Selected pages of LTP.

Ken Ulleck

Haddam Neck Plant
License Termination Plan

Connecticut Yankee Atomic Power Company

1 GENERAL INFORMATION

1.1 Purpose

The objective for decommissioning the Haddam Neck Plant (HNP) site is to reduce residual radioactivity to levels that permit release of the site for unrestricted use and for termination of the 10CFR50 license. The purpose of this HNP License Termination Plan (LTP) is to satisfy the requirements of 10CFR50.82, "Termination of License" (Reference 1-1) using the guidance provided in Regulatory Guide 1.179, "Standard Format and Content of License Termination Plans for Nuclear Power Reactors" (Reference 1-2) and Draft Regulatory Guide-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination." (Reference 1-3)

The LTP describes the decommissioning activities that will be performed, the process for performing the final status surveys, and the method for demonstrating that the site meets the criteria for release for unrestricted use. The LTP contains specific information on:

- Historical Site Assessment and Site Characterization;
- Remaining Decommissioning Activities;
- Site Remediation Plans;
- Final Status Survey Design and Implementation Plan;
- Dose Modeling Scenarios;
- Update to the Site-Specific Decommissioning Cost Estimate; and
- Supplement to the Environmental Report

Each section of the LTP is summarized in Section 1.3.

1.2 Historical Background

The HNP is located on the east bank of the Connecticut River, approximately 21 miles south-southeast of Hartford, at 362 Injun Hollow Road, Haddam, Middlesex County, Connecticut. HNP is owned by Connecticut Yankee Atomic Power Company (CYAPCO). (Reference 1-4)

HNP, Docket No. 50-213 (License No. DPR-61), began commercial operation in January 1968. The plant incorporated a 4-loop closed-cycle pressurized water type nuclear steam supply system (NSSS); a turbine generator and electrical systems; engineered safety features; radioactive waste systems; fuel handling systems; instrumentation and control systems; the necessary auxiliaries; and structures to house plant systems and other onsite facilities. HNP was designed to produce 1,825 MW of thermal power and 590 MW of gross electrical power. (Reference 1-5)

On December 4, 1996, HNP permanently shut down after approximately 28 years of operation. On December 5, 1996, CYAPCO notified the Nuclear Regulatory Commission (NRC) of the permanent cessation of operations at the HNP and the permanent removal of all fuel assemblies from the Reactor Pressure Vessel and their placement in the Spent Fuel Pool (Reference 1-6). Following the cessation of operations, CYAPCO began to decommission the HNP. The Post Shutdown Decommissioning Activities Report (PSDAR) was submitted, in accordance with 10CFR50.82 (a)(4), on August 22, 1997 (Reference 1-7), and was accepted by the NRC (Reference 1-8). On January 26, 1998, CYAPCO transmitted an Updated Final Safety Analysis Report to reflect the plant's permanent shutdown status (Reference 1-9), and on June 30, 1998, the NRC amended the HNP Facility Operating License to reflect

this plant condition (Reference 1-10). On October 19, 1999, the Operating License was amended to reflect the decommissioning status of the plant and long-term storage of the spent fuel in the spent fuel pool. (Reference 1-11) Additional licensing basis documents were also revised and submitted to reflect long-term fuel storage in the spent fuel pool (Defueled Emergency Plan, Security Plan, QA program, and Operator Training Program).

In April of 1999, CYAPCO contracted Bechtel Power Corporation, as the decommissioning operations contractor (DOC), to perform the decommissioning activities at HNP. CYAPCO continues to perform Spent Fuel Pool Island Operations and provides oversight of the activities performed by the DOC.

1.3 Plan Summary

Termination of the NRC license and environmental closure of the HNP site are closely related activities, completion of which will allow the site to be released for future use. The License Termination Plan describes the processes to be used in meeting the requirements for terminating the NRC license. A Site Environmental Closure Plan is also being prepared to describe the processes to be used for non-radiological cleanup and release of the site. This information will be submitted to the appropriate regulatory agencies. An integrated approach to site release processes will be used to the extent practicable.

1.3.1 General Information

This LTP has been prepared for the HNP in accordance with the requirements of 10CFR50.82(a)(9). The LTP is being maintained as a supplement to the HNP Updated Final Safety Analysis Report to support the application for a license amendment to meet 10CFR50.82(a)(9) and 10CFR50.90. Each of the sections required by 10CFR50.82(a)(9) are outlined in the subsections below. Note that figures are located at the end of the corresponding section.

1.3.2 Site Characterization

Section 2 discusses site characterization activities. The site characterization for HNP includes the results of surveys and evaluations conducted to determine the extent and nature of the contamination at the site. The initial characterization, performed in accordance with the guidelines of the "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," (Reference 1-12) began in 1997 and was completed in 1999. This initial characterization included a Historical Site Assessment (HSA), a review of historical documents, and measurements, samples, and analyses to further define the current conditions of the site. The effort also evaluated hazardous and state-regulated non-radioactive materials at the site that may require remediation and disposal.

The HSA consisted of a review and compilation of the following information: historical records, plant and radiological incident files, operational survey records, and annual environmental reports to the NRC. Personnel interviews were conducted with present and former plant employees and contractors to obtain additional information regarding operational events that caused contamination in areas or systems not designed to contain radioactive or hazardous materials.

Information from previous surveys was reviewed for historical information regarding radiological conditions throughout the site. The current HNP Radiation Protection Program requires that site radiological conditions are assessed and documented by performing operational surveys and evaluations throughout the decommissioning process. The radiological data collected during this process will supplement the initial characterization data and provide a basis for developing plans for remediation and final status surveys.

The information developed during the initial HNP characterization program represents a radiological and hazardous material assessment based on the knowledge and information available at the end of 1999. The objectives of this initial characterization program were:

1. To divide the HNP site into manageable sections or areas for survey and classification purposes;

2. To identify the potential and known sources of radioactive contamination in systems, on structures, in surface or subsurface soils, and in ground water;

3. To determine the initial classification of each survey area or unit as non-impacted or impacted Class 1, 2, or 3 as defined in MARSSIM;

4. To develop the initial radiological and hazardous material information to support decommissioning planning including building decontamination, demolition, and waste disposal;

5. To develop the information to support Final Status Survey design including instrument performance standards and quality requirements; and

6. To identify any unique radiological or hazardous material health and safety issues associated with decommissioning.

Operational radiation surveys and additional characterization measurements and samples obtained during cleanup activities will be used to confirm the area classification and effectiveness of the cleanup activities before completing the Final Status Survey.

As a result of the HSA and site characterization, approximately 93 acres of the plant site have been initially identified as "non impacted" as defined in MARSSIM. For those portions of the site that have been identified to be impacted, 53% of the survey areas have been initially identified as Class 1, 27% of the survey areas have been initially identified as Class 2, and 20% of the survey areas have been initially identified as Class 3. Section 2.3.3.2 defines these classification levels. Table 2-6 provides the area classifications for the various survey areas of the HNP site. The results of the surveys are being used to identify areas of the site that require decontamination, as well as to identify the cleanup methods and plan for their associated costs.

1.3.3 Identification of Remaining Site Dismantlement Activities

CYAPCO has begun decontamination and dismantlement activities at the HNP site consistent with activities discussed in the HNP PSDAR. Section 3 of the LTP describes those dismantlement and decontamination activities that remain at the HNP as of May 2000. Also included in this section are estimates of radiation dose to workers from decommissioning activities and projected volumes of radioactive waste.

CYAPCO's primary goals are to decommission the HNP safely and to maintain the safe storage of spent fuel. To the extent practical, impacted facility materials and surfaces will be decontaminated to allow beneficial reuse. Materials that cannot be decontaminated will be sent to an offsite radioactive waste processor to recycle or to a low-level waste disposal site. Completion of decommissioning the HNP site depends on the availability of low-level waste disposal sites. Currently, HNP has access to low-level waste disposal facilities in Barnwell, South Carolina, and in South Clive, Utah.

Spent Fuel Pool Island

One of the significant activities that CYAPCO has performed is the creation of the Spent Fuel Pool Island. This involved separating the systems and components required to support storage of spent fuel in the Spent Fuel Pool from systems that no longer support current and planned decommissioning activities. This minimizes the effects that decommissioning activities have on safe spent fuel storage.

Future Decommissioning Activities and Tasks

The remaining decontamination activities can be placed into several classifications which may be performed concurrently. These include major component removal (e.g., steam generators and reactor pressure vessel), contaminated system removal, clean systems removal, decontamination of site buildings and cleanup of the site land areas.

Decontamination of plant structures can occur at the same time as equipment removal. Decontamination techniques may range from water washing to removal of a layer of building surface material. Contaminated equipment and structural material may be packaged and either shipped to a processing facility, or shipped directly to a low level radioactive waste disposal facility.

Decontamination and dismantlement activities are currently expected to continue until Spring of 2003, with the exception of those activities related to the operation of the Spent Fuel Pool Island. The spent fuel may continue to be stored in the existing Spent Fuel Pool or may be transferred to an independent spent fuel storage installation (ISFSI). Transfer of spent fuel from the Spent Fuel Building to dry storage casks at the onsite ISFSI is planned to begin in 2003 and to be completed in 2004. Following the removal or decontamination of contaminated systems, components, and structures in an area, a comprehensive final radiation survey will be completed. This survey will confirm that the site meets the cleanup criteria. The final status survey results will be compiled in a series of reports by area(s) and will be made available for NRC inspection. Following completion of the final status survey and in the absence of any NRC inspection action finding the report deficient, buildings may be demolished and the concrete debris used on site as backfill.

1.3.4 Site Remediation Plans

Section 4 of the LTP describes various methods that can be used during HNP decommissioning to reduce the levels of radioactivity to that which meet the NRC radiological release criteria (i.e., does not exceed 25 mrem/yr total effective dose equivalent (TEDE) and is as low as reasonably achievable (ALARA). This section describes the methodology that will be used to demonstrate that the residual radioactivity has been reduced to a level that is ALARA in compliance with the NRC requirements.

An ALARA analysis determines when cleanup, beyond that required to meet the 25 mrem/yr TEDE dose limit, is appropriate. Figure 4-1 shows the ALARA evaluation process. Generic ALARA screening values may be determined at the planning stage, prior to the start of cleanup, or after some or all of the characterization work is complete. Survey unit-specific ALARA evaluations may be performed later in the remediation and survey processes.

These ALARA evaluations establish remediation levels at which additional cleanup actions are to be taken to reduce residual radioactivity. These different types of cleanup actions may include, but are not limited to chemical decontamination, wiping, vacuuming, scabbling, or high pressure washing. The methodology and equations used for calculating remediation levels are given in NRC's Draft Regulatory Guide DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination".

1.3.5 Final Status Survey Plan

The primary objectives of the final status survey are to:

- select/verify survey unit classification,
- demonstrate that the level of residual radioactivity for each survey unit is below the cleanup criterion, and
- demonstrate that the potential dose from small areas of elevated activity is below the release criterion for each survey unit.

The purpose of the Final Status Survey Plan is to describe the methods to be used in planning, designing, conducting, and evaluating final status surveys at the HNP site to demonstrate that the site meets the NRC's radiological criteria for unrestricted use. Section 5 of the LTP describes the Final Status Survey plan which is consistent with the guidelines of MARSSIM. The HNP survey plan allows for the use of advanced technologies as long as the survey quality is equal to or better than traditional methods described in MARSSIM. Since MARSSIM is not readily applicable to complex nonstructural components within buildings, the criteria in Regulatory Guide 1.86 (RG 1.86), "Termination of Operating Licenses for Nuclear Reactors" (Reference 1-13), will be applied to nonstructural components and systems at the time of final status survey. Components meeting the criteria in RG 1.86 may be released for unrestricted use after completion of the final status survey for the corresponding area. The plan also describes methods and techniques used to implement isolation controls to prevent recontaminating remediated areas. The HNP Final Status Survey Plan incorporates measures to ensure that final survey activities are planned and communicated to regulatory agencies to allow the scheduling of inspection activities by these agencies if so desired.

1.3.6 Compliance with the Radiological Criteria for License Termination

Section 6 together with Section 5, Final Status Survey Plan, describes the process to demonstrate compliance with the radiological criteria of 10CFR20.1402 (Reference 1-14) for unrestricted future use for the HNP site. CYAPCO has selected the Residual Radiation (RESRAD) computer code to model dose from soils and ground water, and its counterpart, RESRAD-BUILD, to model dose from structures.

Two primary scenarios have been selected as input to the RESRAD codes for calculating the radionuclide-specific derived concentration guideline levels (DCGLs). DCGLs are the concentration and surface radioactivity limits that will be the basis for performing the final status survey. These models are the resident farmer scenario for site soils and ground water, and the building occupancy scenario for site buildings. Since concrete buildings may be demolished after acceptance of the final status surveys, two future potential uses of concrete debris have been evaluated to ensure that the reuse is adequately bounded by doses calculated in the LTP. The first evaluation considered the use of concrete debris as backfill on site. This evaluation uses the resident farmer scenario to calculate impacts from the concrete including the conservative assumption that future drinking water originates in a well located in the buried debris. The second considers future excavation and reuse of the concrete debris. The results of these two additional scenarios have been analyzed to ensure the most limiting radionuclide-specific DCGLs are used to calculate operational DCGLs for building surface surveys.

It is recognized that the methods in MARSSIM and the building surface DCGLs are not directly applicable to use with complex nonstructural components. Therefore, nonstructural components remaining in buildings (e.g., pumps, heat exchangers, etc.) will be evaluated against the criteria of

RG 1.86 to determine if the component can be released for unrestricted use. Materials, surveyed and evaluated as a part of normal decommissioning activities and prior to the implementation of the final status survey, will be surveyed for release using current site procedures to demonstrate compliance with the "no detectable" criteria. Materials which do not pass this criteria will be controlled as radioactive materials.

1.3.7 Update of Site-Specific Decommissioning Costs

In accordance with 10CFR50.82 (a)(9)(ii)(F), Section 7 provides an updated site-specific estimate of the remaining decommissioning costs. It also includes a comparison of these estimated costs with the present funds set aside for decommissioning and a description of the means to ensure that there will be sufficient funds for completing decommissioning.

1.3.8 Supplement to the Environmental Report

In accordance with 10CFR50.82 (a)(9)(ii)(G), Section 8 demonstrates that decommissioning activities will be accomplished with no significant adverse environmental impacts. Decommissioning and license termination activities remain bounded by the site-specific decommissioning activities described in:

- the PSDAR,
- the previously issued environmental assessment,
- the environmental impact statement,
- NUREG-0586, "Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities (FGEIS)" (Reference 1-15), and
- NUREG-1496, "Generic Environmental Impact Statement in Support Rulemaking for Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities." (Reference 1-16).

The HNP PSDAR was submitted to the NRC in accordance with 10CFR50.82 (a)(4)(i). In the PDSAR, CYAPCO performed an environmental review to evaluate actual or potential environmental impacts associated with proposed decommissioning activities. This evaluation used NUREG-0586 and two previous site-specific environmental assessments as its basis. One site-specific assessment was performed from the conversion of the provisional operation license to a full-term operating license, and another was performed more recently from the recapture of the construction period time duration. The environmental review concluded that the impacts due to HNP decommissioning are bounded by the previously issued environmental impact statements.

As discussed in Section 6, the DCGLs for site buildings are calculated using the building occupancy scenario as the primary modeling scenario. Because use of the demolished, decontaminated buildings as backfill is being considered, additional modeling scenarios have been considered as discussed in Section 6.5 (i.e., resident farmer for concrete debris and excavator). Buildings which are decontaminated at or below the DCGLs could be allowed to remain standing after the final status survey. These buildings could then be demolished and the debris dispositioned in a number of different manners. Consideration of the building occupancy scenario (as well as other scenarios) in determining the DCGL is compatible with the information in SECY 00-41 (Reference 1-17). SECY 00-41 concluded that the building occupancy and resident farmer scenarios, as well as assumptions used in the FGEIS to estimate public dose, are sufficiently conservative to bound such a condition. Section 8 also provides a summary description of the process CYAPCO will use to ensure that the non-radiological aspects of decommissioning meet state and federal requirements for release of the site.

1.4 Decommissioning Approach

1.4.1 Overview

This section provides an overview of CYAPCO's approach to decommissioning the HNP site. References to the section in the LTP, where details concerning the particular step or stage of the decommissioning process are described, are given in parentheses.

Upon the decision to permanently cease power operations at the HNP site, CYAPCO began site characterization activities (Section 2). This characterization effort, which was performed to the guidelines of MARSSIM, included a historical site assessment (HSA); a review of historical survey documentation; and measurements, samples, and analyses to further define the present radiological conditions of the site. The effort also addressed the status of the site relative to hazardous and state regulated non-radioactive materials.

The initial site characterization, together with geologic and hydrogeologic investigations of the site, provides the basis for the conceptualization of the site and the selection of the appropriate scenarios, models, and critical groups to address the possible future uses of the site. Conceptualization (creating the overall model for the site), which considers future use, characterization, geologic and hydrogeologic data, is also important in selecting the dose modeling code to be used to calculate the derived concentration guidelines (DCGLs). These DCGLs correspond to a dose to the average member of the selected critical group that is as low as reasonably achievable and does not exceed 25 mrem/yr TEDE (Section 6).

Concurrent with site characterization and the conceptualization of the site, decommissioning activities are taking place. Activities performed during this period include the removal of contaminated components from the site for final disposition and demolition of some site buildings (Section 3).

Remediation of some site structures and soils will be performed, based upon the input of the initial site characterization and the cleanup levels determined by dose modeling. Title 10 of the CFR, Section 20.1402 has a dual criteria, namely 25 mrem/yr TEDE and ALARA. Accordingly additional remediation activities are evaluated to determine the cost/benefit of remediation beyond that which is necessary to meet the DCGLs. If the additional remediation activities are determined to be appropriate, they will be performed. Once areas have been remediated to the required level, administrative controls will be put into place to prevent recontamination of the areas. (Section 4)

The Final Status Survey Plan (Section 5) describes the methodology by which plant areas and buildings will be verified to be at or below the DCGLs, and thus meet the site release criteria for unrestricted use. Once final status surveys are performed for a specific area or building, the data collected will be documented in a report and made available to the NRC as evidence of completion of activities and acceptability of the area for unrestricted release. CYAPCO plans to communicate the schedules for these final status surveys, to the NRC so that independent confirmatory surveys can be scheduled and performed, as necessary.

CYAPCO may pursue demolition activities once final status survey results for an area or group of areas are completed. The final status survey results will be compiled in a series of reports by area(s) and will be made available for NRC inspection. CYAPCO may choose to demolish the surveyed structure(s) and use the concrete for onsite fill. It is important to note that CYAPCO plans to demonstrate that buildings meet the criteria for release for unrestricted use prior to their demolition and use as backfill on the site. The dose modeling approach described in Section 6 evaluates potential exposures resulting from the concrete debris to ensure that the doses are bounded by the conservative DCGLs specified in the plan. CYAPCO

does not intend to use on-site burial, dispersal or incineration of any low-level radioactive waste. Materials remaining onsite will meet the appropriate DCGLs for unrestricted release, and thus is not low-level radioactive waste.

CYAPCO may also choose to remove specific areas from the 10CFR50 license after they have been surveyed and the results documented and provided to the NRC for its review and concurrence. A more detailed discussion of the phased release approach is provided in the following subsection. Upon completion of remediation, final status surveys, and confirmation that areas and buildings on the HNP site meet the site release criteria, CYAPCO will have completed the decommissioning process.

1.4.2 Phased Release Approach

CYAPCO may choose to remove specific areas from the license in a phased manner. The approach for phased release and removal from the license, after approval of the License Termination Plan, is as follows:

1. Following completion of decommissioning activities and final status survey of a survey unit, CYAPCO will compile a final status survey report to address the area or building, where decommissioning and remediation tasks are complete and the criteria of 10CFR20.1402 has been met. The results of these surveys are documented in a report and made available to the NRC for its inspection. The final status survey report will contain the following:

   - a description and location of the building or the area to be released;
   - certification that dismantlement/decommissioning activities, as described in the LTP, have been completed for the subject building or area;
   - an evaluation of the potential for possible recontamination of the area and a description of controls in place to prevent such recontamination;
   - final status survey results for the building or area, as demonstration of compliance with the LTP release criteria; and
   - expected timing for removing the area from the 10CFR50 license.

2. Once a building or area has been verified ready for release, no additional surveys or decontamination of the subject building or area will be required unless administrative controls to prevent recontamination are known or suspected to have been compromised. Following completion of the final status survey and in the absence of any NRC inspection action finding the report deficient, the subject building may be demolished and the associated debris dispositioned as construction debris in accordance with state and federal requirements. The subject area may be removed from the license either before or after demolition activities.

3. CYAPCO will review and assess the impacts on the following documents before releasing an area from the license:

   - Updated Final Safety Analysis Report and Technical Specifications;
   - Environmental Monitoring Program;
   - Offsite Dose Calculation Manual;
   - Defueled Emergency Plan;

- Security Plan;
- Post Shutdown Decommissioning Activities Report;
- 10CFR100 Siting Criteria; and
- Environmental Report.

The reviews will include the impacts on the discharge of effluents and the limits of 10CFR 20, as they pertain to the public. After any impacts have been resolved, CYAPCO will inform the NRC of its intent to remove the subject area from the license.

4. Upon completion of the HNP Decommissioning Project, a final report will be prepared, summarizing the release of areas of the HNP site from the 10CFR50 license.

1.5 License Termination Plan Change Process

CYAPCO is submitting this License Termination Plan as a supplement to the Updated Final Safety Analysis Report. Accordingly, the License Termination Plan will be updated in accordance with 10CFR50.71(e). Once the LTP has been approved, the following change criteria will be used, in addition to those criteria specified in 10CFR50.59, 10CFR50.82(a)(6), and 10CFR50.82(a)(7). Changes to the LTP require NRC approval prior to being implemented, if the change:

(a) Increases the radionuclide-specific derived concentration guideline levels (as discussed in Section 6) or area factors (as discussed in Section 5.4.6);

(b) Increases the probability of making a Type I decision error above the level stated in the LTP (discussed in Section 5.5.1.1);

(c) Increases the investigation level thresholds for a given survey unit classification (as given Table 5-10); or

(d) Changes the classification of a survey unit from a more restrictive classification to a less restrictive classification (as discussed in Section 5.4.2).

This change process will be reflected in the application for the proposed license amendment accompanying the LTP.

1.6 References

1-1 Code of Federal Regulations, Title 10, Part 50.82, "Termination of License."

1-2 Regulatory Guide 1.179, "Standard Format and Content of License Termination Plans for Nuclear Power Reactors," January 1999.

1-3 Draft Regulatory Guide-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination," August 1998.

1-4 Haddam Neck Facility Operating License (DPR-61) issued December 27, 1974, as amended December 14, 1999.

1-5 Haddam Neck Updated Final Safety Analysis Report, dated August 4, 1998.

1-6 Letter B16066 from CYAPCO to the USNRC, "Haddam Neck Plant Certifications of Permanent Cessation of Power Operation and that Fuel Has Been Permanently Removed from the Reactor," dated December 5, 1996.

1-7 Letter CY-97-075 from CYAPCO to the USNRC, "Haddam Neck Plant Post Shutdown Decommissioning Activities Report," dated August 22, 1997.

1-8 USNRC Memorandum from Fairtile to Weiss dated January 28, 1998, regarding CYAPCO Post-Shutdown Decommissioning Activities Report.

1-9 Letter CY-98-005 from CYAPCO to the USNRC, "Decommissioning Updated Final Safety Analysis Report," dated January 26, 1998.

1-10 USNRC Safety Evaluation, related to Amendment No. 193 to Facility Operating License No. DPR-61, Connecticut Yankee Atomic Power Company, Connecticut Yankee Atomic Power Station, Docket 50-213, dated June 30, 1998.

1-11 USNRC Safety Evaluation, related to Amendment No. 195 to Facility Operating License No. DPR-61, Connecticut Yankee Atomic Power Company, Connecticut Yankee Atomic Power Station, Docket 50-213, dated October 19, 1999.

1-12 NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual)," dated December 1997.

1-13 Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," June 1974.

1-14 Code of Federal Regulations, Title 10, Part 20.1402, "Radiological Criteria for Unrestricted Use."

1-15 NUREG-0586, "Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," dated August 1988.

1-16 NUREG-1496, "Generic Environmental Impact Statement in Support Rulemaking for Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities," dated

1-17 SECY 00-41, "Use of Rubblized Concrete Dismantlement to Address 10CFR Part 20, Subpart E, Radiological Criteria for License Termination," February 14, 2000.

4.3 Remediation Actions

Remediation actions may be required to reduce the residual radioactivity levels below the applicable cleanup criteria as provided in Sections 5 and 6. The specific remedial actions depend on the type of area under consideration. These area types are categorized as one of the following:

1. Structures (including building interiors and exteriors, major freestanding exterior structures, exterior surfaces of plant systems, and paved exterior ground surfaces);

2. Soils; and

3. Nonstructural plant systems (including interior surfaces of process piping and components).

4.3.1 Structures

Concrete from contaminated structures will be remediated to a level meeting the radiological criteria for unrestricted release of the site, as discussed in Section 6. After completion of final status surveys and absent any findings during NRC inspections, concrete building debris from decontaminated structures may be used as backfill and placed into the remaining subsurface building foundations. Nonstructural materials will be assessed using the process in Section 5.6.

Methods for remediating structures may include a variety of techniques ranging from water washing to surface material removal. A number of factors determine the choice of the remediation method for a given area, including: the size of the contaminated area, the extent of contamination, surface material, depth of contamination, and accessibility.

Remediation activities for an area may include wiping, vacuuming, and washing with low-or high-pressure applications. Surfaces may also be remediated using surface removal techniques such as scabbling or grinding. Use of surface removal techniques controls the removal depth, minimizing the waste volume produced.

For concrete surfaces, remediation methods may include core drilling, concrete sawing, or scabbling. Scabbling removes the concrete surface by bush heads, rotopeen devices, flappers, or similar devices and is effective for removing contamination that resides close to the surface. Abrasive blasting may also be used as an effective technique for contamination removal from surfaces that are not necessarily smooth. Also, chipping, jackhammering, and other similar aggressive methods may be needed for removal of concrete surfaces as deep as the first mat of reinforcing steel. .Strippable coatings can be used to remove contaminants from surfaces where more aggressive methods may not be appropriate or when other techniques are not successful.

4.3.2 Soils

Soil contamination above the remediation level will be removed and disposed of as radioactive waste. Offsite fill may used to replace the excavated materials. As discussed previously in Section 2, the site characterization process will establish the location, depth and extent of soil contamination. As needed, additional investigations will be performed to ensure that any soil contamination profiles that may change during the remediation actions are adequately identified and characterized.

8 SUPPLEMENT TO THE ENVIRONMENTAL REPORT

8.1 Introduction

The HNP Supplement to the Environmental Report was prepared and submitted in conjunction with the HNP Post-Shutdown Decommissioning Activities Report (Reference 8-1). The Supplement to the Environmental Report was previously provided to Federal and State agencies and is hereby incorporated by reference into this report. The report concluded that the environmental impacts of decommissioning activities are bounded by previously issued environmental impact statements—NUREG-0586, "Final Generic Environment Impact Statement (FGEIS) on Decommissioning of Nuclear Facilities," (Reference 8-2); Final Environmental Statement, Haddam Neck Nuclear Power Plant, Docket No. 50-213, October, 1973 (Reference 8-3); and "Environmental Assessment for Proposed License Extension," dated November 23, 1987 (Reference 8-4).

This conclusion was based on the following considerations:

1. The postulated impacts associated with the method chosen, DECON, have already been considered in the FGEIS.

2. There are no unique aspects of the plant or decommissioning techniques to be utilized that would invalidate the conclusions reached in the FGEIS.

3. The methods to be employed to dismantle and decontaminate the site are standard construction based techniques fully considered in the FGEIS.

4. The site-specific person-rem estimate for all decommissioning activities has been calculated using methods similar to and consistent with the FGEIS.

Specifically, this review concludes that the HNP decommissioning will result in generally positive environmental effects, in that:

- Radiological sources that create the potential for radiation exposure to site workers and the public will be minimized.

- The site will be returned to a condition that will be acceptable for unrestricted use.

- The thermal impact on the Connecticut River from facility operations will be eliminated.

- Noise levels in the vicinity of the facility will be reduced.

- Hazardous materials and chemicals will be removed.

- Local traffic will be reduced (fewer employees, contractors and materials shipments than are required to support an operating nuclear power plant).

- Decommissioning will not adversely affect any endangered or threatened species on the site.

- Historic remains of the Venture Smith homesite have not been disturbed.

Furthermore, the HNP decommissioning will be accomplished with no significant adverse environmental impacts in that:

- No site specific factors pertaining to the HNP would alter the conclusions of the FGEIS.
- Radiation dose to the public will be minimal.
- Decommissioning is not an imminent health or safety problem and will generally have a positive environmental impact.
- The total occupational radiation exposure (excluding public and transportation dose) impact for the proposed decommissioning activities has been estimated in the PSDAR at approximately 935 person-rem, which is less than the 1,115 person-rem exposure estimate of the FGEIS for a PWR. This estimate is based primarily on January 1997 plant dose rate surveys with no credit for (1) decay in place of radionuclides (such as Co-60), (2) sequenced removal of higher dose rate components first, (3) aggressive ALARA program initiatives, (4) increased worker efficiency with experience, or (5) smaller scale decontamination initiatives.
- The release of soil and facility structures will be performed in accordance with MARSSIM. The methods and procedures described in MARSSIM have been determined by the NRC to be acceptable and are not inimical to the health and safety of the public. Therefore, no significant environmental impacts are anticipated from the release of site soils and structures.
- The release of facility non-structural components will be performed in accordance with Regulatory Guide 1.86. The methods and procedures described in this document have been determined by the NRC to be acceptable and are not inimical to the health and safety of the public. Therefore, no significant environmental impacts are anticipated from the release of non-structural components.
- PSDAR radiation exposure due to transportation of radioactive waste (includes both occupational and offsite radiation exposures) has been estimated. The occupational exposure due to transportation is approximately 61 person-rem. The cumulative radiation exposure to on-lookers and the general public due to transportation is approximately 11 person-rem. These values are bounded by the FGEIS values of 100 person-rem for transportation occupational exposure and 21 person-rem for the general public exposure.
- Radiation exposure to offsite individuals for expected conditions, or from postulated accidents, is bounded by the Environmental Protection Agency's Protective Action Guides and NRC regulations. Doses due to the release of radionuclides in effluents will be a small fraction of the allowable limits.
- No significant impacts are expected from the disposal of low level radioactive waste. The total volume of HNP low level radioactive waste for disposal has been estimated at 283,117 cubic feet, which is well bounded by the FGEIS volume of 647,600 cubic feet. The actual HNP volume may be further reduced by additional utilization of volume reduction techniques.
- The non-radiological environmental impacts from decommissioning are temporary and are not significant. The largest occupational risk associated with decommissioning HNP is related to the risk of industrial accidents. The primary environmental effects are short-term, small increases in noise levels and dust in the immediate vicinity of the site, and truck traffic to and from the site for hauling

equipment and waste. No significant socioeconomic impacts, other than those associated with cessation of operation (loss of jobs and taxes), or impacts to local culture, terrestrial or aquatic resources have been identified.

- Given the low level of contamination and the expected volume of waste, disposal of low level radioactive waste offsite in a timely manner should be possible. If for any reason some portion of these waste needs to be stored temporarily onsite, adequate space exists. No significant environmental impacts are anticipated from temporary onsite storage, because CYAPCO will ensure compliance with all applicable federal, state, and local regulations.

8.2 Environmental Impacts of Termination Activities Not Previously Addressed

The total occupational radiation exposure (excluding public and transportation doses) as given in the PSDAR was given as approximately 935 person-rem, which was stated to be less than the 1,115 person-rem exposure estimated in Section 4.3.1 of the FGEIS for a PWR. The estimate in the PSDAR was based upon January 1997 plant dose rate surveys with no credit for: decay in place of radionuclides, sequenced removal of higher dose rate components first, aggressive ALARA program initiatives, increases in worker efficiencies with experience, and smaller scale decontamination initiatives.

The public exposure due to radiological effluents continue to remain well below the limits of 10CFR20 and the ALARA dose objectives of 10CFR50, Appendix I. This conclusion is supported by the data submitted to the NRC in the 1999 Annual Radioactive Effluent Report for HNP in which individual doses to members of the public are calculated for liquid and gaseous effluents.

The PSDAR estimated the amount of low level radioactive waste to be approximately 283,117 ft^3, well within the FGEIS estimated volume of 647,600 ft^3. Table 3-3 estimates the total low level radioactive waste burial quantity as a result of HNP decommissioning and currently projects volumes less than the PSDAR estimate. Thus, these values and the waste volume that remains at the HNP are bounded by the amount assumed in the FGEIS.

The PSDAR assumed that spent fuel would continue to be stored in the spent fuel pool (wet storage). As previously noted, at this time it is anticipated that spent fuel will be moved to an ISFSI constructed onsite. The environmental impacts of transporting spent fuel to and storing the spent fuel in the ISFSI will be addressed in activities associated with licensing the ISFSI.

As previously discussed in Section 6, the DCGLs for site buildings are calculated using the building occupancy scenario as the primary modeling scenario. Because use of the demolished, decontaminated buildings as backfill is being considered, additional modeling scenarios have been used, as discussed in Section 6.5 (i.e., resident farmer and excavator for concrete debris). Buildings, decontaminated to or below the DCGLs (and considering ALARA) could be allowed to remain standing at the time of license termination. After decontamination, these buildings could be demolished and the debris dispositioned in a number of different manners. Consideration of the building occupancy scenario (as well as other scenarios) in determining the DCGL is compatible with the information in SECY 00-41 (Reference 8-5). SECY 00-41 concludes that, although the GEIS analyses do not specifically address the use of demolition debris as backfill, the building occupancy and resident farmer scenarios, as well as assumptions used in the GEIS to estimate public dose are sufficiently conservative to bound such a condition.

Abandoning concrete foundations in place, and filling holes and basements with concrete debris fill will not cause any significant adverse impacts to ground water. The CT DEP recognizes concrete debris as "clean fill" and, as such, does not pose a pollution threat to ground or surface waters (Reference 8-6).

Ground water monitoring data acquired from onsite wells give no indication that the existing concrete foundations have adversely impacted ground water quality.

Another important aspect of HNP site cleanup involves the assessment and remediation, as appropriate, of non-radiological hazards identified at the site. Planning and implementation of these activities will be performed in accordance with applicable Federal, state and local environmental regulations. An Environmental Closure Plan (ECP) is being developed to describe the processes and methodologies to be used for this cleanup. The ECP will identify non-radiological sampling and analysis plan elements, proposed cleanup criteria, detailed work package development and implementation steps, and the reporting requirements to be met in obtaining DEP release of the site for non-radiological purposes. CYAPCO will work with the Connecticut Department of Environmental Protection (CT DEP) and the US EPA during ECP development to ensure that the approach and strategy for the non-radiological site closure is acceptable. Certain elements of the non-radiological cleanup will be integrated with similar activities for the radiological cleanup of the site. Examples are site survey area designation, sample collection and control processes, and development of selected procedures that serve common purposes.

CYAPCO has reviewed the Natural Diversity Data Base (Reference 8-7) compiled by the CT DEP to ensure that ongoing decommissioning activities do not impact any critical biological resources that are located on the site. Field walkdowns are performed in areas of the site undergoing decommissioning or remediation to verify that endangered or threatened species are not present.

CYAPCO is also working with the Connecticut Historical Commission, the Thomas J. Dodd Research Center of the University of Connecticut, and the National Park Service to develop documentation on the historic and technological significance of the HNP. Documentation is being prepared to the standards of the Historic American Engineering Record and will be provided to the State Historical Commission for future use. Archeologists from the State Historical Commission are also working with CYAPCO to preserve the Venture Smith home site located on the property. This site is being considered for the National Register of Historical Places (Reference 8-8).

8.3 Conclusions

As evaluated above, there is no new information or significant environmental change associated with license termination activities with respect to the decommissioning activities previously evaluated. This License Termination Plan does not describe any different or additional plant activities beyond those that already may be conducted as described in the HNP PSDAR and the UFSAR. Therefore, the environmental impacts associated with the license termination activities described herein are bounded by the previously approved environmental assessment as referenced above.

8.4 References

8-1 Letter CY-97-075 from CYAPCO to the USNRC, "Haddam Neck Plant Post-Shutdown Decommissioning Activities Report," dated August 22, 1997.

8-2 NUREG-0586, "Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," August 1988.

8-3 USNRC, Final Environmental Statement, Haddam Neck (Connecticut Yankee) Nuclear Power Plant, Docket No. 50-213, October 1973.

8-4 Letter, USNRC to CYAPCO, "Environmental Assessment for Proposed License Extension," dated November 23, 1987.

8-5 SECY-00-41, "Use of Rubblized Concrete Dismantlement to Address 10 CFR Part 20, Subpart E, Radiological Criteria for License Termination, " dated February 14, 2000.

8-6 Connecticut General Statutes, 22a, "Environmental Protection", Section 209, "Definitions."

8-7 CTDEP to CYAPCO letter, "Natural Diversity Data Base," April 24, 2000.

8-8 Letter, CT Historical Commission to NUSCO, "Connecticut Yankee Nuclear Facility," dated June 1, 1998,

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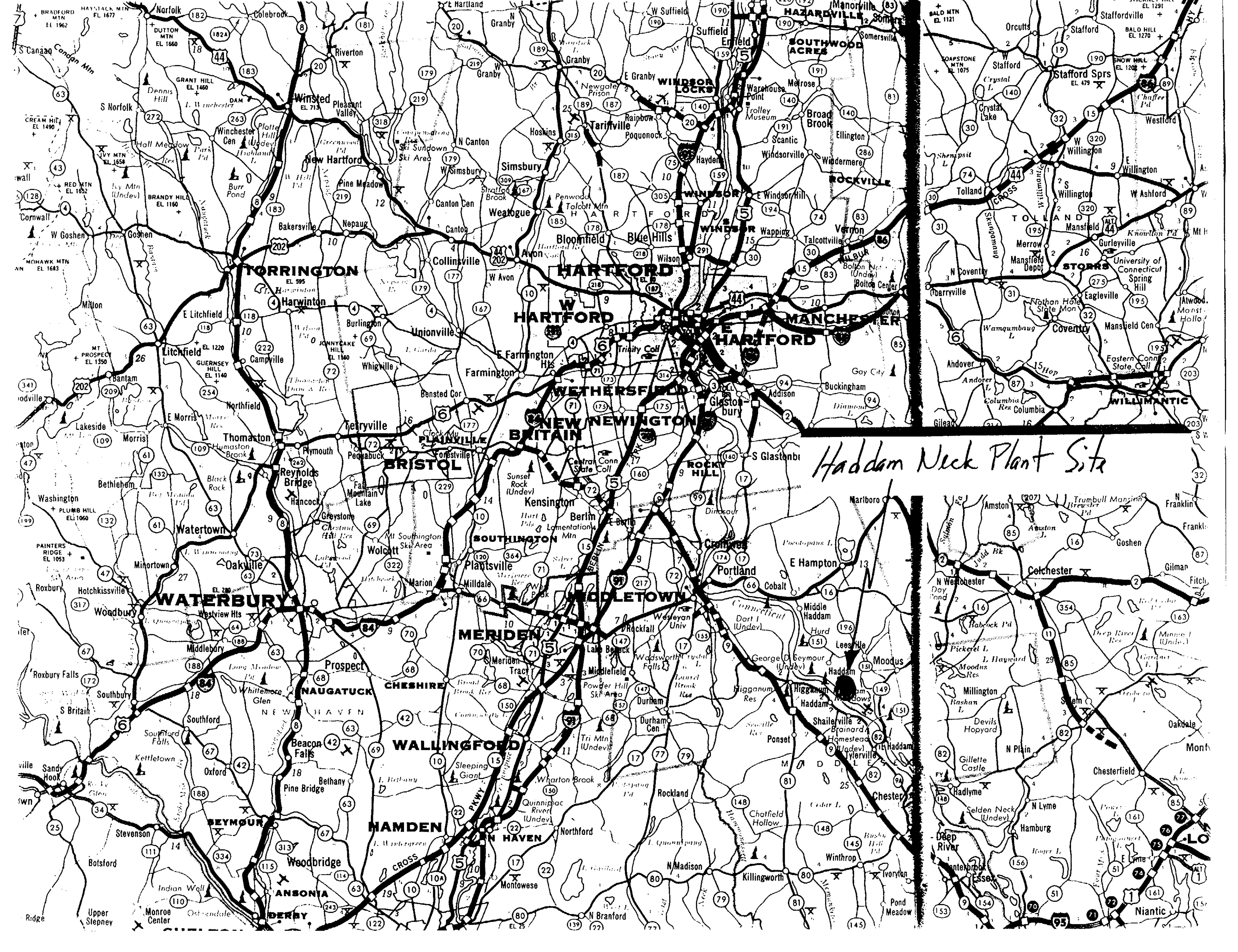
Haddam Neck Plant Site
HARTFORD
W HARTFORD
E HARTFORD
MANCHESTER
WETHERSFIELD
NEW BRITAIN
NEWINGTON
TORRINGTON
WATERBURY
BRISTOL
MERIDEN
MIDDLETOWN
WALLINGFORD
HAMDEN
NAUGATUCK
CHESHIRE
SOUTHINGTON
PLAINVILLE
SEYMOUR
ANSONIA
DERBY
STORRS
WILLIMANTIC
TOLLAND
HAZARDVILLE
SOUTHWOOD ACRES
WINDSOR LOCKS
WINDSOR
S WINDSOR
ROCKVILLE
ROCKY HILL
Haddam
Higganum
Moodus
Colchester
Portland
Glastonbury
E Hampton
Middle Haddam
Chester
Deep River
Essex
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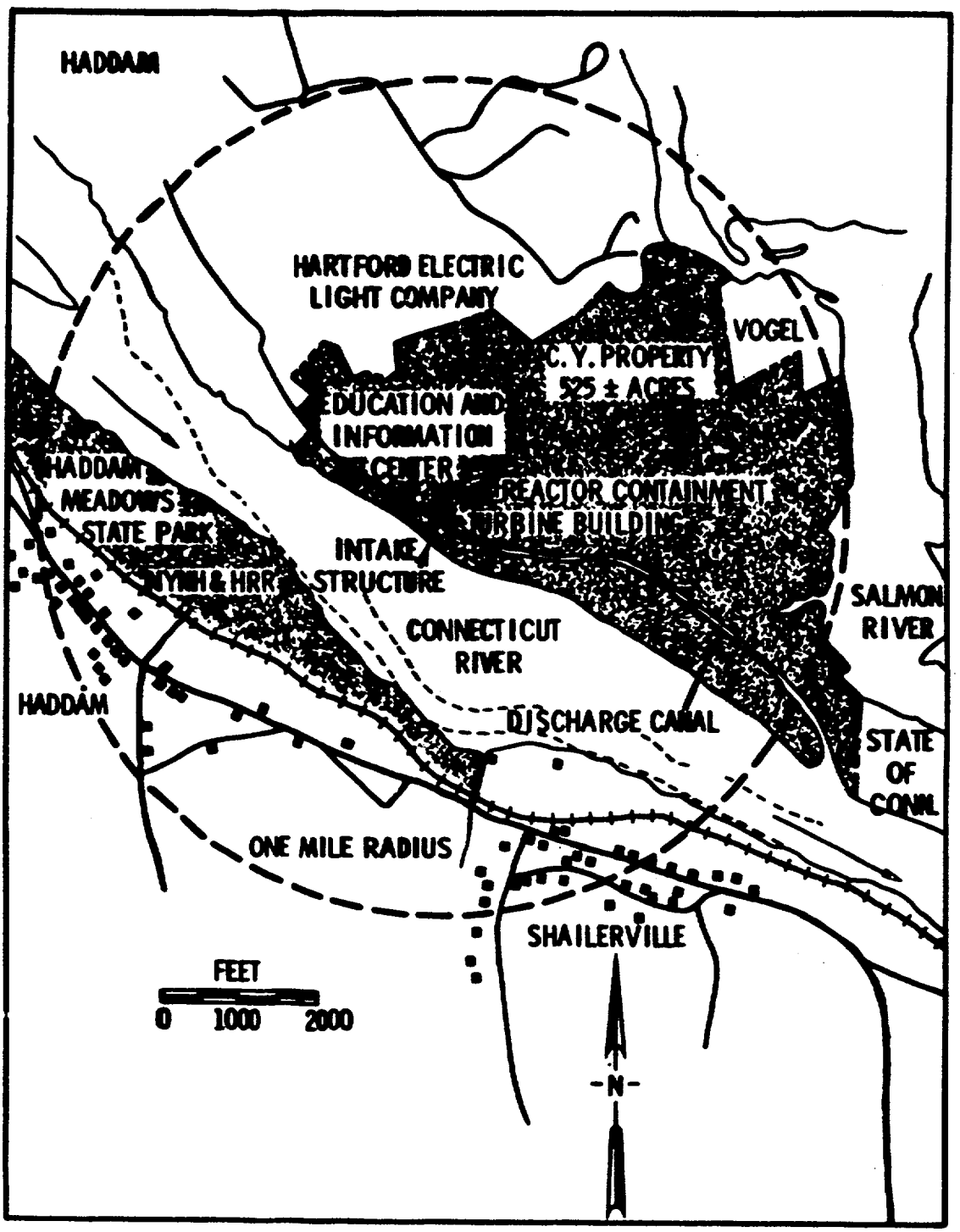
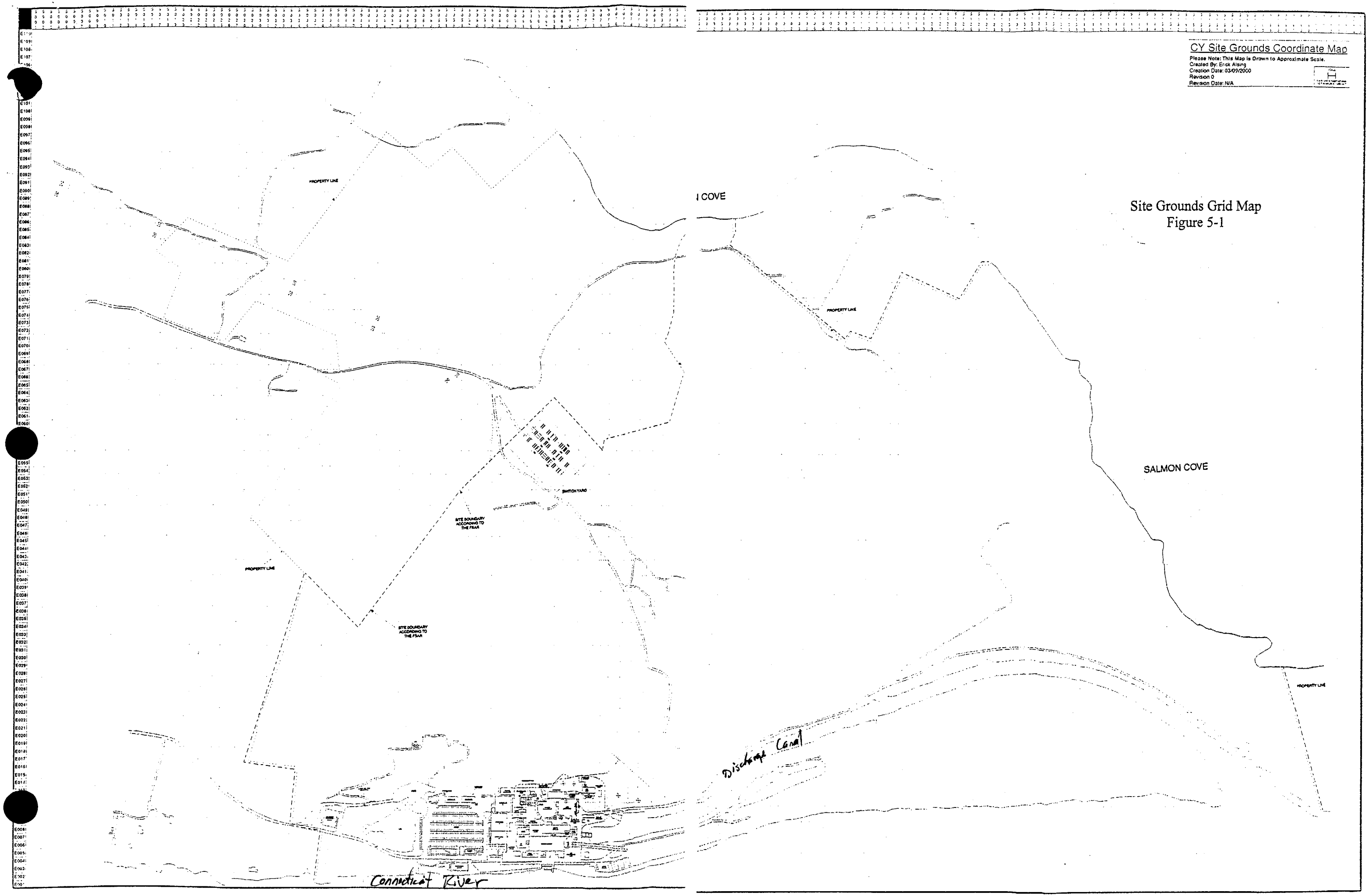


FIGURE 2.2 PLANT SITE AND ABUTTING PROPERTIES

CY Site Grounds Coordinate Map

Please Note: This Map is Drawn to Approximate Scale.
Created By: Erick Alsing
Creation Date: 03/09/2000
Revision 0
Revision Date: N/A



Site Grounds Grid Map
Figure 5-1

Selected pages of 1973 EIS for operations license

DOCKET-50213--228

Final

environmental statement

Related to the

HADDAM NECK (CONNECTICUT YANKEE) NUCLEAR POWER PLANT

CONNECTICUT YANKEE ATOMIC POWER COMPANY

DOCKET NO. 50-213

Paul Jones 8076

October 1972

UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING

TABLE 2.5[30]

OCCURRENCES OF STABILITY CATEGORIES (%)

Unstable	21.5
Neutral	7.7
Stable	26.5
Very Stable	44.4

The winds at 25 ft MSL and 129 ft MSL show considerable variation.(a) Winds are most frequent down the river valley (southeast) and a secondary peak occurs for wind flowing up the valley. The distribution of directions of flow is more uniform at the 25 ft level. The 129 ft level has a very low frequency from north and northeast, whereas the 25 ft level did not show such a severe minimum. This is the wind direction for which the tower is in the lee of the high land area, north and northeast of the site. Also for all directions, the upper level had 16% calm compared to only 1.7% at the lower level. These marked differences between wind conditions at the two levels indicate that local topographic or other features are markedly influencing air movement near the ground. A limited tracer study of the site showed the applicant's diffusion estimate to be generally conservative for the conditions during which tests were conducted.[32]

2.5 ECOLOGY OF SITE ENVIRONS

2.5.1 Terrestrial Ecology

2.5.1.1 Flora

The dominant potential climax vegetation in the vicinity of the Haddam Neck site is Appalachian Oak Forest.[33] From the colonial period until recently, the area was periodically logged and/or cleared for agriculture. The present forests are dominated by trees mainly of sprout origin.[34] The forests on the site are considered to have resulted from 50 years of regrowth and are dominated by red and black oak, red maple, black birch, beech and hemlock.[35]

(a) The 129 ft MSL instruments were at 108 ft above the terrain. The 25 ft MSL instruments were 15 ft above the terrain.

Succession to climax would result in a forest dominated by white and red oak, with lesser numbers of the following species: red and sugar maple, black birch, bitternut hickory, pignut hickory, mockernut hickory, chestnut, beech, tulip tree, hemlock, and scarlet, bear, chinquapin, black and swamp chestnut oak.[33] Species now common, indicative of subclimax conditions, include black birch, sassafras, hornbeam and hickory. The broad canopies of the large oaks and dead chestnuts, as well as the dead red cedars indicate that portions of the area had been in pasture for some time prior to regrowth to the present forest.[35]

In studies sponsored by the applicant, the local vegetation was divided into four communities and common species identified in each: slopes and highlands, edge areas, riparian zone and wetlands.[36,37,38]

The slopes and highlands support the sprout forests mentioned above. This forest covers about 70% of the site. The edge areas include openings in the forest resulting from both natural and human influences. Those naturally produced are in various stages of succession, while those that are man-caused are maintained in early successional stages. Depending on duration of the regrowth period, the edge areas vary from old field communities dominated by grasses and forbs to communities dominated by shrubs and dense thickets of cherry, aspen, poplar, and birch sprouts.

The riparian zone consists of the flood plain adjacent to the rivers. It is associated with the Hadley-Podunk-Rumney soils and supports a flora dominated by alders, willows and aspen as well as grasses, rushes and sedges.

The wetlands include a swamp forest at the northern end of the site and marshes in depressions on the flood plain. The former type should include red maple, white elm, pin oak, swamp white oak, sour and/or sweet gum as the dominant forest components.[34] The marshes have a flora similar to that described for the riparian zone, except that they are dominated by herbaceous rather than woody vegetation. (The applicant has provided a complete list by common and Latin name of plant species in his Environmental Report, p. 2.8-6,-9.)

The types of land in the 985-acre transmission line rights-of-way corridors required for the plant include forests, agricultural, abandoned agricultural, and industrial. The vegetation types in these rights-of-way, although not described in detail by the applicant, are similar to the vegetation of the site.

2.5.1.2 Wildlife

The wildlife is dominated by woodland and ubiquitous species. Its diversity is further increased by the presence of forest edge, marsh and riparian habitats. The applicant lists 39 different species of birds which have been observed at the site as well as 28 other birds

known to be residents in the vicinity.[39] Mammal species known to inhabit the site include eastern cottontail, racoon, mole, skunk, squirrels, chipmunk, muskrat and white-tail deer. Twelve other species expected to be in the general vicinity are listed by the applicant.[40] Reptiles and amphibians observed at the site include northern black racer, northern water snake, turtles, salamanders, toads, leopard frog and spring peeper.[40]

The staff found only one terrestrial vertebrate species that is considered "rare or endangered" which may occur in the vicinity of the site, the bog turtle, Clemmy muhlenbergi. Carr[41] indicates that it occurs throughout Connecticut, while Conant[42] indicates that it is only found in the western part of the state. Its populations occur in scattered, very localized situations such as those described as wetlands on the Haddam Neck site.

2.5.2 Aquatic Ecology

2.5.2.1 General

Biota in the Connecticut River near the site are dominantly freshwater organisms. Nevertheless, tidal movement which introduces saltwater up to a point 2 miles downstream from the plant, results in an assortment of stenohaline and euryhaline aquatic organisms which stray into the Haddam Neck region. Hence, in addition to the strictly freshwater forms (certain Odonata, Coleoptera, Pelecypoda and teleosts) there may occur some stenohaline forms such as certain Annelida, Isopoda, Amphipoda, Diptera, Mollusca and a variety of teleosts, and a few euryhaline forms of teleosts and crustaceans. Anadromous fishes such as the shad will also frequent the Haddam Neck region while on their migration to spawning grounds in the Connecticut River and its tributaries.

2.5.2.2 Planktonic and Periphytic Algae

A large variety of diatoms, green, blue-green, and flagellated algae comprise the periphytic and planktonic communities. These are listed in reference 22. Many of the genera listed as periphytic forms are not sessile, and were likely the result of phytoplankton forms being collected (or possibly trapped) with the periphyton slides. Dominant algal forms from both communities in the Haddam Neck region were the green alga Scenedesmus, the blue-green algae Microcystis, and Oscillatoria, and the diatoms Melosira, Nitzschia, Hannea (sic), Cocconeis, and Fragilaria. Both communities were dominated by diatoms. The presence of a large variety of genera comprising both communities during the period when the plant was operating is indicative of community stability. The general profile of algal forms is typical of a river ecosystem with a relatively slow velocity.[43] Phytoplankton populations were quantitatively examined from 1965 to 1969.[44] Before the plant went into operation, the period of highest cell concentration in the surface waters was during the summer (max. conc. of 260,000 cells/ml). A two-year preoperational mean for surface water phytoplankton concentrations

was 19,000 cells/ml. (see Figure 5.9). These maximum and mean values are considerably higher than those reported by Williams for the Delaware River (maximum of 3,000 counts/ml, mean of 960 counts/ml), the Hudson River (maximum of 1,500 counts/ml, mean of 630 counts/ml), or the Illinois River (maximum of 60,000 counts/ml, mean of 17,000 counts/ml).[43] However, Williams counted all colonial or clumped cells as a "count," while Buck in the University of Connecticut Marine Research Laboratory study, may have counted each cell (colonial, filamental or clumped cells counted individually) in the microscopic field, although he does not describe the method used in his report.[44]

A few chlorophyll determinations were made during 1967 in the region of the plant. These values ranged from 6 to 56 µg/liter for total chlorophyll pigments. Chlorophyll C was by far the dominant pigment which confirms the dominance of planktonic diatoms in the Connecticut River. There were no quantitative measurements made for periphyton.

2.5.2.3 Zooplankton

Predominant zooplankters occurring in the Haddam Neck region are the cladocerans Daphnia dubia, Daphnia pulex, Bosmina sp., Leptodora kindti, and the copepod Eurytemora affinis. Highest concentrations occur from May through September with June having the greatest mean levels of over 700 organisms/m^3.[45]

2.5.2.4 Benthic Fauna

The occurrence and distribution of benthic fauna in the Connecticut River have been studied in the area of Haddam Neck since June 1965. Sampling was usually carried out bimonthly, but was less frequent at times when the river was frozen. Sampling Station No. 2 was located near the plant intake, Station No. 10 at the discharge channel mouth, and Station No. 16 6.4 km downstream from the discharge channel mouth. Station No. 16 served as a control, but it would have been better if the control were located upstream. Nevertheless Stations 2 and 10 were studied for about 2 years before operation, so these data may also serve as control values.

During the preoperational study period the dominant benthic invertebrates in the Haddam Neck region were the oligochaete Limnodrilus hoffmeisteri, the polychaete Scolecolepidis viridis, the amphipod Gammarus fasciatus, three larval diptera in the genera Chironomus, Psectrotanypus and Cryptochironomus, the snail Ferrissia sp., and the bi-valve molluscs Lampsilis cariosa, Elliptio complanata, Pisidium casertanum and P. nitidum.

Available data indicate relative abundance but do not provide a conclusive quantitative picture for all species. For the most abundant benthic invertebrates, data for Pisidium sp., Limnodrilus hoffmeisteri, Psectrotanypus sp. and Cryptochironomus sp. provide a measure of abundance. L. hoffmeisteri ranges from 0 to more than 4800 organisms/m^2, Pisidium sp.

from 0 to more than 400 organisms/m^2, Psectrotanypus sp. from 0 to more than 700 organisms/m^2 and Cryptochironomus sp. from 0 to more than 600 organisms/m^2 when Stations 2, 10 and 16 are considered collectively.

A measure of diversity in the species of benthic fauna reveals certain information concerning the ecological well-being of a benthic community. Generally, a community having a high species diversity will be more resistant to environmental change and also reflect the absence of an effect from past environmental changes. Conversely, a community with a low species diversity may reflect an unfavorable response to environmental change, and also be less resistant to further change. Species diversity was measured from the Haddam Neck region of the Connecticut River using benthic fauna data from mid-1965 through 1968. Diversity was calculated using Margalef's formula for a species diversity index:

$$D = \frac{S-1}{\text{natural Log } N}$$

where S is the number of species present and N is the total number of individuals present.[46] For Station 2 the diversity index ranged from 0 to 1.37 in preoperational years with an average of 0.54. At the north of the discharge canal the species diversity ranged from 0 to 1.78, with an average of 0.78. Since there are numerous methods used to compute species diversity, it is often difficult to compare values obtained for other ecosystems. (A diversity index is best applied when comparing pre- and postoperational conditions associated with some suspected perturbationary event, which is done in Section 5.)

2.5.2.5 Fish

The most common fishes appearing in the Haddam Neck region are the white catfish, brown bullhead, white and yellow perch, sunfishes, spot-tailed shiner, darter, white sucker, killifish, common eel, carp and shad. The applicant presents a complete list of fishes common to the Haddam Neck region in Appendix B of the Environmental Report, "Connecticut River investigations, 6th Semiannual Report," pp. 49-50.

Although the shad is the most important commercial species, the Connecticut River also provides a substantial sport fishery. Creel censuses in 1965 reveal catches of greater than 1 fish per hour. The most important sport fish species are the white and yellow perch, brown bullhead, white catfish, sunfish and eel. The waters of the Haddam Neck region provide a relatively diverse array of species caught by rod fishermen. A total of 21 species are mentioned in the 2-year creel census. The 15 most frequently taken fish are given in Table 2.6.

TABLE 2.6

PERCENTAGE TOTAL CATCH AND ESTIMATED TOTAL NUMBER AND WEIGHT OF EACH FISH SPECIES CAUGHT IN THE SPORTS FISHERY IN THE HADDAM AREA OF THE LOWER CONNECTICUT AND SALMON RIVERS DURING 1965[47]

Species	Percent Total Catch	Estimated Numbers	Estimated Weight (lbs)
White perch	21.7	4519	2289
White catfish	24.5	5103	2641
Brown bullhead	20.3	4227	1630
Yellow perch	6.3	1312	462
American eel	15.0	3123	791
Pumpkinseed	7.4	1542	340
Bluegill	0.7	145	40
Largemouth bass	0.2	42	31
Sucker	0.2	42	55
Brown trout	0.1	21	28
Northern pike	0.1	21	52
Alewife and blueback herring	2.0	417	230
American shad	1.2	250	772
Lamprey eel	0.2	42	51
Carp	0.1	21	98

The American shad is the best known and commercially important fish species in the Connecticut River. The annual fluctuation of numbers of shad returning to the river to spawn is large. The range in yearly spawning runs is from 500,000 to 1,250,000 individuals, with a "normal" run size of about 750,000. Female shad travel a 5-year migrational pattern in the Atlantic coastal waters before they return to spawn; the males, a 4-year migrational pattern.[48] There is insufficient knowledge concerning the nature of the migrational pattern or the events occurring during migration to explain the large fluctuation in annual upstream spawning migration. The shad spawn in the numerous tributaries of the Connecticut River and the young begin their downstream migration to the Atlantic in early fall when they are from 3 to 5 in. long.

The Connecticut River also once supported a commercial fishery for sturgeon, but the numbers of sturgeon have become too small in the last two decades to maintain this fishery. The Atlantic salmon was once an important fish in the Connecticut River, but dams constructed in the 18th and 19th centuries have eliminated the salmon in this river by preventing them from reaching their spawning grounds. In recent years Federal and State agencies have been experimenting with reintroduced Atlantic salmon in the Connecticut River. Smolts have been released below Holyoke, Massachusetts each spring since 1968. They appear to have successfully migrated downriver, but returns have not yet been observed.

Fish species in Connecticut waters identified as endangered are the shortnose sturgeon (Acipenser brevirostrum), the Atlantic sturgeon (Acipenser oxyrhynchus), the round whitefish (Prosopium cylindraceum), the Atlantic salmon (Salmo salar), and the burbot (Lota lota).[49] Of these only the Atlantic sturgeon and the Atlantic salmon have been found in the Haddam Neck region, and then only rarely.