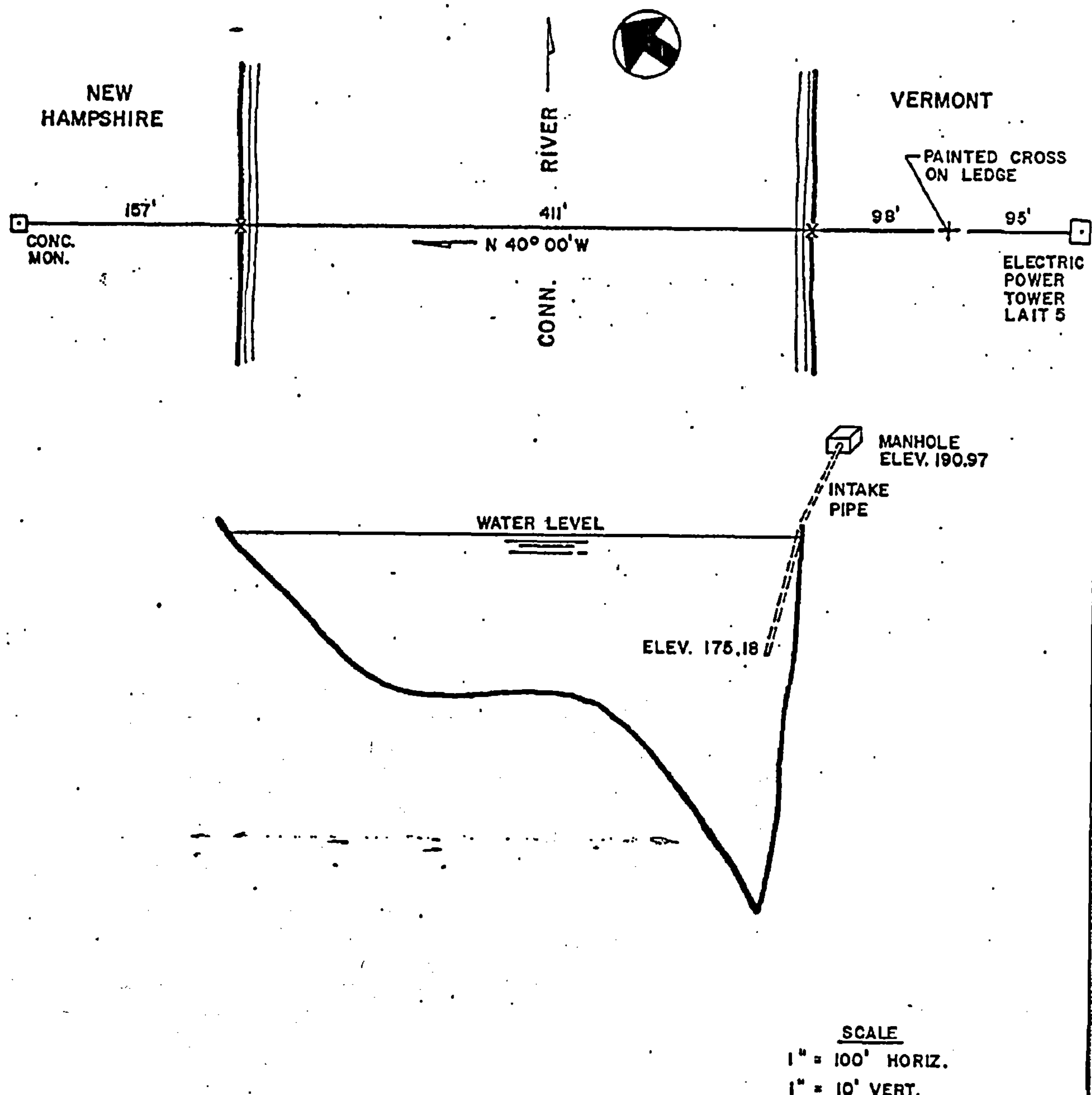

FIGURE 8.4