Attachment G

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May 28, 2015

<u>VIA ELECTRONIC FILING</u>
Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Re: TransCanada Hydro Northeast Inc.'s Revised Study Plan, Project Nos. 1892-026, 1855-045, and 1904-073 – Historic Architectural Resources Survey

Dear Secretary Bose:

TransCanada Hydro Northeast Inc. ("TransCanada") is the owner and licensee of the Wilder Hydroelectric Project (FERC No. 1892), the Bellows Falls Hydroelectric Project (FERC No. 1855), and the Vernon Hydroelectric Project (FERC No. 1904). The current licenses for these projects each expire on April 30, 2018. On October 31, 2012, TransCanada initiated the Integrated Licensing Process by filing with the Federal Energy Regulatory Commission ("FERC" or "Commission") its Notice of Intent to seek new licenses for each project, along with a separate Pre-Application Document for each project.

TransCanada submitted its Revised Study Plan for the three projects, as required by 18 C.F.R. §5.15(c)(1) on August 14, 2013 and in accordance with Revised Study 33-Cultural and Historic Resources Study, enclosed please find the report entitled *Technical Report, Historic*

Architectural Resources Survey, Wilder Hydroelectric Project (FERC No. 1892) Hartford, Vermont, and Lebanon, New Hampshire; Vernon Hydroelectric Project (FERC No. 1904) Vernon, Vermont, and Hinsdale, New Hampshire; Bellows Falls Hydroelectric Project (FERC No. 1855) Bellows Falls, Rockingham, Vermont, and Walpole, New Hampshire prepared for your review and comment. Also included are copies of the letters forwarding the report to the Vermont and New Hampshire SHPOs.

If there are any questions regarding the information provided in this filing or the process, please contact John Ragonese at 603-498-2851 or by emailing john_ragonese@transcanada.com.

Sincerely,

John L. Ragonese
FERC License Manager

Enclosure: Technical Report, Historic Architectural Resources Survey, Wilder Hydroelectric Project (FERC No. 1892) Hartford, Vermont, and Lebanon, New Hampshire; Vernon Hydroelectric Project (FERC No. 1904) Vernon, Vermont, and Hinsdale, New Hampshire; Bellows Falls Hydroelectric Project (FERC No. 1855) Bellows Falls, Rockingham, Vermont, and Walpole, New Hampshire.

TECHNICAL REPORT

HISTORIC ARCHITECTURAL RESOURCES SURVEY

Wilder Hydroelectric Project (FERC No. 1892)
Hartford, Vermont, and Lebanon, New Hampshire
Vernon Hydroelectric Project (FERC No. 1904)
Vernon, Vermont, and Hinsdale, New Hampshire
Bellows Falls Hydroelectric Project (FERC No. 1855)
Bellows Falls, Rockingham, Vermont, and Walpole, New Hampshire

John J. Daly

Submitted to:

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Submitted by:

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PAL

PAL Report No. 2954 May 2015

PAL Publications

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MANAGEMENT ABSTRACT

TransCanada Hydro Northeast Inc. (TransCanada) is seeking licenses from the Federal Energy Regulatory Commission (FERC) to continue the operation of three hydroelectric power generating facilities on the Connecticut River: the Wilder Hydroelectric Project (FERC Project No. 1892-026, the “Wilder Project”) in Hartford, Vermont, and Lebanon, New Hampshire; Bellows Falls Hydroelectric Project (FERC Project No. 1855-045, the “Bellows Falls Project”) in the Village of Bellows Falls, Rockingham, Vermont, and Walpole, New Hampshire; and Vernon Hydroelectric Project (FERC Project No. 1904-073, the “Vernon Project”) in Vernon, Vermont, and Hinsdale, New Hampshire (collectively referred to as the “projects”).

The FERC relicensing of the hydroelectric projects is a federal undertaking as defined under Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended, and its implementing regulations under 36 CFR 800. FERC, as the permitting agency, is the Lead Federal Agency for the undertaking. In compliance with the FERC regulations governing relicensing efforts at 18 CFR Part 5, TransCanada has prepared a Revised Study Plan (RSP) to evaluate potential impacts of the relicensing, including impacts to historic properties.

The Public Archaeology Laboratory, Inc. (PAL) conducted the survey and evaluation of historic architectural resources (the “survey”) on behalf of TransCanada and as a component of Study 33: Cultural and Historic Resources Studies, which is included within TransCanada’s RSP. Prior cultural resource management investigations and related consultation have identified the Wilder, Bellows Falls, and Vernon projects as historic properties determined or potentially eligible for listing in the National Register of Historic Places (National Register). PAL’s survey was designed to document existing conditions of the Vernon and Bellows Falls projects, which were previously determined eligible for listing in the National Register, and evaluate the Wilder Project in accordance with the National Register Criteria for Evaluation.

PAL’s survey confirmed that the Bellows Falls Hydroelectric Development Historic District and the Vernon Hydroelectric Development Historic District continue to be eligible for listing in the National Register. PAL recommends that the Wilder Project is eligible for listing in the National Register as the Wilder Hydroelectric Development Historic District. PAL’s survey recommendations include definitions of the applicable National Register criteria and areas of significance, as well as geographic boundaries and lists of contributing and non-contributing resources within each district.

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CHAPTER ONE

INTRODUCTION

This report presents the results of a historical architectural resources survey and evaluation conducted by The Public Archaeology Laboratory, Inc. (PAL) for the Wilder, Bellows Falls, and Vernon Hydroelectric projects, under contract to TransCanada Hydro Northeast Inc. (TransCanada).

TransCanada is seeking licenses from the Federal Energy Regulatory Commission (FERC) to continue the operation of three hydroelectric power generating facilities on the Connecticut River: the Wilder Hydroelectric Project (FERC Project No. 1892-026, the "Wilder Project") in Hartford, Vermont, and Lebanon, New Hampshire; the Bellows Falls Hydroelectric Project (FERC Project No. 1855-045, the "Bellows Falls Project") in the Village of Bellows Falls, Rockingham, Vermont, and Walpole, New Hampshire; and the Vernon Hydroelectric Project (FERC Project No. 1904-073, the "Vernon Project") in Vernon, Vermont, and Hinsdale, New Hampshire (collectively referred to as the "projects," and also referred to in previous documentation as "stations" or "developments") (Figures 1-1 – 1-3).

The current licenses for the three hydroelectric projects expire on April 30, 2018. On October 31, 2012, TransCanada filed with FERC its Notice of Intent (NOI) to seek new licenses for each project, along with a separate Pre-Application Document (PAD) for each project. In their comments on the project PADs, FERC, VTSHPO, NHSHPO, and the Nolumbeka Project requested additional information about cultural resource studies that have been or will be conducted at the Wilder, Bellows Falls, and Vernon projects as part of the overall FERC relicensing process. TransCanada filed its Proposed Study Plan on April 16, 2013, and after further consultation filed a Revised Study Plan (RSP) on August 14, 2013 (TransCanada Hydro Northeast Inc. 2013a).

Within the RSP, Study 33: Cultural and Historic Resources Studies provides for the following historic properties identification surveys:

- Vernon Project 2013 archaeological monitoring program/update of Phase IA Archaeological Reconnaissance Survey;
- Phase IB archaeological identification surveys for all three projects;
- Phase II archaeological site evaluation surveys for all three Projects
- TCP Identification Survey within the three projects;
- Survey and evaluation of historic architectural resources; and
- Development of Historic Property Management Plans.

This report fulfills TransCanada's obligation to complete the survey and evaluation of historic architectural resources (the "survey") within the Cultural and Historic Resources Study (Study 33) the RSP.

Authority

The licensing of the hydroelectric projects by the FERC constitutes a federal undertaking that is subject to review under Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended, and its implementing regulations 36 CFR 800. FERC is the Lead Federal Agency for the undertaking and is responsible for complying with Section 106 of the NHPA.

FERC regulations at 18 CFR 5 address historic properties within the applicant relicensing process, stipulating that applicants must consult with the relevant federal, state, and interstate resource agencies and other interested parties to ensure appropriate resource protections, including historic properties. An applicant's Study Plan, which must be fulfilled prior to relicensing, identifies and describes any necessary studies as identified by the applicant, consulting agencies, and interested parties to identify or assess the impacts of relicensing these resources.

Previous Cultural Resource Investigations

The Wilder, Bellows Falls, and Vernon projects have previously been determined or evaluated for listing in the National Register as historic districts through several cultural resource investigations and related consultation over the past 33 years as described below.

Wilder Project

The Wilder Project, built in 1950, is a 35,600-kiloWatt (kW) concentrated-fall type hydroelectric development consisting of a gravity-type earth and concrete Dam, Powerhouse, Garage, Oil Shed, Visitors' House, Connecticut River Office (CRO), Consolidated Control Center (CCC) building, Fish Ladder, and electrical switch/transformer yards (TransCanada Hydro Northeast Inc. 2013b). The Wilder Project has never been formally determined eligible for listing in the National Register. A full inventory of architectural resources within the FERC boundaries of the Wilder Project was compiled in the *Deerfield and Connecticut River Hydroelectric Projects System-wide Historical and Photographic Documentation* completed by PAL in 1999 (Doherty and Kierstead 1999, hereinafter referred to as the 1999 *Deerfield and Connecticut River Documentation*). The purpose of that documentation was to identify and evaluate potential historic architectural properties within the boundaries of all the hydroelectric developments that are currently owned by TransCanada on the Deerfield and Connecticut rivers. Survey information was used to evaluate the significance of the resources and to prepare state-level written and photographic archival documentation that would provide a permanent record of the historic developments and serve as a baseline for assessing the impacts of subsequent project-related undertakings that had the potential to impact a project's qualities of significance. The documentation included a historic context statement for the development of hydroelectric power facilities on the two rivers and information about all individual aboveground resources within the project boundaries that contribute to their historical significance. Copies of the documentation for the Connecticut River Projects were submitted to the VTSHPO and NHSHPO for transmittal to the states' archives and local archival repositories in the vicinity of the projects.

In 2013–2014, TransCanada built a new Consolidated Control Center building on the grounds of the Wilder Project in Vermont. The proposed work was reviewed under Section 106 of the NHPA and 30 VSA 248.b. The survey recommended that components of the Wilder Project constituted a historic district eligible for listing in the National Register, but no formal determination was made. Identified contributing resources within the potential Wilder Hydroelectric Project Historic District consist of the Dam, Powerhouse, Garage, Oil Shed, and Visitors' House (aka Old Visitors' Center) (TransCanada Hydro Northeast Inc. 2013a).

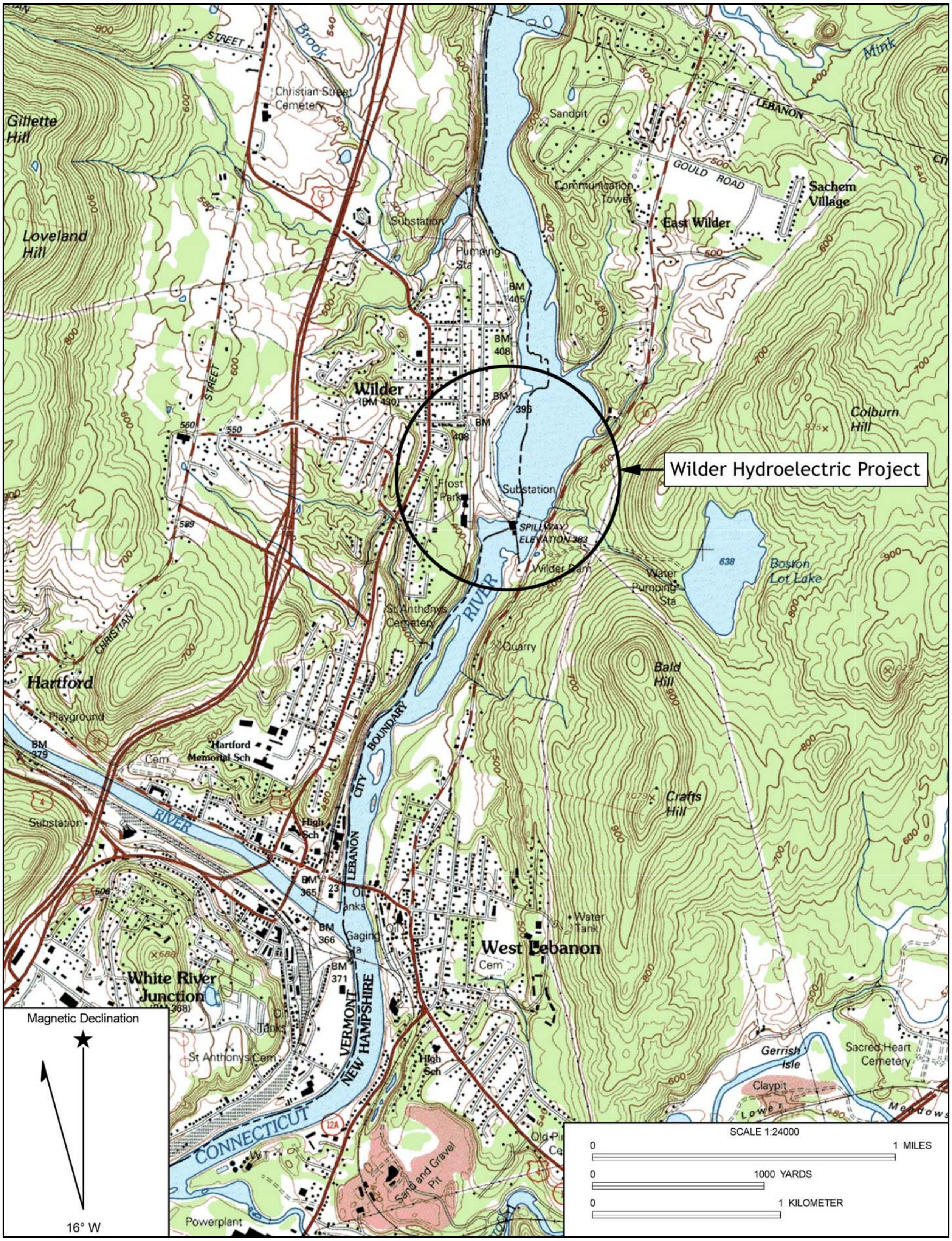

Figure 1-1. Location of the Wilder Hydroelectric Project on the USGS Hanover, Vermont-New Hampshire 7.5' Quadrangle.

Bellows Falls Project

The Bellows Falls Project, built in 1925–1928, is located on the periphery of downtown Bellows Falls. The 40,800-kW, divided-fall type development consists of a Dam, Canal, Tail Race, Powerhouse, Gauge House, Crew Shack, Six-Man Garage, Line Shed, the so-called "Red Barn," a Visitors' Center, Fish Ladder, and two Switchyards (TransCanada Hydro Northeast Inc. 2013c). The Bellows Falls Project was determined eligible for listing in the National Register as the Bellows Falls Hydroelectric Development[1] Historic District. Components of the project were initially evaluated for National Register eligibility in 1982, when a portion of the Canal was listed in the National Register as a contributing resource within the Bellows Falls Downtown Historic District (Henry 1981). This district's boundaries excluded the project Powerhouse, but included the portion of the Canal between Bridge Street on the south and the Green Mountain Railroad Bridge on the north. The Bellows Falls Island Multiple Resource Area was subsequently listed in the National Register in 1990 (Mulholland et al. 1988) and included a number of historic resources on Bellows Falls Island that were associated with the industrial development of the area during the nineteenth and early twentieth centuries. The Bellows Falls Hydroelectric Powerhouse was named in the documentation as a contributing resource, but it is not listed in the National Register. In accordance with the Section 101(a)(6) of the National Historic Preservation Act, the Keeper of the National Register (Keeper) determined the property eligible for listing.

In 1992, the Bellows Falls Project was identified as a property eligible for listing in the National Register as a historic district within the *Hydroelectric Generating Facilities in Vermont Multiple Property Submission* (MPS) (Bowers 1992). The MPS, signed by the Keeper and listed in the National Register in 2004, provides the overall context and registration requirements for listing individual hydroelectric power facilities in Vermont that were constructed between 1882 and 1941. However, the Bellows Falls Project is not listed in the National Register under this MPS (TransCanada Hydro Northeast Inc. 2013a).

The Bellows Falls Project was included in the 1999 Deerfield and Connecticut River Documentation (Doherty and Kierstead 1999). Resources that contribute to the significance of the Bellows Falls Hydroelectric Project Historic District were identified as the Dam, Canal, Powerhouse, Gauge House, Crew Shack, Six-Man Garage, Line Shed, and Red Barn.

Vernon Project

The 32,400-kW Vernon Project was built in 1907–1909, enlarged in 1920, and had four of its turbine-generator units replaced in 2006. The concentrated-fall type hydroelectric project consists of a Dam, Powerhouse, Superintendents House, Superintendent's Garage, Hoister House, Pump House, Crew Shack, switchyard, fish ladder, and a smaller pump house added about 1970 (TransCanada Hydro Northeast Inc. 2013d). FERC, in consultation with the VTSHPO and NHSHPO, determined in 2006 that the Vernon Project is eligible for listing in the National Register as the Vernon Hydroelectric Development Historic District. The project was initially identified as eligible for listing in the National Register as a historic district within the *Hydroelectric Generating Facilities in Vermont MPS* (Bowers 1992), but was never formally nominated to the National Register. It was subsequently included in the 1999 *Deerfield and Connecticut River Documentation* (Doherty and Kierstead 1999).

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[1] For clarity within this document and consistency with previous cultural resources assessments, the term "Project" is used to refer to TransCanada hydroelectric facilities in their entirety, while the term "Development" is used to refer to those components of a Project that have status as a historic property listed in, determined eligible for listing in, or recommended eligible for listing in the National Register of Historic Places, or, within Chapter 3, as necessary for consistency with historical documents, which typically referred to the Projects as developments.

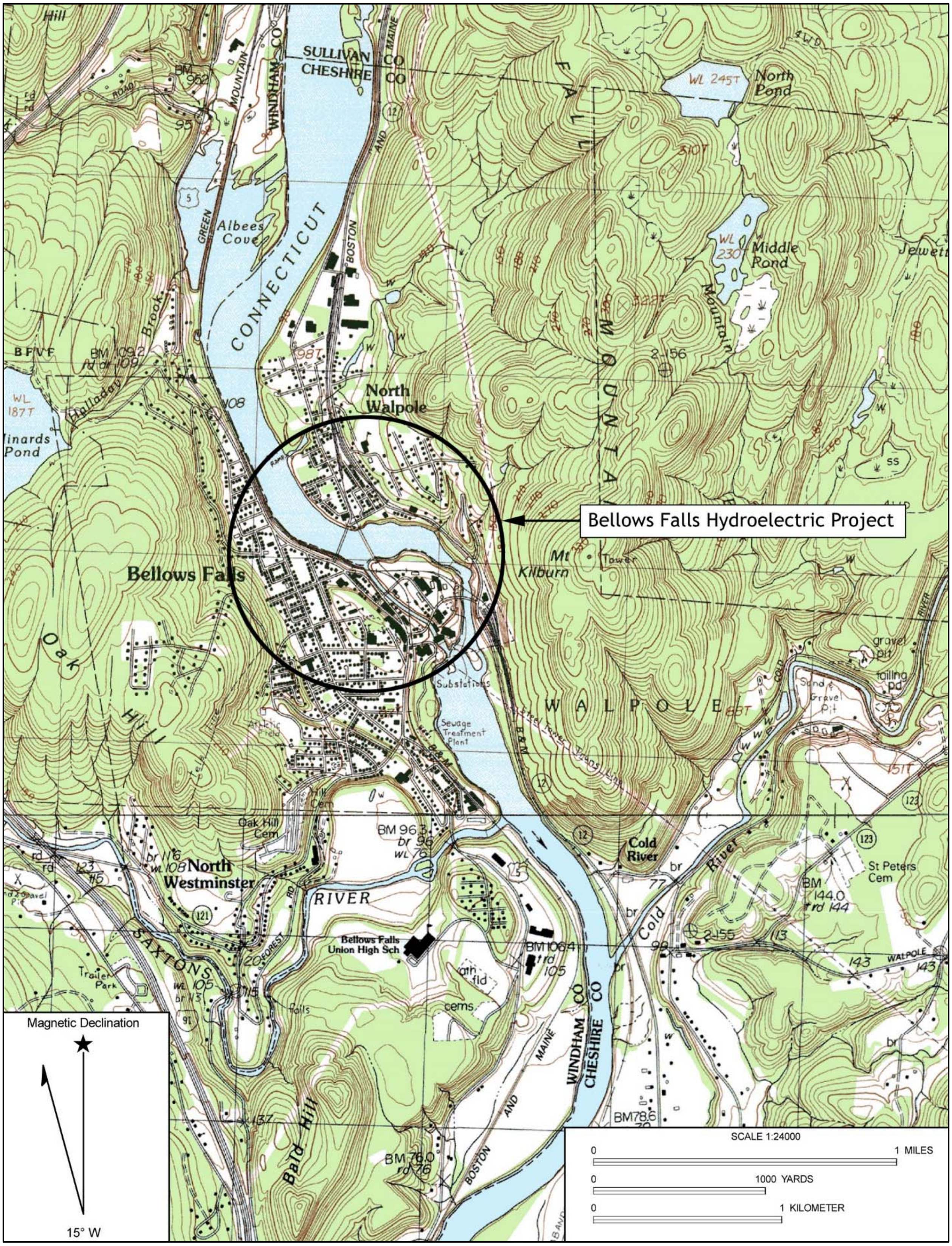

Figure 1-2. Location of the Bellows Falls Hydroelectric Project on the USGS Bellows Falls, Vermont-New Hampshire 15' Quadrangle.

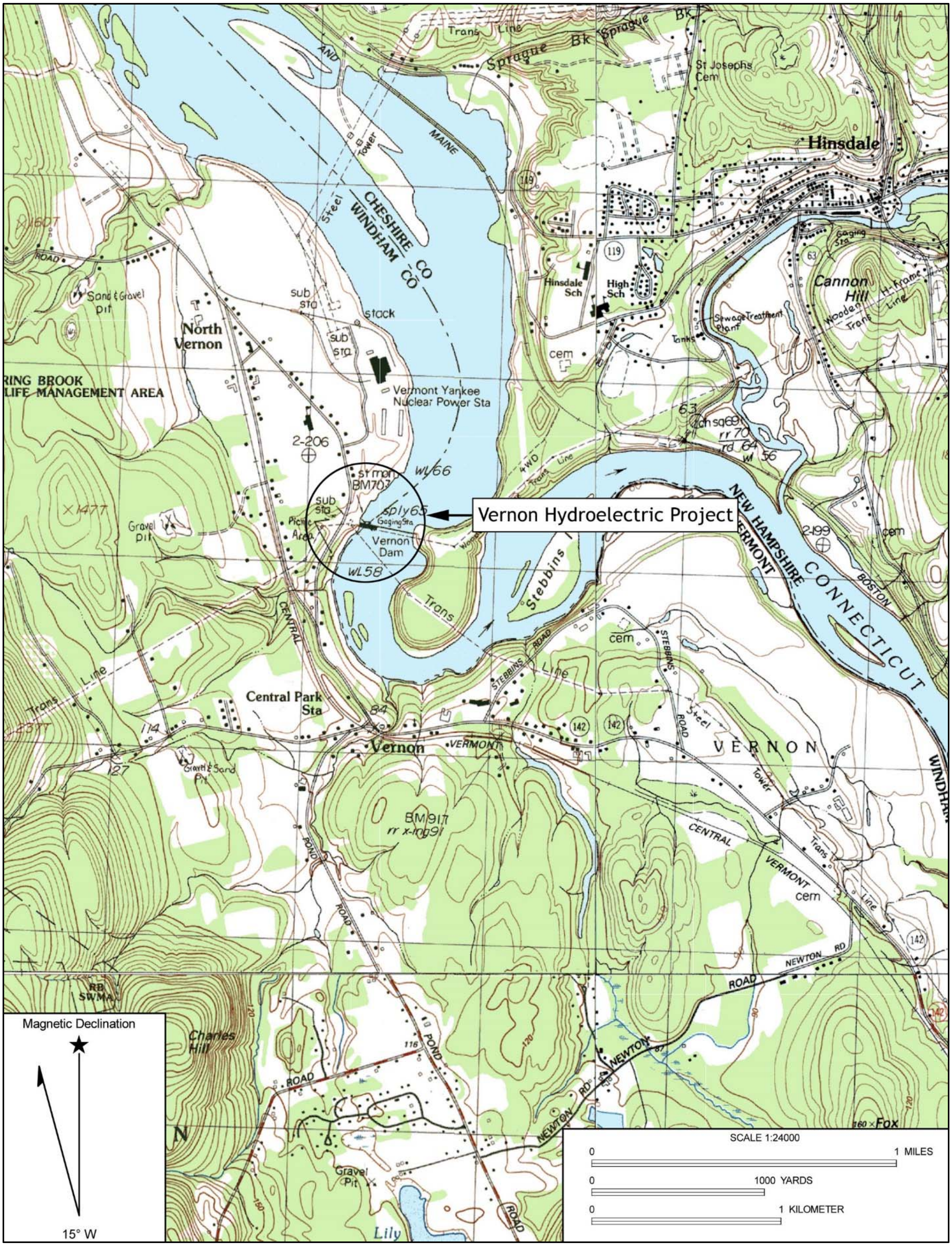

Figure 1-3. Location of the Vernon Hydroelectric Project on the USGS Brattleboro, Vermont-New Hampshire 15' Quadrangle.

In 2006–2008, a TransCanada project to upgrade the generating capacity at the Vernon Project required an amendment to the project license. In accordance with Section 106 of the NHPA, FERC and TransCanada consulted with the VTSHPO and NHSHPO and other parties regarding the project's effects on historic properties and determined that the historic architectural resources within the Vernon Project are eligible for listing in the National Register as a historic district under National Register Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. The historic district derives its primary significance as the first large-capacity electrical generation facility in New England designed to deliver electricity via a long-distance transmission network. Contributing resources within the identified Vernon Hydroelectric Project Historic District are the Dam, Powerhouse, Superintendent's House (in poor condition), Superintendent's Garage, Hoister House, Pump House, and Crew Shack (TransCanada Hydro Northeast Inc. 2013a).

The effects of the proposed 2006–2008 upgrade project on the historic Powerhouse were resolved through the execution of a Memorandum of Agreement that specified a variety of mitigation activities, including the preparation of a Historic Properties Management Plan (HPMP). Completed and approved in 2008, the HPMP specifies the treatment and management of historic properties within the Vernon Project boundaries (Olausen and Cherau 2008).

PAL Scope

PAL's scope of work for the historic architectural resources survey as defined by the RSP was to assess the existing condition of all resources previously identified in PAL's 1999 survey, to identify any other potentially significant resources within the APEs, and to evaluate the significance of resources not yet formally determined eligible for listing in the National Register. Therefore, the RSP methodology was intended to confirm the National Register status and baseline conditions of the Bellows Falls and Wilder hydroelectric projects and to provide recommendations for the National Register eligibility for the Wilder Project. The results of the historic architectural survey will be used as a basis for FERC's effects assessment for the projects' relicensing and for a Historic Property Management Plan that will address any future effects that might result from TransCanada's operation, maintenance, or capital improvement activities at the projects.

Survey Personnel

Research and fieldwork for the survey were completed from August to October 2014. PAL personnel involved in the survey were Stephen A. Olausen (senior architectural historian); John J. Daly (senior industrial historian), and Gretchen Pineo (assistant architectural historian).

CHAPTER TWO

METHODOLOGY

The goals of the historical architectural resources survey for the Vernon, Bellows Falls, and Wilder Hydroelectric projects, as defined by the TransCanada RSP, were to

- assess existing condition of all resources previously identified as potential historic properties in PAL's 1999 survey;
- identify any other potentially significant resources within the APEs; and
- evaluate the significance of resources not yet been formally determined eligible for listing in the National Register.

To achieve these goals, PAL staff used archival research, field survey, and evaluation methodologies in accordance with the Secretary of the Interior's *Standards and Guidelines for Identification* (1983) and *National Register Bulletin 24, Guidelines for Local Surveys: A Basis for Preservation Planning* (1985).

Archival Research

PAL collected information about documented and inventoried historic properties within the project APEs, contextual data about the developmental history of hydroelectric generation facilities in New England, and about the operational and physical development of the three hydroelectric projects using primary (unpublished) and secondary (published) resources, including the following: the National Park Service (NPS) National Register Information System (NRIS) and the Vermont Division for Historic Preservation (VDHP) Historic Sites and Structures Survey (HSSS); *From the Rivers: The Origins and Growth of the New England Electric System* (Landry and Cruikshank 1996); *Hydroelectric Development in the United States, 1880–1940* (Hay 1991); and *Hydroelectric Generating Facilities in Vermont MPS* (Bowers 1992). PAL also examined primary and secondary histories, historical maps and atlases, and photographs and plans for the three projects on file at TransCanada to document physical changes in the three projects.

PAL also reviewed cultural resource management reports, including its *Deerfield and Connecticut River Hydroelectric Projects System-wide Historical and Photographic Documentation* (Doherty and Kierstead 1999) and all research files, reports, and historical documents pertinent to historic architectural resources related to previous investigations done for TransCanada.

Field Survey

A PAL industrial historian and an assistant architectural historian performed the survey fieldwork within the Project APE in August 2014. All buildings and structures recorded during the 1999 system-wide historical documentation were revisited and the additional permanent resources present on TransCanada property at each of the three projects were also surveyed. Detailed written notes were taken on the physical attributes, condition, and integrity of all buildings and structures, and about the overall setting of the development and its resources. High-resolution digital photographs were taken of each resource to record exterior views and major interior elevations. Additional photographs recorded the resources in relation to one another and their surroundings. Photo logs and location maps were maintained to record the location and view for each photograph.

Data Synthesis and National Register Evaluation

Following the completion of the archival research and field survey tasks, PAL analyzed the collected historical and survey data to prepare historic contexts and to make recommendations concerning the significance and eligibility of identified historic architectural properties for listing in the National Register. Relevant contexts and National Register eligibility recommendations were prepared using the *National Register Bulletin 16A: How to Apply the National Register Criteria for Evaluation* (NPS 2002).

The quality of significance may be present in districts, sites, buildings, structures, and objects that are associated with an important historic context and that retain historic integrity of those features necessary to convey significance. The formulation of historic contexts is a logical first step in the design of an architectural survey and is crucial to the evaluation of historic properties. Historic contexts provide an organizational framework that groups information about related historic properties based on a theme, geographic limits, and chronological periods. A historic context should identify gaps in data and knowledge to help determine what significant information may be obtained from the resource. Each historic context is related to the developmental history of an area, region, or theme (e.g., agriculture, transportation, and waterpower), and identifies the significant patterns which a particular resource may be an element. Only those contexts important to understanding and justifying the significance of the property need be discussed.

Historic contexts are developed by

- identifying the concept, time period, and geographic limits for the context;
- collecting and assessing existing information about these time periods;
- identifying locational patterns and current conditions of the associated property types;
- synthesizing the information in a written narrative; and
- identifying information needs.

The NPS has established four criteria for listing significant properties in the National Register (36 CFR 60). The criteria are broadly defined to include the wide range of properties that are significant in American history, architecture, archaeology, engineering, and culture. The criteria (known by the letters A–D) allow for the listing of properties

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or
B. that are associated with the lives of persons significant in our past; or
C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
D. that have yielded, or may be likely to yield, information important to prehistory or history.

Historic properties need only achieve significance under one of these criteria to be eligible for listing in the National Register.

Another critical component in assessing the significance of a historic property is an evaluation of its integrity. Historic properties either retain integrity (i.e., convey their significance) or they do not. The National Register criteria recognize seven aspects or qualities that, in various combinations, define integrity:

- location, the place where the historic property was constructed or the place where the historic event occurred;
- design, the combination of elements that create the form, plan, space, structure, and style of a property;
- setting, the physical environment of a historic property;
- materials, the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property;
- workmanship, the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory;
- feeling, a property's expression of the aesthetic or historic sense of a particular period of time; and
- association, the direct link between an important historic event or person and a historic property.

To retain historic integrity, a property will always possess several, and usually most, of these qualities. The retention of specific aspects of integrity is paramount for a property to convey its significance. Determining which of these aspects or qualities are most important to a particular property requires knowing why, where, and when the property is significant (NPS 2002).

CHAPTER THREE

HISTORIC CONTEXT

Historic Hydroelectric Generating Projects on the Connecticut River

In 1903, Malcolm Greene Chace (1875–1955) and Henry Ingraham Harriman (1872–1950) established Chace & Harriman, a company that in its many incarnations over the course of the following decades grew into one of the largest electric utility companies in New England. The company built a series of hydroelectric facilities on the Connecticut and Deerfield rivers in Vermont, New Hampshire, and western Massachusetts, that were intended to provide a reliable and less expensive alternative to coal-produced steam power (Table 3-1, Figure 3-1). Designed primarily to serve industrial centers in Massachusetts and Rhode Island, the facilities also provided power to residential customers and municipalities in New England. Chace & Harriman became the New England Power Association (NEPA) in 1926, which became the New England Electric System (NEES) in 1947. NEES was purchased by U.S. Generating in the 1990s, which in turn was bought by PG&E Generating. In 2004–2005, TransCanada acquired all the hydroelectric projects established by Chace & Harriman and successor companies on the Connecticut and Deerfield rivers (Landry and Cruikshank 1996:2–5, 29, 39, 67, 141; Cook 1991:13). This context statement provides a history of Chace & Harriman's and successor companies' hydroelectric projects and related technological and architectural developments on the Connecticut River.

Table 3-1. Chace & Harriman Hydroelectric Projects and Reservoirs on the Deerfield and Connecticut Rivers (generating unit and capacity figures reflect current status).

Hydroelectric Station	Year in Service	Location	Generating Units	Capacity (MW)
Vernon	1909	Vernon, VT, and Hinsdale NH	10	32
Deerfield No. 3	1912	Buckland and Shelburne, MA	3	6
Deerfield No. 2	1913	Conway and Shelburne, MA	3	7
Deerfield No. 4	1913	Buckland and Shelburne, MA	3	6
Deerfield No. 5	1913	Rowe and Florida, MA	1	14
Somerset	1913	Somerset, VT	N/A, storage reservoir	
Searsburg	1922	Searsburg, VT	1	5
Harriman	1924	Readsboro and Whitingham, VT	3	40
Sherman	1927	Rowe and Monroe, MA	1	6
Bellows Falls	1928	Walpole, NH, and Rockingham VT	3	49
Comerford	1930	Monroe, NH, and Barnet VT	4	167
McIndoes	1931	Monroe, NH, and Barnet VT	4	10
Wilder	1950	Lebanon, NH, and Hartford VT	3	40
Moore	1957	Littleton, NH, and Waterford VT	4	190

Source: Data TransCanada 2015.
N/A = Not applicable.

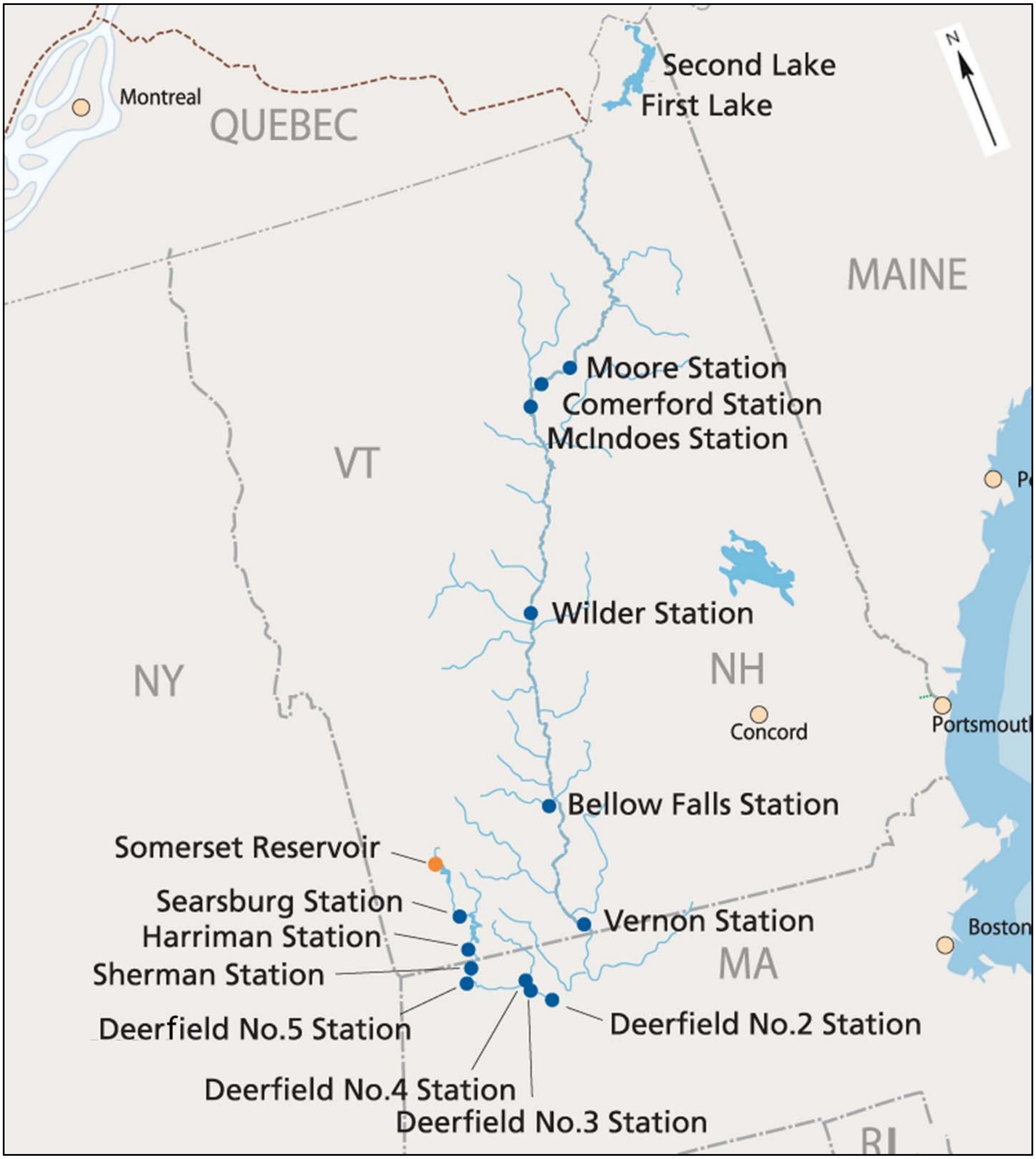

Figure 3-1. Map of TransCanada predecessor hydroelectric developments on the Connecticut and Deerfield rivers.

The history of electric power generation in the United States is characterized by several stages of development. From about 1880 to 1895, direct current was produced by steam and/or hydroelectric stations and transmitted over small geographic areas, providing power to arc and incandescent lights. Improvements in the 1890s focused on the potential of hydroelectric power for the transmission of alternating current over long distances. In the 1920s, equipment and designs became more standardized and the structure of management companies became increasingly complex. While the Depression limited further growth of the industry, a new era emerged after World War II with streamlined management structures and increased regulations and government involvement (Cook 1991:4; Landry and Cruikshank 1996:2–5). The first of the 14 hydroelectric facilities built on the Connecticut and Deerfield rivers by Chace & Harriman and its successors were developed in the early 1900s, shortly after the potential of hydroelectric power was realized on a large scale. Subsequent facilities were constructed during the maturation of the industry in the 1920s, and two of the stations were completed in the post-World War II era. The history of the companies that built these stations is intrinsically linked with broader trends in the history of electric generation, hydropower technology, and industrial architecture in America. As such, the facilities in Vermont, New Hampshire, and Massachusetts together tell the story of hydroelectric power from its late nineteenth-century origins to the present.

Early American Electrical History

Electrical power first gained popularity in America in the 1870s with the introduction of the arc lamp by inventor Charles Brush of Cleveland. With their bright light and short life span, arc lamps predominated in commercial applications and public street lighting. Initially, these lamps ran on individual generators called dynamos. As their numbers increased, businesses began to support the construction of urban generating stations that could run up to a maximum of 60 lamps connected in series. These early stations used coal to drive a steam engine, which then turned a generator to produce electricity. The complex technology involved and the small size of the stations kept prices high and demand limited, posing little competition to the established gas-lighting companies. Despite these disadvantages, by 1880 Brush had installed central electrical stations in major American cities such as San Francisco, New York, Philadelphia, and Boston, and had more than 5,000 arc lights in operation (Glover and Cornell 1951:671; Landry and Cruikshank 1996:11–14; Marcus and Segal 1989:143–5).

About the same time, Thomas Alva Edison's Edison Electric Company developed the enclosed incandescent light. In contrast to arc lamps, a large number of incandescent lights could be wired in parallel with low voltage direct current (DC), lowering the cost of illumination, and the enclosed nature of the light, composed of a filament within a vacuum tube, made it suitable for indoor use—factors that immediately increased the demand for electric lights among residential consumers and created a fierce rivalry with the existing gas companies. When Edison opened his first central generating station in New York City in 1882, the electrical power was initially distributed for free, enticing many converts (Landry and Cruikshank 1996:14–15; Marcus and Segal 1989:145–148).

Although Edison Electric had few rivals in the distribution and production of DC incandescent lighting, the technology had limited application until the development of alternating current (AC). The dissipation of DC electricity over distance meant most stations were in downtown areas, neglecting the demand for electricity in rural areas and preventing the exploitation of most potential waterpower sites. DC also required a continual expansion in the number of powerhouses, as each quickly reached its maximum capacity.

The introduction of AC electricity by George Westinghouse made electrical power more practical for both household and industrial use, allowing variations in voltage and decreased energy loss during transmission. At the 1893 World's Fair in Chicago, Illinois, Westinghouse won a contest that allowed him to build a generating station at Niagara Falls. His station was a brilliant success, transmitting power over 26 miles to

Buffalo, New York, and resulted in high profits, which triggered a “hydromania” for powerhouse construction and long-distance transmission. AC electricity was quickly embraced by those in thinly populated areas who had not received DC power because of its prohibitively high cost. With its greater flexibility, lower cost, and unrestricted capacity, AC power began to challenge DC in the cities, encouraging the creation of larger central stations that could spread power throughout the outlying areas (Glover and Cornell 1951:674; Landry and Cruikshank 1996:18–23; Marcus and Segal 1989:149–150).

By the beginning of the twentieth century, 18 utility companies in Massachusetts generated hydroelectric power, although in most cases it was a supplement to, or back-up for, coal-produced steam power. The cost of transporting great amounts of coal to New England was high, however, and as hydroelectric technology improved, it became an obvious alternative. Unfortunately, most rivers were located in northern New England, far from the industrial centers that demanded the power source and many lacked the reservoirs needed to ensure a steady flow of water. Soon, demand had grown such that the Massachusetts legislature passed a law allowing special permits for new utility companies. Thus began the odyssey of Malcolm Greene Chace and Henry Ingraham Harriman, who built a series of remote hydroelectric power plants along the Connecticut and Deerfield rivers, successfully transmitting the new power to the manufacturing centers of the region.

Chace & Harriman and the New England Company (1903–1926)

In 1903 Chace, the son of a textile worker, and Harriman, whose father was a judge and textile machinery inventor, formed Chace & Harriman with the intent of exploiting hydroelectric power in Maine. In 1907 a potential site was identified, not in Maine, but at Vernon, Vermont, on the Connecticut River. This river, which flows approximately 400 miles from Third Connecticut Lake in northern New Hampshire to Long Island Sound, dropping 2,000 feet (ft) over this length. With its many falls, the river had attracted mills since colonial times. Local investors already had plans for its development as a hydroelectric power source by the time Chace & Harriman took over the project in 1907. The design of the Vernon Development was largely the work of the mechanical engineering firm of Charles (Chas) T. Main, Inc. of Boston. An 1876 graduate of the Massachusetts Institute of Technology, Main was an authority on water and steam power and his firm, established in 1907, was involved in the design of more than 80 hydroelectric facilities by the time of his death in 1943. The construction of the Vernon station was completed by J. G. White & Company of New York in 1909, with 450 workers assigned to the project (Landry and Cruikshank 1996:26–35; Cook 1991:18–19).

Vernon was an ambitious facility that required raising the river 30 ft, which flooded all or parts of 150 farms. Construction was finished within two years, however, and Chace & Harriman attempted to secure rights-of-way for transmission into north-central Massachusetts. After many complicated financial arrangements, including the creation of a holding company and a subsidiary company (Connecticut River Power Company of Maine and Connecticut River Transmission Company of Massachusetts, respectively), they received special permission to enter Massachusetts markets, provided sales were restricted to bulk customers. The first generator at the Vernon station went on line on July 27, 1909, supplying 60-cycle AC power at 19 kilovolts (kV) to the Estey Organ Works in Brattleboro, Vermont. By 1910, eight generating units produced a total of 20 megawatts sent at 66 kV a distance of more than 60 miles, dwarfing the output of all other stations in the east (Figures 3-2 and 3-3). The unprecedented voltage and distance of transmission, and the construction of a line into Worcester, Massachusetts, quickly secured large customers such as the American Steel and Wire Company and Worcester Electric Light Company (Landry and Cruikshank 1996:26–35).

As demand grew and the Vernon facility became unable to provide enough power during the dry season, Chace and Harriman focused their attention on the Deerfield River, which runs through southern Vermont and western Massachusetts before joining the Connecticut River below Turners Falls. Chace & Harriman

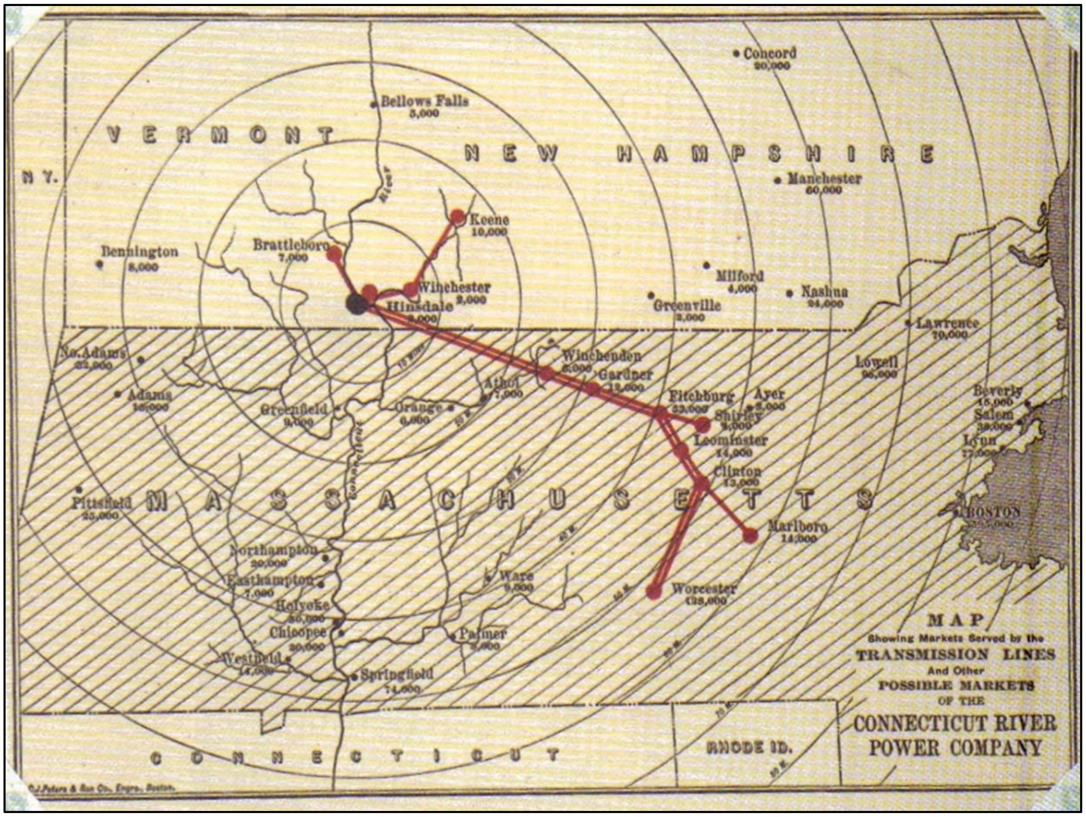

Figure 3-2. 1910 promotional map showing proposed connections between the Vernon Project (black dot) and metropolitan areas of central New England (Landry and Cruikshank 1996:31).

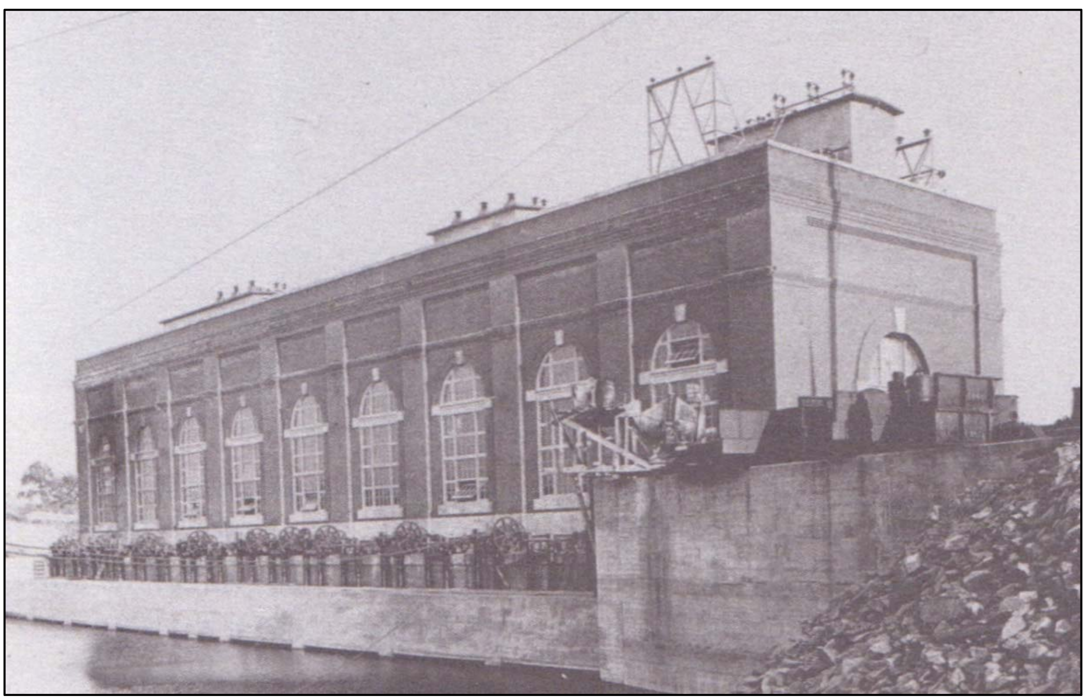

Figure 3-3. 1909 view of the completed Vernon Powerhouse, looking southeast (Landry and Cruikshank 1996:30).

created a Massachusetts-based company, New England Power, and a related construction management company, The Power Construction Company, to build and manage the Deerfield facilities. J. G. White & Company and Charles T. Main, Inc. were employed as design consultants on the Deerfield River projects Between 1911 and 1913, New England Power completed the Somerset Reservoir, a three-mile-square (2.5 billion cubic foot) reservoir in Somerset, Vermont, and three standardized stations (Deerfield Nos. 2, 3, and 4) providing a total capacity of 18 megawatts. A fourth station, Deerfield No. 5, had a larger capacity of 15 megawatts. These stations, in combination with improved transmission lines, allowed the company to expand its transmission network through western Massachusetts (Cook 1991:18–19; Cavanaugh et al. 1993a; Cavanaugh et al. 1993b; Landry and Cruikshank 1996:38–40).

In 1914, Chace & Harriman's various companies were consolidated into the New England Company, a Massachusetts voluntary trust. At that time, the company provided more power than all other companies in Massachusetts combined, except for Boston Edison. Rather than providing competition to steam power stations, however, the hydroelectric generating stations provided a convenient counterbalance to their output. In the winter, when more power was needed because of shorter daylight hours, water was more plentiful; in the summer, when demand decreased, so did the flow of water. Advances in electric motor development also increased daytime industrial usage, expanding overall demand and distributing consumption more evenly over a 24-hour period. As the New England Company became more dominant in its position and demand continued to grow, the company needed to find its own seasonal steam power backup and build more stations. Satisfying these needs would require contracts with steam power producers, large investments in land, and costly reservoir construction (Landry and Cruikshank 1996:42–43).

World War I caused severe shortages and a drastic increase in the cost of power. The price of coal doubled and the workforce was severely reduced, inspiring a push toward conservation and the adoption of daylight savings time. New construction was limited to connections to areas of strategic military importance, forcing small utilities to buy power from larger utilities, which were better able to balance power distribution to accommodate shifting needs. Despite rate increases caused by wartime shortages, annual kilowatt sales between 1916 and 1920 grew from 246 million to 431 million. The war also fostered an interconnection of transmission lines among utilities and, by 1920, the New England Company controlled 300 miles of line, a fivefold increase from a decade earlier, creating a network that stretched from Lake Erie to the Atlantic Ocean. To ease the wartime power shortage, the U.S. Department of the Interior agreed to work with the New England Company to pay for the Davis Bridge Development (later named Harriman) in Whitingham, Vermont, completed in 1924. The Harriman Development supplied 40,000 kW, almost doubling the total output of the Deerfield River. The facility's large size necessitated the construction in 1927 of a smaller hydroelectric station downstream at Sherman to even out any sudden discharges (Cavanaugh et. al. 1993b; Landry and Cruikshank 1996:52–53).

Despite the large scale of the Harriman development, demand for electricity continued to increase beyond the available supply. Much of this demand came from residential customers who were beginning to use electric appliances and electric lights. In 1918, less than one-third of American homes were wired for electricity; by 1929, the number had grown to more than two thirds. Therefore, as soon as Harriman was finished, the company broke ground at a site 30 miles north of Vernon at Bellows Falls, the downtown location of a small subsidiary known as the Bellows Falls Power Company. This company had been created by Chace & Harriman in 1912 through the purchase and reorganization of a canal company and two small hydroelectric companies. In 1918, they decided to rebuild the canal and build a new power station, guaranteeing the Fall Mountain Paper Company (partial owners of the water rights) a supply of electricity. Within eight years, the paper company shut down and sold their water rights to Bellows Falls Power. The construction of a new hydroelectric station began immediately, despite delays caused by the flood of 1927 (Figure 3-4). While the old canal provided one million gallons of water per minute and produced 10,000 horsepower (hp), the new canal was able to send 4.2 million gallons per minute to the turbines, providing

Figure 3-4. View of Bellows Falls Project while under construction on May 27, 1927, looking north-northwest. Excavations and structural framing for the Powerhouse and Tailrace are outlined at lower left (TransCanada collection).

60,000 hp to produce 49,000 kW. This dramatic increase in water capacity was achieved through the construction of a new dam, which was slightly higher than its predecessor. Although the head was only 60 ft, the power capacity of the Bellows Falls station matched that of Harriman (Landry and Cruikshank 1996:59–62, 72).

International Paper Company and the New England Power Association (1926–1947)

After World War I, the New England Company was desperately in need of financial backing and feared the loss of its customer base to the larger holding companies that had emerged in the prosperous years after the war. To assuage these worries, Chace and Harriman decided in 1926 to sell most of their company to the International Paper Company. While the International Paper mills were no longer economical paper producers, they were still capable of creating hydroelectric power. Archibald Graustein, president of International Paper, was open to replacing his failing paper empire with a power empire. At the same time, Chace and Harriman were anxious to get an infusion of equity capital from International Paper, thereby allowing their company to launch a counterattack against bigger companies and establish a larger customer base. Therefore, Graustein, Chace and Harriman developed the New England Power Association (NEPA), which was essentially a compilation of its old holding companies and all of its subsidiaries. International Paper, Northeastern Power, and Stone & Webster were ceded a majority position in the enterprise in exchange for $20 million, and Chace and Harriman retired to the board of directors. This reorganization was followed by a wave of acquisitions handled by the newly hired president, Frank Comerford. Even with the increased efficiency and capacity of the existing hydroelectric stations, the most efficient power sources continued to combine steam and waterpower, leading Comerford to purchase a gas company, multiple retail units, and more steam plants before the onset of the Depression (Landry and Cruikshank 1996:65–84).

Harriman had purchased the rights to an area known as Fifteen Mile Falls on the Connecticut River in 1910. At the time, the Falls' low volume made development impractical, and Harriman soon sold his rights. Immediately after Chace & Harriman's reorganization in 1926, however, NEPA was more confident and re-purchased the site. The Falls' power potential was high, allowing for two large reservoirs of an extremely high volume. Unfortunately, NEPA's customer base was not large enough to justify building at such a large, yet cost-efficient size. To solve this problem, Comerford arranged a deal with Boston Edison in which that company would buy one-third of the station's output (150 million kilowatts [kW]) at $2 million per year for 20 years. Thus began one of NEPA's greatest engineering feats. To divert the river, reshape the old river bed, and build the dam, NEPA excavated more than 1 million cubic yards of rock, mixed and poured 300,000 cubic yards of concrete, and consumed 5,000 tons of structural steel. A small town of workmen emerged on a hillside in Barnet Township, Vermont, to construct the complex, which doubled NEPA's peak capacity for hydroelectricity by adding 160 megawatts and saving 200,000 tons of coal that would have been needed for steam power. Water first spun the turbines in September 1930 after a month of accumulation in the reservoir behind the dam. Aptly named "Comerford," the station transmitted power to a switching station in Tewksbury, Massachusetts, traveling 126 miles through 2,000 steel towers and over 800 miles of aluminum cable (Landry and Cruikshank 1996:87, 90–91).

NEPA had planned three projects at Fifteen Mile Falls. The second project was located seven miles downstream from Comerford. A small auxiliary plant, the new facility was designed to even out any sudden discharges of water. This plant, called McIndoes Falls, came on line in 1931, one year after Comerford, bringing the Fifteen Mile Falls capacity to a total of 175,300 kW (Figure 3-5). The stations at Comerford and McIndoes Falls were both designed by Charles T. Main. The development of the third site at Fifteen Mile Falls was postponed until a further increase in demand warranted the investment (Landry and Cruikshank 1996:90–91, Cook 1991:18–19).

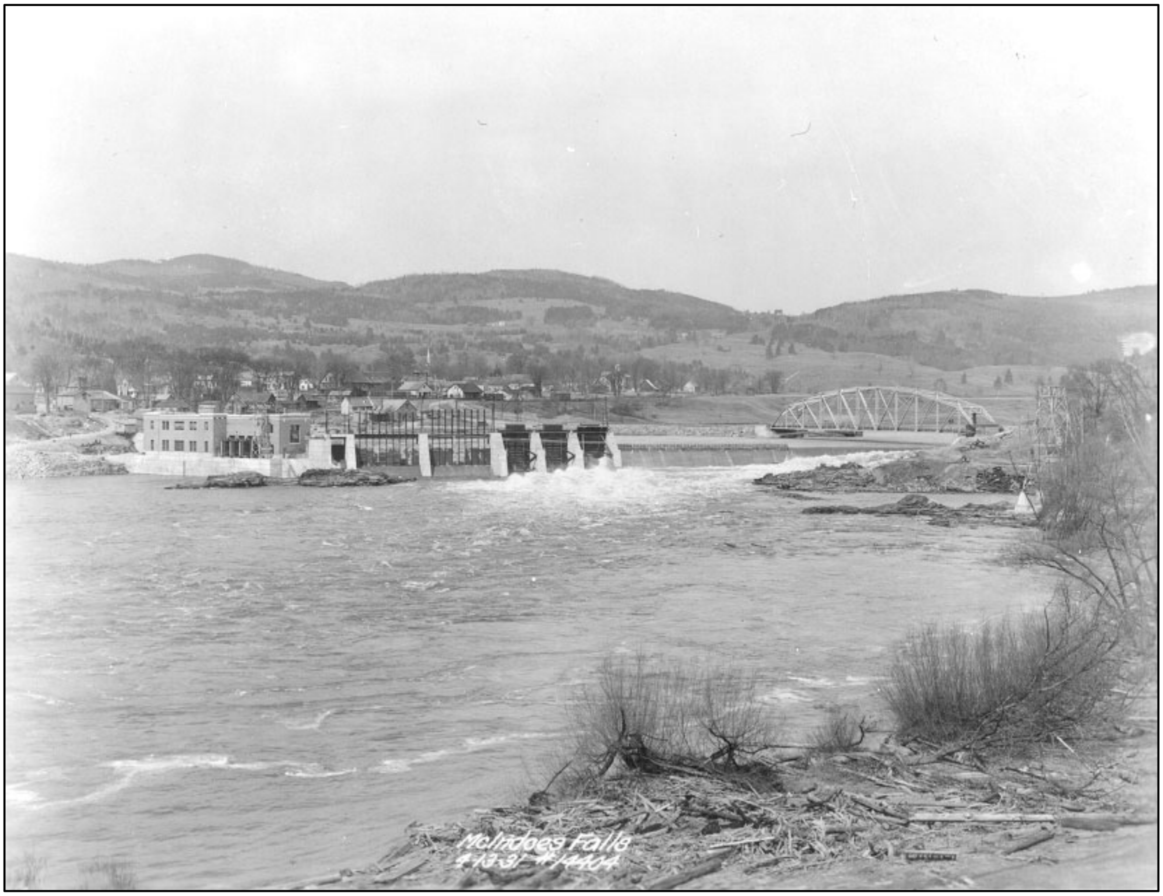

Figure 3-5. McIndoes Falls Development, Monroe, NH/Barnet, VT, built 1931. April 13, 1931, view looking northwest from the New Hampshire side of the Connecticut River, showing, from left to right, the powerhouse and dam.

NEPA's period of expansion in the early 1930s came to a halt with the Depression, as the company struggled to pay for McIndoes Falls. Investors were scared off, emergency taxation was introduced, andNEPA was plagued with cumbersome finances, an overly complicated organization, overcapitalized holdings and several new businesses. A series of natural disasters also plagued the company during the 1930s, including the great flood of 1936 and the Hurricane of 1938, both of which caused damage to several of NEPA's facilities. In 1932, the company's retail sales, which had always risen, declined for the first time and employment levels fell. When enraged investors forced the government to investigate utilities after the market crash, NEPA's convoluted financial organization was disclosed and the company was forced to implement an immediate simplification of the corporate structure. The Federal Trade Commission then passed the "Public Utilities Holding Company Act," which prohibited holding companies that unnecessarily complicated corporate structure and gave the Federal Power Commission the power to regulate interstate utilities. After working with the government on this issue, Harriman resigned; Comerford became president of Boston Edison; and International Paper and many of its subsidiaries were liquidated.

The Depression also spurred several positive changes, allowing NEPA to emerge as a stronger company when the economy finally bounced back. Government intervention made NEPA independent again by 1947 and created a simpler organizational structure. The lower demand forced a decrease in rates, and an intensification of "load-building" programs—aggressive marketing and merchandising programs designed to increase residential demand. NEPA sold appliances to increase household electricity use and pushed for rural electrification by encouraging the agricultural use of utilities. By 1940, demand was again rising and employment was up, allowing NEPA to incorporate line extensions and upgrades (Landry and Cruikshank 1996:93–119).

With the onset of World War II, reliable and increased levels of electrical capacity were essential and NEPA therefore resumed and accelerated improvement projects that had languished during the Depression. In 1941, new executives including President Irwin Moore and Vice-President William Webster took up leadership of the company, guiding it through the war-time challenges. War production increased electricity demand, but the company simultaneously faced a severe curtailment in fuel oil for its power plants. This difficulty was overcome by the conversion of many power plants to coal, and also offset by limited increases in civilian energy use during the war. Many NEPA employees had left, and those that remained were under pressure to meet the heavy demands of the many military and war-related factories despite severe shortages of labor and materials. Many of NEPA's employees also worked with the government to speed the transition of new weapons from experimental to operational. This advanced technical involvement gave NEPA the experience that later would give it a prominent role in post-war energy planning (Landry and Cruikshank 1996:121–135).

New England Electric System and Deregulation (1947–Present)

On June 3, 1947, NEPA was renamed New England Electric System (NEES), creating a new holding company and refinancing all other assets, including 3 wholesale companies, 36 retail companies, a service company, a street railway, and 4 miscellaneous companies. At the same time, a number of large shoe and textile manufacturers began to close, bringing unemployment to New England and threatening load growth. The public began to blame utilities, which were consistently more expensive in New England than elsewhere in the country. Contrary to popular belief, utilities were expensive because of the higher costs of transporting fossil fuels over a large distance and the need for materials to withstand harsh weather. In addition, the failure of businesses was due less to high utility bills and more to increases in unionization, wages, and taxation. The public also failed to acknowledge its increasing use of electricity, noting only the rising total cost. Regardless of the facts, dissatisfaction quickly led to the demand for public utilities. As the economy became more diversified, however, new jobs were offered at higher wages, increasing load and eventually silencing the outcry against private utility companies (Landry and Cruikshank 1996:137–149).

Despite the fact that hydroelectric power remained economical, post-war development included only two new hydroelectric plants, both on the Connecticut River. These complexes were the last conventional hydroelectric stations on the Connecticut River brought into the NEES system. In 1950, a $16-million, 33-megawatt plant went online in Wilder, Vermont, 40 miles north of Bellows Falls (Figure 3-6). This plant replaced an earlier facility called Olcott Falls and experienced substantial local opposition. The new 2,000-foot-wide dam raised the water level 15 feet, and while extending the existing pond 27 miles upstream, did not increase flood related impacts. Steep banks kept flooding to a minimum, affecting only 1,200 acres of land, including 335 acres of farmland. To ease tensions, NEES agreed to pay for the flooded land and to move any affected utilities such as railroads and roads (Landry and Cruikshank 1996:149–151; Lee 1949).

The new Wilder complex met some of the increasing peak electricity demand, but in 1952 a group of utility executives known as the Electric Coordinating Council of New England issued a dark forecast. They predicted that peak load requirements would more than double over the next 20 years, from 3,800 megawatts to 8,000 megawatts. The generous reserve margins of the depression era had dropped to 16 percent, meaning that even more peak-load power would be needed. Bob Brandt, the head of power planning in the 1950s, worked with the Federal Power Commission and neighboring utilities to ensure that New England would remain covered. Only one potential site remained undeveloped: the property at the

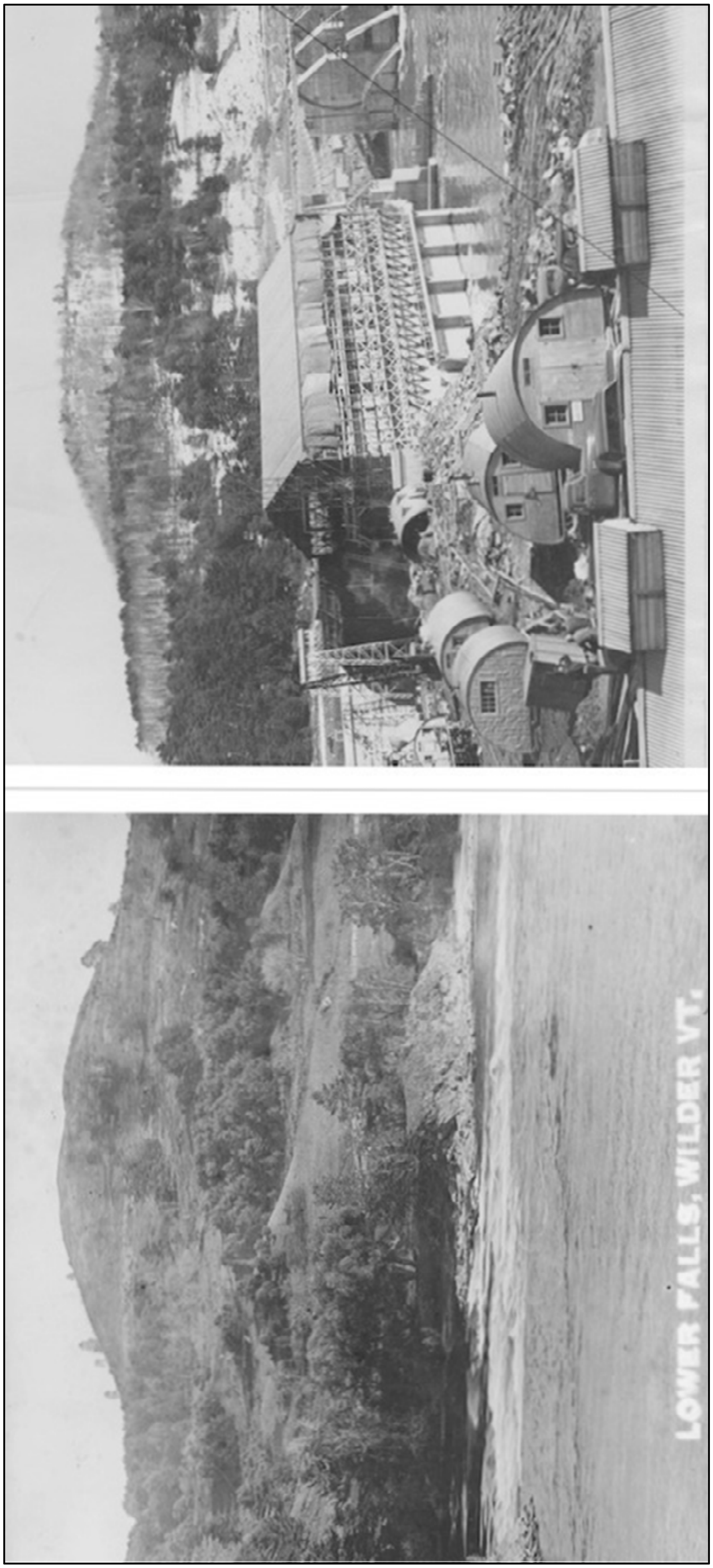

Figure 3-6. Historical photographs of Olcott Falls and the Wilder Project before and during construction, looking east from Vermont to New Hampshire (TransCanada collection).

upper part of the Fifteen Mile Falls area, originally purchased in the 1920s. Although the site's development would have been excessive and impractical several decades ago, NEES was now criticized for taking so long to build an additional station. The new Samuel C. Moore station (named after President Irwin Moore's father and the company's longtime general manager) resembled Comerford in size and construction, with a massive concrete and earth core dam that created a reservoir covering 3,500 acres. The powerhouse, with four identical turbines producing 190 megawatts at full capacity, was located below the dam. The $41-million project took three years to complete, and employed 500 people. It was $9 million below budget and began producing electricity in 1957. This large conventional hydroelectric project allowed the Connecticut River to operate as a hydropower delivery system, combining multiple reservoirs and powerhouses. As the river wound from Moore to Vernon, each cubic foot of water produced 37 kW-hours for the system. Downstream stations added an additional 530 megawatts and the Deerfield tributary another 110 megawatts. No other river of comparable length in the country could equal the Connecticut for hydropower development (Landry and Cruikshank 1996:149–150).

In 1954, President Eisenhower signed Senator John Pastore's bill allowing the private development of nuclear power. NEES' vice president, William Webster, who had returned from consulting on the wartime Atomic Energy Commission in 1951, was convinced that nuclear power was the energy of the future. He arranged a consortium of nine northeastern and midwestern companies to study the commercial applications of nuclear fission. Webster announced the formation of the Yankee Atomic Electric Company as soon as the bill was passed. He wanted all the regional utilities to share in the benefits and the risks inherent in the development of the new technology. Nine other utilities, and key government officials, businesses, and the press, decided to back the project. In 1957, after the completion of a smaller experimental facility by Westinghouse and Stone & Webster at Shippingport, Pennsylvania, construction began on the plant at a cost of $39 million, well below the $57-million estimate. It was the second commercial atomic plant in the country and set many of the standards for subsequent reactors (Landry and Cruikshank 1996:162–167).

In the 1960s, regional prosperity and lower-cost power put NEES in a stronger operating position. Substantial savings from continual consolidation and the growing use of computers simultaneously allowed for wage increases and a decrease in electrical rates. These two factors combined with tax cuts to allow New England to reach the national average in economic and load growth despite its limited population increase. By 1962, NEES' electric properties had been consolidated along functional lines into one retail company, a single-power wholesaler, and a service company in each state. Webster, president of the company since 1959, saw three possibilities for increased prosperity: lower costs through newer plants, economies of scale through higher loads, and lower fuel costs. NEES had completed its first full-scale nuclear power plant in Rowe, Massachusetts, in the Deerfield River Valley, in 1960. Looking at the success of that plant, Webster decided to seek further prosperity by increasing the number of nuclear plants in the system. In response to the blackout of 1965, Webster also believed in power pooling with other regional utilities and sharing resources in times of natural disaster. Consequently, the New England Power Exchange (NEPEX) was organized in 1967 to link all utilities to prevent shortages or blackouts. Shortly thereafter, the New England Power Pool (NEPOOL) was formed to develop region-wide power dispatching (Landry and Cruikshank 1996:170–195).

The beginning of the fuel crisis in America was marked by a sharp increase in the price of imported oil in 1973. Escalating inflation exacerbated the crisis, causing many power companies to return to burning coal despite a heightened public awareness of and sensitivity to pollution. NEES began a large-scale initiative to lower costs, improve finances, and develop a new customer relations strategy. Nuclear plants, which had been the hope of the future, were no longer tenable because of high interest rates, skeptical investors, and grass-roots environmental opposition. Thus NEES began a new strategy based on conservation and domestic fossil fuels and a concentration on domestic oil exploration. A large research and development department was created to explore alternate fuel sources and ways to reduce pollution. The company also established conservation and load management to minimize capacity requirements, diversified energy sources, and purchased power from plants that ran off of renewable energy sources such as trash, solar power, and wind. Together, these changes reduced dependence on imported oil, allowing the country and the company to weather the crisis (Landry and Cruikshank 1996:199–229).

When economic prosperity returned in the 1980s, the focus on cost-consciousness and conservation remained. Most of the steam-generating units had been converted to coal and fuel prices fell dramatically. NEES emerged from the 1980s poised to face any future restructuring with stronger finances, an improved generating position, and slow load growth. The public's ever-increasing environmental awareness, however, caused a number of small, yet significant changes. While hydroelectric plants are on balance non-polluting, they can prevent fish from migrating upstream to spawn. In the early 1980s, state wildlife officials required NEES to construct "fish ladders," which channel fish around dams and turbines. These bypass mechanisms, built at a cost of $10 million each, were installed at Vernon in 1981, and later at Bellows Falls and Wilder, allowing anadromous fish such as Atlantic Salmon and shad to reproduce. By the 1990s the fish population in the Connecticut River had again reached healthy levels (Landry and Cruikshank 1996:231–242).

The 1990s hailed the concept of deregulation, which created a more competitive power-generating market that allowed private power producers to utilize extant transmission and distribution systems, thereby providing consumers with a wider choice of producers. This development caused many large utilities, including NEES, to agree to separate power generation from transmission and distribution. In the case of NEES, the switchyards and generator step-up transformers at the Connecticut River projects were sold to National Grid. Later in the decade, NEES was bought by U.S. Generating (subsequently known as U.S. Generating New England and eventually PG&E Generating. TransCanada acquired all the Chace & Harriman and successor companies' Deerfield and Connecticut River projects in 2005.

Hydropower Technology on the Connecticut River

At the end of the nineteenth century, hydroelectric generating technology was in its infancy, and used equipment configurations adapted from textile mill practice and other water-powered industrial applications. During the first quarter of the twentieth century, hydroelectric engineers developed a variety of water delivery systems and standardized mechanical and electrical equipment that allowed generating capacity to meet growing demand. The former Chace & Harriman Connecticut River projects incorporate a range of water delivery infrastructure and generating equipment reflecting the history of hydropower technology from its earliest forms to mature industry standards.

The Vernon Development (1909), Chace & Harriman's first hydroelectric station, was conceived as a single project. Vernon was important technologically as the first northeastern U.S. hydroelectric plant built remote from a load center to deliver its load via long-distance transmission lines. Transformers at Vernon raised the electricity to 66 kV, enabling it to be transmitted over 60 miles to Gardner and Fitchburg, Massachusetts, a voltage and distance unprecedented in the Northeast. When Chace & Harriman turned their attention to the Deerfield River (1911–1927), they envisioned developing the whole river drainage as an integrated, multi-station system, much like the Big Creek and other hydroelectric systems being developed in California. Upstream reservoirs at Somerset (1911) and Harriman (1924) ensured a reliable, regulated flow of water, and re-regulating facilities like Sherman (1927) reduced the upstream peaking plant discharge upstream of the daily run-of-river powerhouses below. This integrated, river-as-system approach was also used by the New England Power Association and New England Electric System to develop the three Connecticut River projects at Fifteen Mile Falls, Comerford (1930), McIndoes Falls (1931), and Moore (1957), where McIndoes absorbed surges of water from Comerford and Moore.

Hydroelectric facilities incorporate two types of water delivery systems: concentrated-fall and divided-fall. In a concentrated-fall system, the dam and powerhouse are integral or closely spaced and the impoundment behind the dam acts as a forebay that provides water directly to the powerhouse. In a divided-fall system, the dam and impoundment are located at some distance from the powerhouse. Divided-fall systems are usually found in more rugged terrain, such as that found along the Deerfield River. On the wide Connecticut River, which has a more regular flow, most hydroelectric projects are the concentrated-fall type, with the noteworthy exception of Bellows Falls, where the presence of the existing village and the river geography required that the Dam and impoundment be set over 1,700 feet upstream of the Powerhouse, and the three connected via a large power canal.

Damming the Connecticut River for hydroelectric projects involved considerable feats of engineering and logistics to divert the river flow and construct dams on the river bed. Larger dams on the Deerfield River, which were not subject to the possibility of overtopping, used variations on the hydraulic-fill method in which a series of parallel dikes of rock and earth were built up with dump cars or railroad cars and water was sluiced over the dikes to wash the loose material into the space between them to form a core that was impervious to water (Hay 1991:53). However, the dams on the Connecticut River incorporated ogee-profile, gravity-type spillway sections. Gravity dams rely on their own weight on their bedrock foundation to hold back the water behind them. The first concrete gravity dam was built in San Mateo, California, in 1887 (Hay 1991:xix). This type of dam was a departure from the rock-filled wooden crib dams that were typical in New England at the time and came into standard use in the region during the first quarter of the twentieth century (Cook 1991:18–19). Former Chace & Harriman gravity dams are typical in their linear form and ogee profile and these dams incorporate a variety of height-regulating equipment such as flashboards and sluice gates. Most of the larger dams use tainter-type gates; however, the Bellows Falls dam (1928) is unique on the Deerfield and Connecticut rivers for its use of roller-type gates.

In addition to constructing new water delivery infrastructure, Chace & Harriman and successor companies also adaptively reused and modified preexisting industrial waterpower infrastructure for subsequent hydroelectric development. This was not an unusual practice in New England, where many major waterpower privileges had been developed for industry (Hay 1991:44). Examples include the use of the International Paper Company's mill rights and power canal at the Bellows Falls Development on the Connecticut River, as well as several developments on the Deerfield River.

One of the most important improvements in hydroelectric technology was the development of the modern vertical-shaft turbine-generator unit, which dictated the configuration of powerhouse infrastructure, including the penstocks, generator room, and foundation substructure. About 1900, most turbines were set vertically, which was a more efficient orientation hydrologically. However, the thrust bearing technology required to practically link vertical turbines and generators had not yet been developed, and most electrical generators were designed for horizontal shaft operation. Early vertical-shaft hydroelectric turbine-generator configurations consisted of single- or multiple-runner Francis-type fixed-blade turbines set into open flumes, where the weight of the water in the open flume pressing against the turbine blades spun them by force of gravity. Horizontal Francis turbine-generator settings placed the turbine in a cylindrical steel case that was prone to efficiency-robbing turbulence and made maintenance of submerged bearings problematic. These were the limitations of the two basic turbine-generator configurations when Chace and Harriman began planning their hydroelectric projects.

The first practical direct-connected vertical turbine-generator units were developed in 1905 by Gardner S. Williams and placed into service in a hydroelectric plant at Sault Ste. Marie, Michigan. This new technology may have influenced the choice for vertical units at Chace & Harriman's 1909 Vernon powerhouse, which incorporated vertical turbine settings with triple Francis runners in open flumes for the first eight units installed. These generating units were a hybrid of new and old technology: they incorporated new vertical bearing technology with open flumes and stock pattern turbines, which were typical of lower-efficiency, late nineteenth-century mill waterpower technology (Hay 1991:65–67).

Early vertical thrust bearings, however, were maintenance-prone because they used mechanical ball, cone, or roller bearings that wore out rapidly. This may have prompted Chace & Harriman to choose horizontal shaft settings for its Deerfield Nos. 2, 3, and 4 developments built in 1911–1913, with turbines set in cylindrical, riveted sheet steel "boilerplate" cases with the shaft passing through a stuffing box into the powerhouse where the generators were located. Subsequent improvements in vertical thrust bearings incorporated pressurized oil-films, although these systems required pumps and extensive piping. In 1898, Albert Kingsbury developed the pressure-wedge thrust bearing, which did not require pumped oil. This bearing saw its first application in 1912 at the McCalls Ferry hydroelectric station on the Susquehanna River in Pennsylvania. The introduction of pressurized oil-film and Kingsbury pressure wedge-type bearings resulted in a dramatic change in hydroelectric plant design, as it made possible vertical-shaft turbine and generator settings of much greater size. By 1915, many plants were built with vertical settings (Hay 1991:71–75). The Deerfield Nos. 2, 3, and 4 developments are Chace & Harriman's only horizontal-shaft units; its other Deerfield River and all the Connecticut River projects incorporate vertical-shaft turbine settings using variations on oil-film bearings.

The development of successful vertical-shaft turbine settings led to advances in turbine efficiency. New powerhouse substructures began to be built with specially designed scroll cases surrounding the turbines. These spiral-shaped cast concrete or metal channels directed water into the turbine blades in a spiral motion, increasing the efficiency of the turbines. Improved elbow-shaped draft tubes were also developed to improve the efficiency of tailraces that carried water way from the turbines (Hay 1991:80–85).

In 1920, the New England Company added two new generating units to the Vernon powerhouse that consisted of two vertical-shaft, Francis-type, single fixed-runner turbines set into concrete substructures with scroll cases and draft tubes. The improved efficiency of this new technology prompted the company to reequip units 5–8 with improved wheel cases and runners to improve efficiency in 1921–1922. In 1923 and 1925, units 1–4 were radically redesigned with their triple-runner turbines replaced with single-runner units and updated substructures. All units were subsequently outfitted with improved, Gibbs-type vertical thrust bearings. The variety of turbines and substructures installed at Vernon is evidence of efforts to keep its equipment in line with industry advances over time (New England Power 1992: "Vernon Development"; New England Power System n.d.: "Vernon Station").

During the 1920s, increasingly large and powerful vertical-shaft turbine-generator units with improved thrust bearings and scroll case/draft tube substructures were used on the Deerfield River, particularly at Harriman, which was the largest hydroelectric power project east of Niagara Falls. These developments established the mode adopted for the New England Power Association's expanding development of the Connecticut River, starting with the Bellows Falls Development in 1928. After the Bellows Falls Development was completed, the Connecticut River projects, including Comerford, McIndoes Falls, Wilder (1950), and Moore, were dramatically larger in physical size and generating capacity. The increase in generating capacity was due to ever-increasing power of head, turbine runner diameter, and generator size. Harriman's multiple-unit, vertical-shaft, large-diameter, single-runner, Francis-type turbine arrangement, combined with oil-pressure bearings and special scroll cases and draft tubes, would all be incorporated into the Connecticut River developments. Technologically, these design attributes were typical of hydroelectric generating facilities in the mid-twentieth century that incorporated interconnected standardized equipment configurations to provide electricity to larger areas. The powerhouses incorporated the major elements that characterized large-scale hydroelectric generating technology at the time: multiple, vertical-shaft, single-runner, large-diameter, high-horsepower, low-rpm turbines with scroll cases cast into their foundations; vertical thrust bearings; and improved tailrace draft arrangements. The technological advances incorporated in the Connecticut River projects consisted mainly of changes in turbine blade design and speed control governors (Cook 1991:4; Hay 1991:xi–xii).

The Comerford Development was a massive undertaking and the largest hydroelectric project in New England when completed in 1930. The powerhouse generated 162,300 kW, twice the combined capacity of the three previous New England Power Association Connecticut River hydroelectric projects. The high generating capacity of these large units is evidence of the ability of technological advances to meet increased electrical demand. The Comerford turbine-generator units incorporate fixed-blade, Francis-type turbines. Although this type of turbine has its origins in nineteenth-century technology, the runners at Comerford and later, Moore Development (discussed below), are of modern design, incorporating highly efficient vane contours, and are appropriate for their high-head water sources that provide flows of little variation (Hay 1991:78–80).

In 1931, the McIndoes Development was built downstream from Comerford as a run-of-river station to even out any large releases of water from Comerford. It was not a high-capacity station; its most significant technological feature was its use of variable-pitch, Kaplan propeller-blade turbines, a first for New England (Cook 1991:26). The first Kaplan-type propeller runner in the U.S. was installed at the Lake Walk powerhouse in Del Rio, Texas, in 1929 (Hay 1991:xix). Kaplan-type turbines were smaller, lighter, less prone to debris damage, operated at higher speeds, and were more economical for low-head applications like at the McIndoes Falls Facility, where the volume of water was more variable (Hay 1991:79). The low-head Wilder Development also incorporated Kaplan-type, variable-pitch propeller turbines.

During the mid-1930s, a significant change took place in the technology of governor mechanisms that controlled turbine runner speed. Turbine governors used a feedback-loop system with a speed sensor attached to the generator shaft that actuated a hydraulic arm that controlled the wicket gate openings on the turbine, thus regulating its speed. All Chace & Harriman Connecticut River powerhouses up to and including the McIndoes powerhouse incorporated hydraulic systems with traditional flyball-type mechanical governors. By the 1920s, the Woodward Company of Rockford, Illinois, dominated the market for this type of equipment; during the mid-1930s, the company introduced governors with electromagnetic speed sensors attached to generator shafts that no longer required that governors be located close to turbines, and “cabinet” type governor stands could be placed almost anywhere near the unit (Hay 1991:88–89). The original hydraulic, flyball governor units were in place and in varying states of modification at McIndoes Falls and all other earlier powerhouses. The first-generation “cabinet” governor control units are still in place at Wilder and Moore, although they have been superseded by more modern equipment. At Comerford, the early cabinet governors have been removed and are stored at the Moore powerhouse (Cultural Resource Group and Louis Berger & Associates 1997:15).

The Moore Development, completed in 1957, has a generating capacity of 191,300 kW and remains the largest single development of a natural resource for power production in New England. Like Comerford, it uses conventional, although large, Francis-type, fixed-blade turbines appropriate for its high-head setting (New England Power 1992: “Moore Development”).

Automation and remote control are also part of the hydropower technology on Chace & Harriman’s Connecticut River hydroelectric systems. These developments were designed for full-time manned control and later were automated.[2] On the Connecticut River, the Moore and McIndoes projects are controlled from Comerford; the Vernon, Bellows Falls, and Wilder projects are controlled from the Consolidated Control Center (CCC) at Wilder (Cavanaugh et al. 1993).

[2] All of the Deerfield River developments were manually operated except for Searsburg, which, when completed in 1922, was said to be the largest fully automated plant in the United States. All the Deerfield River projects are now controlled from the Harriman powerhouse.

Chace & Harriman's Connecticut River hydroelectric projects are demonstrative of early- and mid-twentieth century hydroelectric generating technology. Only the earliest, triple-runner Francis-type turbines in open flumes at Vernon have been replaced. Turbine settings are typically Francis-type, fixed-blade wheels with specially designed scroll cases and draft tubes. However, Kaplan-type fixed and variable-pitch propeller type turbines are in use on the Connecticut River at the McIndoes Falls and Wilder powerhouses, and modern Saxo-type turbines were installed at Vernon in 2006–2008. The projects include a range of types of dams, spillways, gate mechanisms, water delivery systems, governors, and other mechanical and electrical equipment.

Hydropower Architecture on the Connecticut River

Architecturally, American powerhouses represent a synthesis of constant, highly specific functional and structural requirements and changing popular corporate architectural styles. Powerhouses are a specialized derivative of the "erecting shop," a type of industrial building designed to house moveable cranes for building large, heavy machines. These buildings required wide, open interior spaces unobstructed by interior support columns and incorporated steel-framed outer walls and trussed roofs, often enclosed in a masonry skin. The dimensions of powerhouses are primarily dictated by the size and number of generating units required and by the volume of the interior open space required for the structurally integral traveling crane used to install and maintain the interior equipment.

Because most early twentieth-century heavy manufacturing buildings were privately owned, out of the public eye, and designed to be purely functional, they exhibited little, if any, significant decorative elements. Early twentieth-century powerhouses, however, were often more visible, provided a public service, and were constructed by companies eager to promote an image of strength and reliability. Examples of precedents for elaborate clear-span-interior structures intended to convey a positive public image were banks and large urban railroad terminals that were often modeled after medieval fortresses, Roman baths, or other historical building types.

Throughout the history of powerhouse construction, the regular spacing of wide structural bays and the need for large quantities of natural interior light have inspired a variety of stylistic architectural surface treatments. Early twentieth-century powerhouse architecture was clearly influenced by a lingering Victorian historicism. Most of the architectural schemes for these powerhouses were spare and Classically derived, e.g., Deerfield Nos. 2, 3, and 4 (1912–1913) and Searsburg (1922) powerhouses, which were designed in a restrained Renaissance Revival Style scheme most evident in the large, repeated arched windows and decorative brickwork.

The Vernon Powerhouse (1909) was designed in a restrained Renaissance Revival Style scheme and its decoration includes elements of the Romanesque style, notably the triple machicolations repeated in the cornice in the west and south elevations. The Harriman (1924) and Bellows Falls (1928) powerhouses incorporated a variety of mostly Classical details, but also included skewed Gothic buttresses with cast stone trim at the corners. By the late 1920s, this "Powerhouse Renaissance" style was slowly abandoned in favor of a "Stripped Classicism" that incorporated rectangular windows instead of the previously ubiquitous arched ones and retained a more limited selection of masonry embellishments, such as at Sherman (1927) and at McIndoes Falls (1931). The Sherman Powerhouse was designed in a transitional style that combines the restrained Renaissance Revival style with the emerging stripped Classical Revival Style scheme that was becoming more common for large utility and industrial buildings. The building incorporates a Spanish terra cotta tile roof, a typical Renaissance Revival style roof cladding material, but lacks the hallmark arched windows characteristic of true Renaissance Revival style. The McIndoes Falls Powerhouse incorporates rectangular windows instead of arched windows and the decoration is limited to a thin continuous string course below the roofline.

During the 1930s, the influence of the Art Moderne style incorporated in new skyscrapers and institutional buildings led to the adoption of hybrid styles for industrial buildings that emphasized verticality, such as the Collegiate Gothic style chosen for the Comerford Powerhouse (1930). The building was designed in a Streamlined Moderne version of the Collegiate Gothic style, the most distinctive elements of which are the flat, pointed Gothic arches in the windows that are repeated in the downstream face of the dam, and the general emphasis on verticality. The widespread popularity of the Colonial Revival style manifested itself in powerhouse architecture, as seen at the Wilder Powerhouse (1950), which includes Colonial Revival features: elliptical arches, prominent gable roof returns, mock end chimneys, and ocular gable pediment windows. Ultimately, the functional tenets of Modernism resulted in the abandonment of historical references and decorative elements in powerhouse architecture in favor of buildings incorporating pure geometry and simple materials, such as the Moore Powerhouse (1957), which exhibits bold, sharp, rectangular form; lack of ornamentation; functional use of metal sash and copings; and glass block windows.

CHAPTER FOUR

WILDER HYDROELECTRIC PROJECT

Description

The Wilder Project is located in the towns of Hartford, Vermont, and Lebanon, New Hampshire. The concentrated-fall type hydroelectric development is sited on the Connecticut River at river mile 217.4, approximately 1.5 miles upstream of the White River and approximately 7 miles downstream of the Ompompanoosuc River (Figures 4-1 and 4-2; Photos 4-1 and 4-2).[3] The project utilizes and now covers Olcott Falls, a set of rapids that was the site of an earlier hydroelectric facility. Here, the river makes a slight bend from east to west as it passes the falls, and a natural promontory projects from the west bank of the river. The project is organized to take advantage of this promontory and river curvature, with the Wilder Dam extending on a roughly north-south alignment from the promontory to the opposite river bank. The Vermont-New Hampshire state line passes through the Wilder Dam and Powerhouse, and other buildings and structures for the project are located in both states. With 40–58 feet (ft) of usable head, two turbines of 23,750 horsepower (hp) each, and one turbine of 4,470 hp, the facility has a total generating capacity of 35,600 kiloWatts (kW). The Wilder impoundment (aka "pond") extends 45 miles upstream from the Dam and covers 3,100 acres.

Access to the project in Vermont is from Wilder Dam Road. This asphalt-paved road runs south into the project and onto the promontory and Dam berm. Access from New Hampshire is from North Main Street (NH State Route 10), which parallels the east bank of the river and runs close to the south end of the Wilder Dam, where a short asphalt-paved driveway runs into the TransCanada property and onto the Dam. The river banks and Dam berm where the buildings are set are largely cleared of woody vegetation and maintained as grass. Nine resources make up the existing Wilder Project within TransCanada-owned lands adjacent to the Connecticut River in Vermont and New Hampshire: the Wilder Dam, Wilder Powerhouse, the Oil Storage Shed, Garage, the Visitors' House, the Connecticut River Office (CRO), the Consolidated Control Center (CCC), and two Switchyards (Table 4-1). The resources are described below beginning with the Dam and Powerhouse, then moving to ancillary buildings and structures in New Hampshire and Vermont.

Wilder Dam

The Wilder Dam (1950) spans the Connecticut River and portions of the west and east banks in Hartford and Lebanon (Photos 4-3 through 4-6). The pondage created by the Dam acts as the forebay, supplying water directly to the Wilder Powerhouse and providing the head to power the turbines therein. The Dam structure consists of two sections: a 2,200-ft-long curving earth berm section (aka dike) that lies mostly in Vermont, and a straight 680-ft-long concrete spillway that lies mostly in New Hampshire. The earth berm widens gradually from north to south as it rises to a maximum height of approximately 35 ft. A 20-ft-wide asphalt driveway runs along the crest and an impervious blanket lines the upstream face of the berm below the impoundment level. The spillway commences with a 232-ft-long concrete abutment that extends off the

[3] Descriptive information is derived from field survey data, the 1999 *Deerfield and Connecticut River Documentation* (Doherty and Kierstead 1999), *Wilder Station: Project Description* (New England Power Company 1987) and project plans on file with TransCanada (New England Power Company 1985a, 1985b, 1985c, 1985d, 1988).

northeast corner of the Powerhouse behind the TransCanada Wilder Switchyard (described below). The remainder is a 59-ft-high, linear, poured concrete gravity-type structure built on bedrock and divided into several sections, described here from north to south. The northernmost section consists of the 159-ft-long Powerhouse substructure, which includes a mechanized trash rack cleaning gantry over the eight 20-ft-wide turbine intakes. The spillway to the south is a 521-ft-long ogee-profile gravity-type structure that includes a 10-ft-square skimmer gate, six bays of 30-x-36-ft tainter-type gates, four bays of 17-x-50-ft stanchion-type flashboards, and a 20-x-15-ft skimmer gate. A small, one-story, flat-roofed, brick-walled compressor house is at the north end of the Dam and provides water for a bubbler that keeps the water in front of the intake gates from freezing. A concrete switchback Fish Ladder (added in 1988) extends from the spillway near the south end of the Powerhouse, then descends across the west side of the building (New England Power Company 1992: "Wilder Development").

Wilder Powerhouse

The Wilder Powerhouse (1950) is in Hartford and Lebanon, built against the downstream face of the Wilder Dam spillway at that structure's north end (Figures 4-3 and 4-4, Photos 4-7 through 4-9, see Photo 4-5). The six-by-one-bay (183-x-46-ft), two-story (60-ft-high) building has a slate-sheathed gable roof, brick-clad, steel-framed walls, and a high concrete foundation that incorporates the turbine scroll cases and draft tubes. The Colonial Revival Style building has elliptical arches, prominent gable roof returns, mock end chimneys, and ocular gable pediment windows. A string course wraps around the building at the arch spring line. The six elliptical arch window bays on the long west elevation are divided by shallow piers and include cast stone keystones. Below the window line is a shed-roofed catwalk providing access to the operating mechanism for the turbine draft tubes shut-off gates. Four large sheet metal exhaust vents (for the generator ducts) extend from the foundation wall above the catwalk. The south elevation contains a single elliptical arch. Each of these arches contains a pair of tall, multi-pane, steel sash windows, excepting the southern-most bay, which has aluminum windows. The long east elevation is mostly covered by the Dam, with a narrow band of Powerhouse wall exposed beneath eaves and visible from the Dam crest. This wall features rows of metal ventilation louvers (air intakes for the generator ducts) and a projecting entrance providing access from the Powerhouse to the top of the Dam. The primary entrance is located in the north elevation and consists of a tall, motorized roll-type door topped by a windowed transom and set within an elliptical arch opening.

A lower, flat-roofed, two-story ell extends off the northeast corner of the Powerhouse to connect with the Dam, and is set in a triangular space between the two. The exposed north elevation includes a paneled wood personnel door set into Colonial Revival Style entrance with sidelights, brick columns, and a broken arched pediment with a granite keystone. Windows are multi-pane steel sash, and a steel railing runs along the top of the flat roof.

The Powerhouse interior is devoid of ornamentation, with exposed trusses and roof decking at the ceiling, brick walls, and red quarry tile floors. The interior of the main block of the building consists of the generator floor, an open, full-length, full-height space with a gallery level running along the east side of the space. Below this level is the turbine floor, which is entirely of concrete construction. The main block of the building houses three vertical-shaft generating units (numbered 1–3 from west to east). The two larger units (nos. 1 and 2) dominate the generator floor, are covered by sheet metal ventilation shrouds and have top-mounted exciters. The smaller third unit (no. 3) is located in the south end of the sub-level turbine floor. The two main units consist of S. Morgan Smith, vertical-shaft, 23,750-hp, 112.5-rpm, 180-inch diameter, single-runner, Kaplan-type, variable-pitch propeller turbines equipped with specially cast concrete spiral scroll cases connected to Allis Chalmers 16,200-kW alternating current generators. Each unit is controlled by a Woodward electromagnetic "cabinet" type speed governor mechanism between the units. The smaller

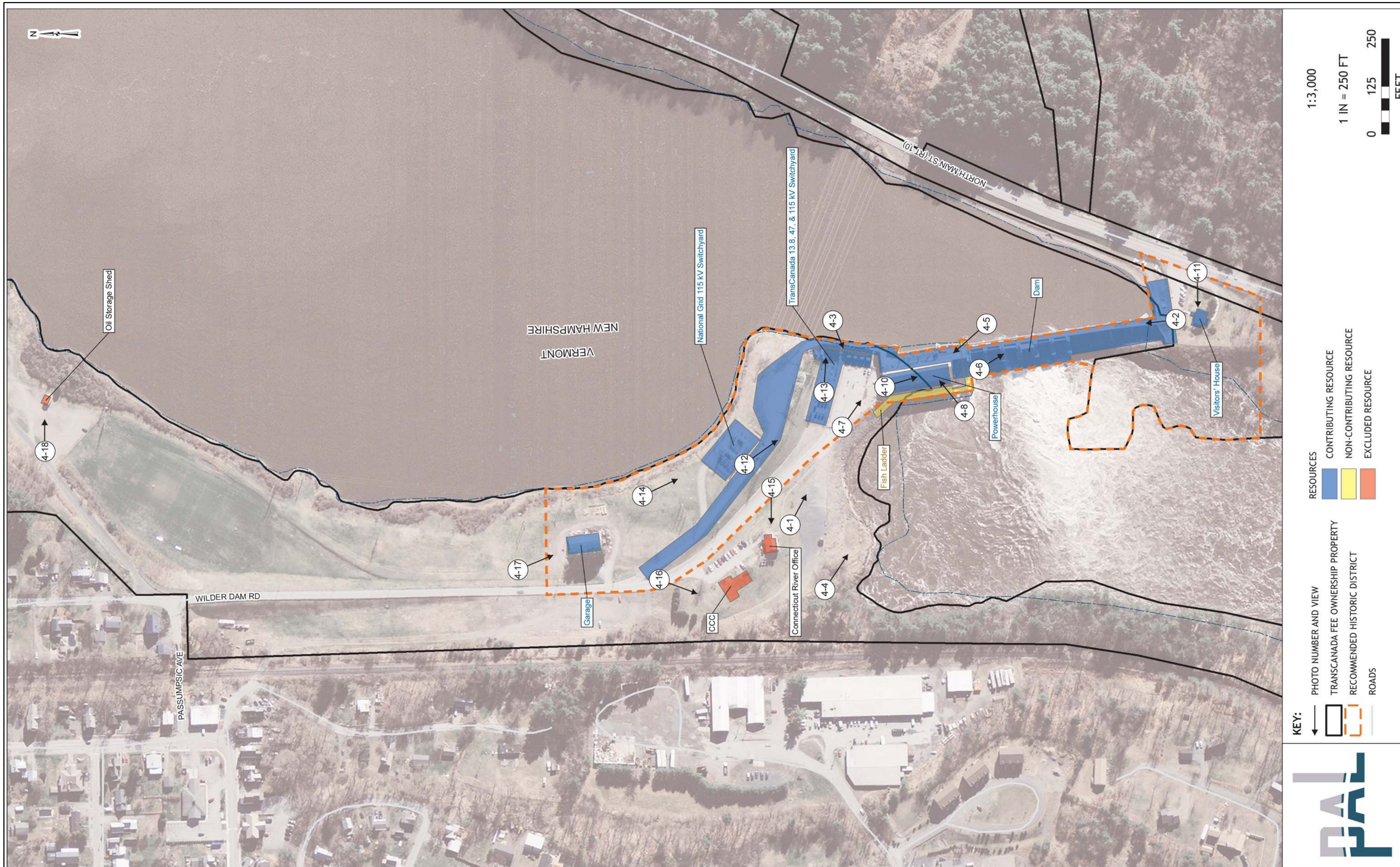

Figure 4-1. Plan of the Wilder Hydroelectric Project showing the location of the recommended Wilder Hydroelectric Development National Register Historic District.

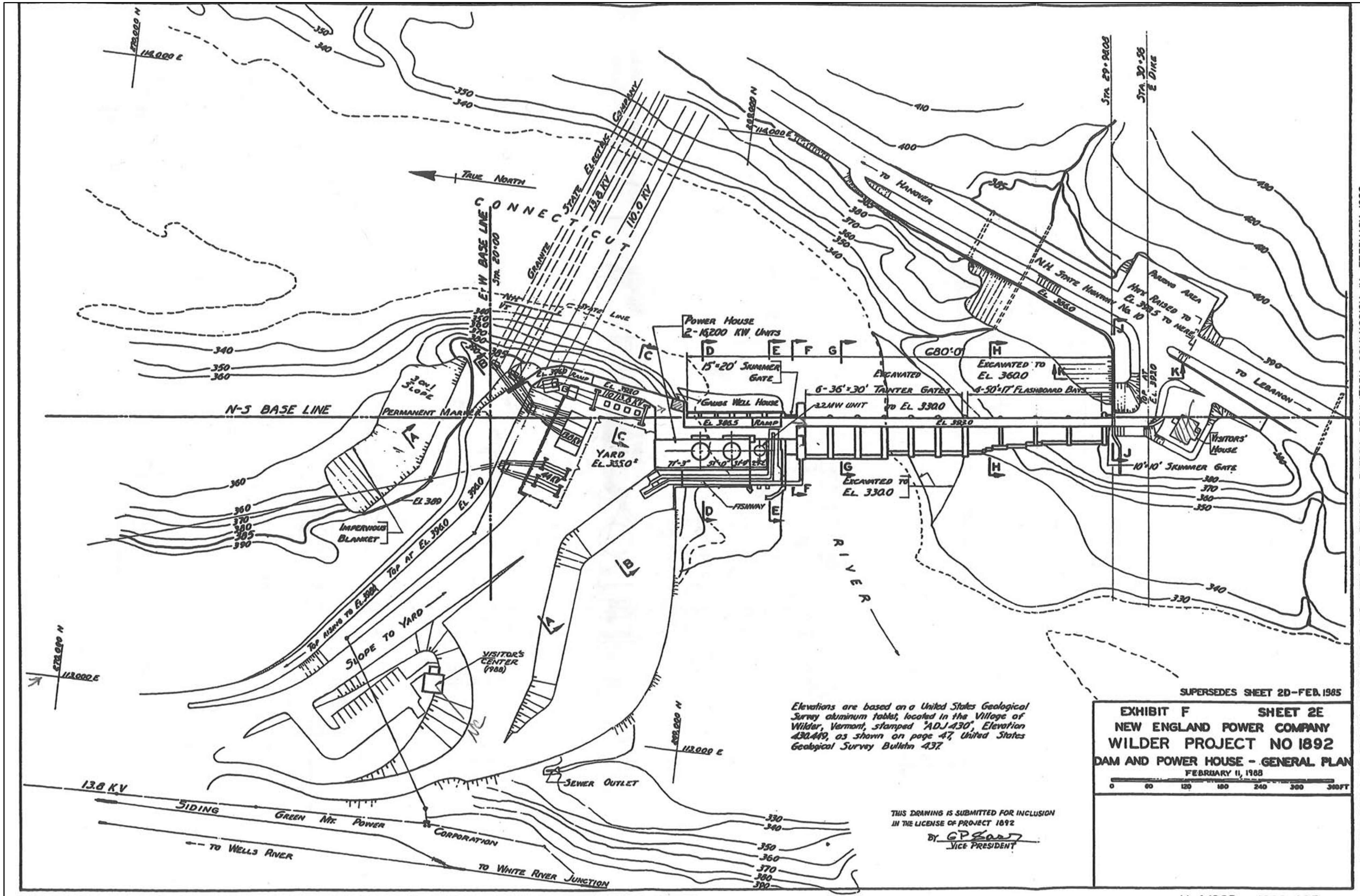

Figure 4-2. General plan of the Wilder Project.

Photo 4-1. General view of Wilder Project, looking south-southeast from Vermont toward the New Hampshire shore.

Photo 4-2. General view of Wilder Project looking north-northeast from the south end of the Wilder Dam, with impoundment to right.

Table 4-1. Wilder Project Existing Resources and Status within the Recommended Wilder Hydroelectric Development Historic District.

Resource Name	Location	Construction Date	Recommended National Register Status*
Wilder Dam	351 Wilder Dam Road, Hartford, VT; Rt. 10, Lebanon NH	1950	C
Wilder Powerhouse	351 Wilder Dam Road, Hartford, VT	1950	C
Visitors' House	Rt. 10, Lebanon, NH	1950	C
Garage	Wilder Dam Road, Hartford, VT	ca. 1950	C
Oil Storage Shed	Wilder Dam Road, Hartford, VT	ca. 1949	Ex
TransCanada 13.8-, 47-, & 115-kV Switchyard	Wilder Dam Road, Hartford, VT	1950	C
National Grid 115-kV Switchyard	Wilder Dam Road, Hartford, VT	1950	C
Fish Ladder	351 Wilder Dam Road, Hartford, VT	1988	NC
Connecticut River Office (CRO)	Wilder Dam Road, Hartford, VT	1988	Ex
Consolidated Control Center (CCC)	275 Wilder Dam Road, Hartford, VT	2014	Ex

*C = Resource that contributes to the significance of the recommended district.
NC = Resource that does not contribute to the significance of the recommended district.
Ex = Resource that is excluded from the recommended district

Photo 4-3. Wilder Project, Dam looking south from Vermont shore.

Photo 4-4. Wilder Project, Dam and Powerhouse, looking east from Vermont shore.

Photo 4-5. Wilder Project, Dam at Powerhouse substructure with east elevation of Powerhouse, looking north.

Photo 4-6. Wilder Project, Dam spillway, looking south.

Photo 4-7. Wilder Project, north end of Powerhouse, looking south.

Photo 4-8. Wilder Project, Powerhouse, looking northeast.

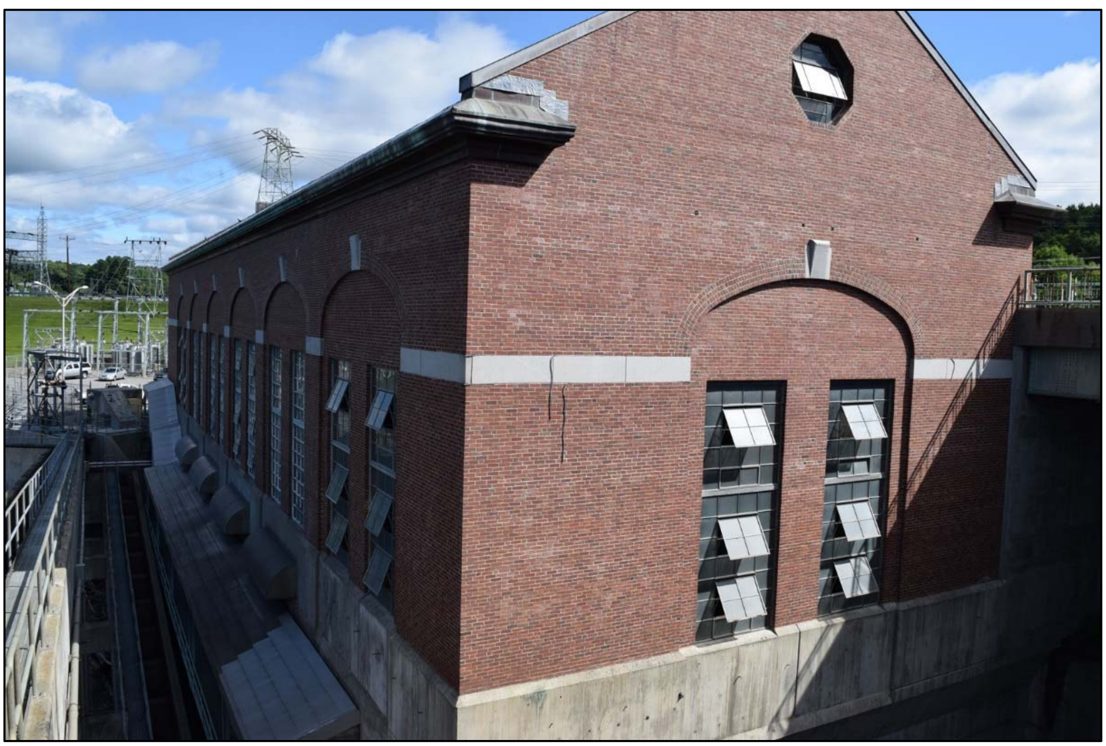

Photo 4-9. Wilder Project, interior of Powerhouse at generator floor, looking south.

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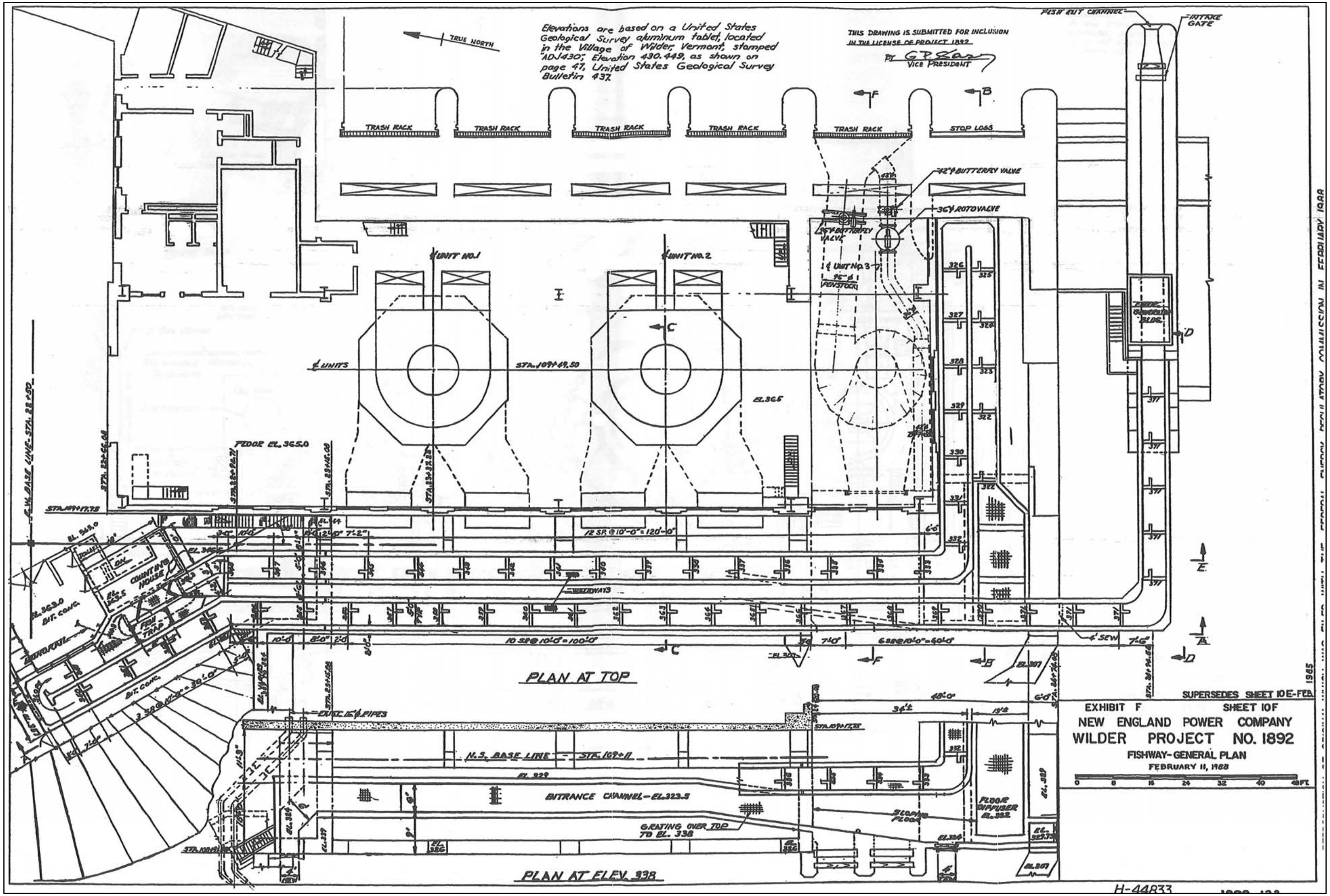

Figure 4-3. Plan of the Wilder Project Powerhouse and Fish Ladder.

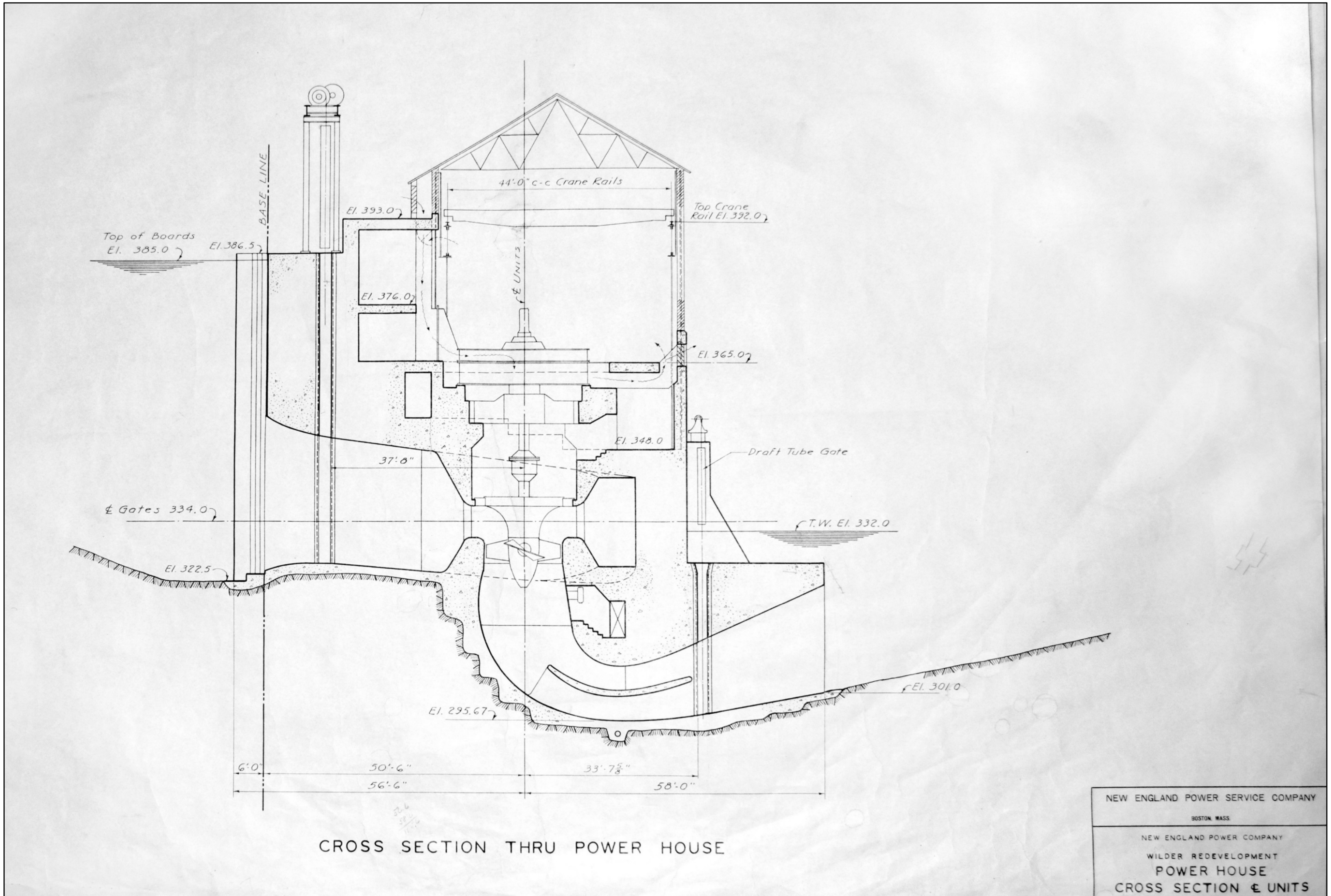

Figure 4-4. Transverse cross-section of the Wilder Project Powerhouse.

third unit, which is designed to operate under minimum flow conditions, consists of a Voith, vertical-shaft, 4,470-hp, 212-rpm, 72-inch diameter, single-runner, Francis-type, fixed blade turbine connected to a Siemens-Allis 3,200-kW alternating current generator with a Woodward governor. The entire generator floor is serviced by a 100-ton motorized horizontal traveling crane that rides on wall-mounted rails that run the length of the long axis of the building. The sub-level turbine floor is dominated by the octagonal poured concrete footings for the generators, within which are the turbine main shaft and thrust bearings. The space also includes oil tanks and pumps for the governor mechanisms.

The control room, machine shop, and ancillary spaces are located in the ell. The ground floor contains a lobby, restrooms, superintendent’s office, vault, storeroom, storage spaces, and a staircase in the southeast corner. The second floor contains a washroom, locker room, and a crew room. The operator’s room on the second floor overlooks the generator floor and contains a control panel consisting of a freestanding wall of panels containing an array of meters, switches, and monitoring equipment for the units. A gallery overlooking the units contains rheostats and other electrical equipment. The basement level includes a large machine shop with a variety of lathes, milling machines, and other machine tools (New England Power Company 1992: “Wilder Development”).

Fish Ladder

The Wilder Fish Ladder (1988) is a poured reinforced concrete structure on an L-shaped footprint that wraps around the southwest corner of the Wilder Powerhouse but is not connected to the building (Photo 4-10). It begins at the river below (west) of the Powerhouse draft tubes, and ascends via multipleswitchbacks over approximately 300 linear ft before terminating at the crest of the Dam spillway, approximately 25 ft south of the south end of the Powerhouse. The ladder rests on free-standing poured concrete piers and is subdivided by concrete baffles into multiple pools. A small fish counting house is near the base of the ladder off the northwest corner of the Powerhouse.

Photo 4-10. Wilder Project, Fish Ladder, looking south.

Visitors' House

The Visitors' House (aka Old Visitors' Center, 1950) is in Lebanon near the south end of the Wilder Dam on a level terrace facing north across the project (Photo 4-11). The remnants of a semicircular driveway extend off the south side of the building and are lined with mature maple trees. A steel flagpole on a concrete footing is set within the arc of the driveway. The one-story, side-gable building, which is executed in a rustic architectural style, is approximately 25-x-35 ft in plan with projecting entry vestibules on both side elevations. It has a standing seam metal roof (added since 1999) with exposed beveled rafter tails and a brick chimney on the interior of the south roof slope. The walls are sheathed in vertical board-and-batten from the eaves to a wood plank stringcourse at the building waistline, and horizontal, rounded planks from the waist line to the foundation. The entry vestibules on the north and south elevations have wood panel and glass doors set in narrow ogee-profile surrounds set under small pediments. The walls of these vestibules were added at an unknown date before 1999 and enclose formerly open-sided entry porches. The regularly spaced fenestration consists of large square openings filled with single-pane windows that replaced the original six-light windows at an unknown date. On the west elevation, facing the river, a band of tall observation room windows runs the width of the wall and wraps around the sides of the north and south elevations. The building rests on a concrete slab foundation. The interior, now used as offices, includes restrooms on the east side, and a large, open room to the west. The ceiling and walls are entirely clad and stained pine and feature a coffered plank ceiling with exposed faux beams, wood dentil crown moldings, vertical beadboard walls, and a horizontal beadboard wainscot.

Photo 4-11. Wilder Project, Visitors' House, looking southwest.

TransCanada Switchyard

The TransCanada 13.8-, 47- & 115-kV Switchyard (1950) is set in a fenced gravel yard at the base of the Dam berm, immediately adjacent to the Wilder Powerhouse (Photo 4-12). The function of the yard is to prepare current supplied by the Wilder generators for distribution. The yard contains bus towers for 13.8-, 46-, and 115-kV transmission lines (five total) and associated generator step-up (GSU) transformers and circuit breakers. All of the towers are of the bolted steel lattice type. A one-story Oil Pump House for transformer oil is in the northeast corner of the yard set against the concrete south face of the Wilder Dam (Photo 4-13). This one-story building has a shallow-pitched shed roof with copper gutters, brick walls, and a concrete slab foundation. A steel slab door is set on the east elevation, and a pair of steel sash windows with concrete sills are set on the south elevation. A steel ladder on the west side of the building climbs to a poured concrete platform, where two 4,000-gallon steel oil tanks are placed. Bronze light poles with glass globes are set at intervals along the yard's fence line.

Photo 4-12. Wilder Project, TransCanada 13.8-, 47-, & 115-kV Switchyard, looking southeast.

Photo 4-13. Wilder Project, Oil Pump House within 13.8-, 47-, & 115- kV Switchyard, looking north.

National Grid 115-kV Switchyard

Two switchyards are in Hartford, set along the earth berm section of the Wilder Dam, near the structure's north end (Photo 4-14). The National Grid 115-kV Switchyard (1950) is set on the upstream (north) side of the Dam berm. It consists of four bus towers and connecting girders set within a yard that is surfaced with gravel and surrounded with a chain link and barbed wire fence. Towers and girders are bolted steel, and circuit breakers, transformers and other electrical equipment are set at the base of the towers. The facility is owned by National Grid and is part of the regional transmission system that connects the Wilder Project to Barre and Bellows Falls, Vermont. It is one of five such transmission or distribution circuits fed by the TransCanada Wilder Switchyard, as described below.

Connecticut River Office

The Connecticut River Office (CRO) and CCC are in Hartford, adjacent to a paved gravel parking lot on the west side of Wilder Dam Road, approximately 400 ft south of the Garage and 600 ft northwest of the Wilder Powerhouse. The CRO was initially constructed as a Visitor Center for not only the Wilder Project but the associated retail electric company as a model energy conservation design based upon an architectural competition (1988). It is set on the crest of a steep slope facing southeast toward the Wilder Powerhouse and Dam (Photo 4-15). The three-by-two-bay, side-gable brick building has a rectangular footprint with a projecting entry set under a hipped roof on the east elevation. The building is two stories, with a walk-out lower level on its south (down-slope) side. It has a standing-seam metal roof with skylights, common brick walls, and a concrete foundation, which is visible on the south side. The fixed bronzed aluminum windows are grouped together in a variety of configurations and have brick sills and lintels. The windows on the south wall occupy almost the entirety of the elevation to provide an observation area overlooking the Dam. Doors are varnished wood and glass.

Photo 4-14. Wilder Project, National Grid 115-kV Switchyard, looking south.

Photo 4-15. Wilder Project, Connecticut River Office, looking northwest.

Consolidated Control Center (CCC)

The CCC (2014) is a one-story, cross-gable building on an asymmetrical, roughly L-shaped plan (Photo 4-16). The office building uses a New England vernacular building vocabulary of asphalt shingles, clapboard and shingle siding with plank trim (all apparently Hardie Plank or other synthetic/composite materials), and double-hung, two-over-two windows. The building rests on a slab foundation.

Photo 4-16. Wilder Project, Consolidated Control Center (CCC), looking southwest.

Garage

The Garage (ca. 1950) is in Hartford, immediately east of Wilder Dam Road, about 900 ft north of the Powerhouse (Photo 4-17). A rough gravel driveway runs around the building, which is set on a level, grassy site near the river's edge. The Garage is an approximately 40-x-120-ft, one-story, side-gable utilitarian building. It has a corrugated metal roof and siding and rests on a concrete slab foundation. The asymmetrically disposed fenestration and entries include a variety of window and door types framed in unadorned wood plank surrounds. Windows use six-light sash units that are paired in vertical openings to create vertical double-hung sets (now mostly covered with plywood and having unknown integrity) and paired in horizontal openings set under the eaves. Two corrugated metal personnel doors are located on the west elevation. On the north elevation is a two-leaf hinged vehicle door assembled from vertical wood planks. A light fixture with an enameled metal shade overhangs the door. Two vehicle doors on the west elevation have been removed since 1999.

Photo 4-17. Wilder Project, Garage, looking southeast.

Oil Storage Shed

The Oil Storage Shed (circa [ca.] 1949) is in Hartford, approximately 2,000 feet (ft) north of the Powerhouse on the west bank of the Connecticut River and within recreational use lands designated the "Kilowatt South Boat Landing and Athletic Field" (Photo 4-18). The utilitarian building, which faces south, is visually isolated from the rest of the project by sloping topography and vegetated river bank. The shed is a small, one-story one-by-three-bay, side-gable storage building on a rectangular footprint. It has a corrugated metal roof, pressed metal clapboard siding, and a concrete slab foundation. A steel slab door is set under a corrugated steel awning on the south elevation. The windows are covered with plywood panels. Louvered vents are set in the gable ends. No alterations have taken place to the building since the 1999 system-wide documentation was completed.

Photo. 4-18. Wilder Project, Oil Storage Shed, looking northeast.

Historical Development

Completed in 1950, the Wilder Project is the second to last in the series of 14 hydroelectric projects constructed along the Connecticut and Deerfield rivers and the fifth of six Connecticut River projects constructed by TransCanada’s predecessor companies in 1907–1957 (Figure 4-5). With demand for electricity increasing in the post-World War II period, the Wilder Project was designed to provide an additional supply source during peak demands for power and was one of only two such projects (the other is the Moore Development on the Connecticut River) that were built by TransCanada’s predecessor companies after the war, when there were few hydropower sites left with sufficient capacity to meet the emergent supply demands (Doherty and Kierstead 1999; Landry and Cruikshank 1996:38-40, 59-62, 90-91).

The Wilder Facility was a redevelopment project, replacing an existing hydroelectric plant at Olcott Falls that had been established in 1910 by the International Paper Company for its paper mill and village at the site. NEPA purchased the property in 1942 and obtained license to operate the existing hydroelectric facility in 1943. At that time, the Federal Power Commission (predecessor of FERC) observed that the existing plant was not fully utilizing the potential of the river at that location and stipulated that NEPA should

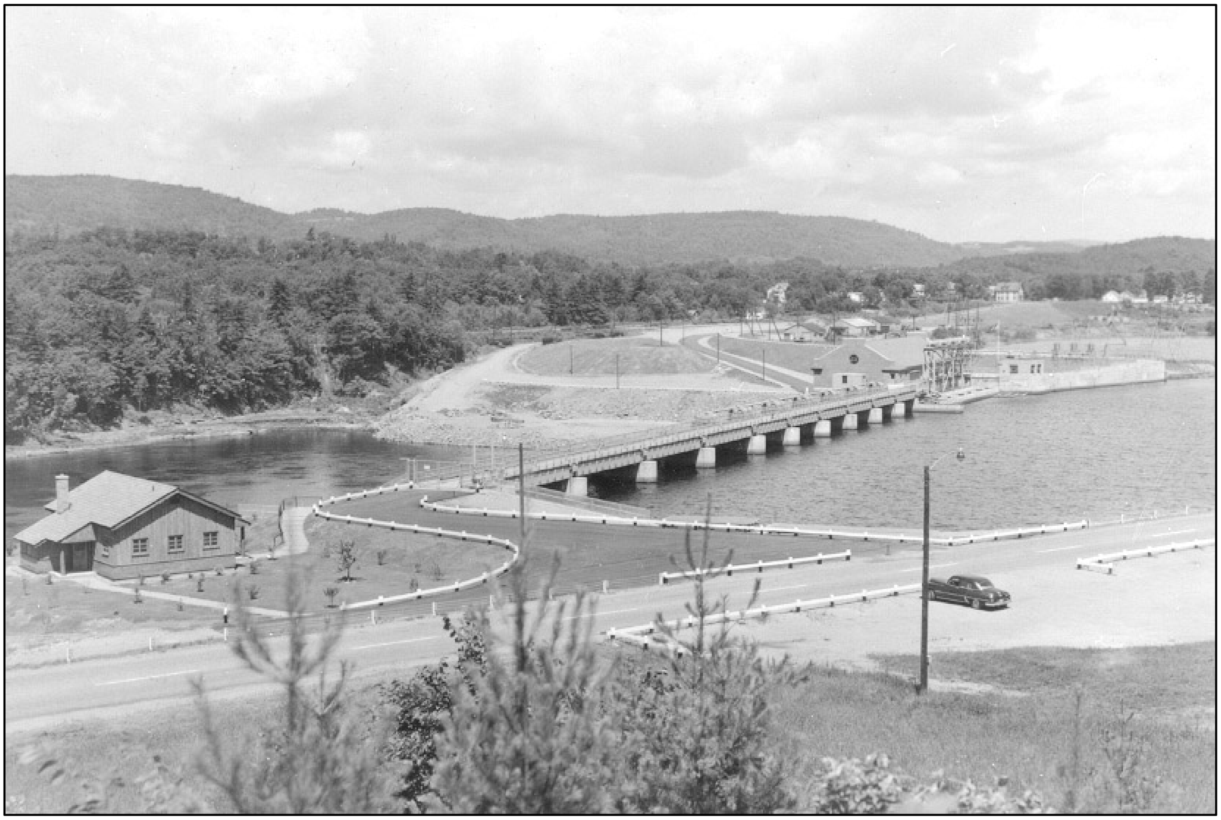

Figure 4-5. July 17, 1952, view of the Wilder Project, looking northwest from the New Hampshire side of the Connecticut River.

reconstruct the project whenever comprehensive planning that incorporated various uses of the river could be completed. NEPA filed redevelopment plans in 1944 and held hearings in 1944–1946. However, the potential 33-megawatt capacity, $16-million project faced significant public opposition because of the extent of the proposed flooding. The new 2,000-ft-wide Dam would raise the water level by 15 ft, extending the existing pond 27 miles upstream near NEES's McIndoes station. Ultimately, 1,200 acres of land, including 335 acres of farmland, were affected by flooding. In an effort to mitigate damages, NEPA agreed to pay for any submerged land and to move any affected utilities, including railways and roads. Conflicts over estimates of flooding had to be resolved in court, interrupting construction on several occasions, and the Wilder redevelopment was not completed until 1950. Design and construction of the project was completed by the New England Power Service Company and the New England Power Construction Company, respectively. Both of these firms were arms of NEPA (Doherty and Kierstead 1999; Harris 1951:3; Landry and Cruikshank 1996:149-151; Lee 1949:5-7).

The completed Wilder Project ranked as the fourth largest hydroelectric development in the NEPA system. Technologically, the Wilder Project is typical of mid-twentieth-century hydroelectric generating facilities, which were characterized by a variety of water management techniques and standardized equipment configurations that were interconnected to provide electricity to larger areas. The Wilder Powerhouse incorporates the major elements that characterize large-scale hydroelectric generating technology at the time, including multiple, vertical-shaft, variable-pitch, adjustable-blade, Kaplan-type, single-runner, large-diameter, high-horsepower, low-rpm turbines with scroll cases cast into their foundations; oil-pressure vertical thrust bearings; improved tailrace draft arrangements; and electromagnetic “cabinet” type speed governors. Architecturally, the Powerhouse demonstrates the continuing evolution of the historicism that typified the design of such facilities since the electrical industry was established. Power companies had favored high-style, dignified designs that could be used to legitimize and dignify their industry by conveying a positive public image. Earlier powerhouses constructed by New England Power Company and others favored the Renaissance Revival Style, and sometimes Romanesque Revival or Gothic styles. By the mid-twentieth century, however, the Colonial Revival Style, as evidenced at the Wilder facility, was increasingly favored for public and utility buildings as an expression of American patriotism and ideals (Cook 1991:4; Harris 1951:3; Doherty and Kierstead 1999; Hay 1991:xi-xii).

Original components of the development included the Dam, Powerhouse, Visitors' House, National Grid and TransCanada Switchyards, Garage, and Oil Storage Shed. The Dam, Powerhouse, and Switchyards are the only resources directly relating to electrical generation and distribution. The Garage and Oil Storage Shed are ancillary structures: the Garage houses maintenance equipment and a shop, and the Oil Storage Shed is designed to contain transformer and lubricating oils. These buildings are typical utilitarian support structures found within all the Connecticut River and Deerfield River hydroelectric projects. The Garage is similar in size, proportion, materials, and details to the garages at the Comerford and Moore projects, which indicates repeated use of an established utilitarian design. The Oil Storage Shed may be a prefabricated structure, although this cannot be confirmed; it is a small building sited on the road that formerly led to the 1910 International Paper Company hydroelectric development. A temporary substation with high tension transformers was built at this location to provide a backup for the regional transmission grid while the current Wilder Project was under construction. The Oil Storage Shed likely was erected as a component of the temporary substation (Doherty and Kierstead 1999; Lee 1949:13).

The Visitors' House is one of two centers established by TransCanada's predecessors within the Connecticut River projects; the other was constructed at the Moore Project in 1957. There was a high level of public interest in the Wilder Project, and, with its location near the communities of Lebanon and Hanover, New Hampshire, and White River Junction, Vermont, the site was readily accessible. Thousands came to visit the construction site; to accommodate the sightseers, NEPA built temporary viewing stands and assigned a guide to explain the work. When construction of the project was complete, NEPA built the Visitors' House with permanent interpretive displays and planned to offer guided tours of the facility. However, plans for public visitation were undercut by the Korean War (1950–1953), which resulted in new security regulations that limited public access to the facility. The rustic architectural style of the Visitors' House contrasts with the design of the Wilder Powerhouse and the Moore Visitors' Center, which incorporate elements of the International and Art Moderne styles. No historical documentation for the source of the Visitors' House architectural design could be located—the rustic style may have been selected as part of an attempt to make the project appear environmentally friendly in response to the stiff opposition of local communities against the project (Doherty and Kierstead 1999; Harris 1951:3).

The Wilder Project was built with the two Allis Chalmers generators and associated turbines (nos. 1 and 2) described above. In 1985–1988, the Powerhouse was enlarged by NEES with the sixth bay at its south end and the present low-flow Voith turbine and Siemens-Allis 3,200 kW generator (no. 3) installed in this addition. The addition is consistent in design and materials with the original portions of the building and nearly indistinguishable from the exterior (Boudreau, personal communication 2014; Doherty and Kierstead 1999; New England Power Company 1985; TransCanada 2013a).

During the 1970s and 1980s, there was increased attention paid by environmental activists to the impacts of hydroelectric facilities on the upstream migration of fish, such as Atlantic salmon and shad, for spawning. Therefore, state wildlife officials requested that NEES construct fish ladders and other bypass mechanisms to route fish around dams and turbines. The Fish Ladder, along with the CRO, were completed at Wilder in 1988 under the same license amendment as the 1985–1988 expansion. The CRO (sometimes referred to as the Wilder Hydro Office, or WHO), which was intended to be used as a visitor's center, was converted for use as a centralized control center for hydroelectric projects on the Deerfield and Connecticut rivers (Landry and Cruikshank 1996: 242; New England Power Co. 1988; TransCanada 2013b).

In 1998, NEES transferred the Wilder Project to U.S. Generating, which quickly sold the property to PG&E. The same year, nationwide energy deregulation resulted in the separation of power generation from transmission companies and, consequently, National Grid acquired the Wilder Project's regional electrical transmission facilities, consisting of the National Grid 115-kV Switchyard and step-up transformers in the TransCanada Switchyard (Doherty and Kierstead 1999; TransCanada 2013a).

TransCanada purchased the Wilder Project in 2005. The company replaced the CRO with a new CCC built in the Wilder Project lands in 2014, and the CRO was vacated (Boudreau, personal communication 2014; Olausen 2013).

National Register Eligibility

The buildings and structures that constitute the Wilder Project are recommended as eligible for listing in the National Register as the Wilder Hydroelectric Development Historic District (see Figure 4-1). The district possesses significance as defined within the *Hydroelectric Generating Facilities in Vermont MPS* (Bowers 1992) under National Register Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. Under Criterion A, the district derives its primary significance from its contribution to the broad patterns of economic and social history in Vermont and New Hampshire. The Wilder Project was an important component of the system of six hydroelectric facilities designed to serve the southern New England electrical market that were built by the New England Power Company and related corporations on the Connecticut River in 1909–1957. Vermont hydroelectric stations historically served as the principal source of electricity in the state and thus have contributed to its industrial and economic development. The Wilder Development was completed to provide an additional peak-demand power source and to fulfill anticipated supply needs in the growing post-World War II electrical market. Under Criterion C, the district is significant for its embodiment of mid-twentieth-century hydroelectric project engineering, specifically as a divided-fall project that incorporated a concrete ogee-profile dam spillway with roller gates, a steel and brick powerhouse, and vertical-shaft turbine and generator configuration using Kaplan-type, variable-pitch propeller turbines set in specially cast concrete spiral scroll cases and draft tubes. This type of purpose-built hydroelectric project represented the maturation of large-scale river-powered electrical generation facilities and, in its adoption of Kaplan turbines, the projects' continued refinement.

The two primary contributing resources in the Wilder Hydroelectric Development Historic District are the Dam and Powerhouse associated with the facility's function as a hydroelectric power generating facility. Various ancillary structures also contribute to the significance of the district: the Visitors' House, Garage, TransCanada 13.8-, 47-, & 115-kV Switchyard, and National Grid 115-kV Switchyard. The Fish Ladder does not contribute to the significance of the district: it is less than 50 years of age and is not functionally related to the electrical generation activities and infrastructure from which the district derives its significance. The New Visitors Center, CCC, and Oil Storage Shed are excluded from the district boundaries. These three resources are located on the periphery of the project lands and concentration of resources associated with electrical generation; CRO and CCC are modern resources not associated with power generation at Wilder. Although associated with the historical development, the Oil Storage Shed is a small-scale, non-countable resource visually separated from the remainder of the project's contributing resources by approximately 2,000 ft of intervening vacant land.

The Wilder Hydroelectric Development retains its integrity. Its setting in the river valley is maintained, as are the locations and physical and functional relationships of all the contributing resources that convey its design as a concentrated-fall hydroelectric facility. Technologically, all the important water control and power generation components remain intact. The property expresses its feeling as an early twentieth-century hydroelectric development and its associations with the development of the hydroelectric power generation industry during that era. The 1988 addition to the Powerhouse did not alter its significant design characteristics, configuration, or the historic-period hydroelectric infrastructure technology.

CHAPTER FIVE

BELLOWS FALLS HYDROELECTRIC PROJECT

Description

The Bellows Falls Project is located on the Connecticut River in the towns of Rockingham, Vermont, and North Walpole, New Hampshire at river mile 173.7, approximately 1 mile upstream of Saxtons River and 3 miles downstream of Williams River (Figures 5-1 and 5-2, Photos 5-1 and 5-2).[4] The divided-fall type complex is sited on the inside curve of an eastward-facing bend of the river to capitalize on the waterpower potential of Bellows Falls, a collection of rapids that descends approximately 60 feet (ft) over a stretch of approximately 3,000 ft. The Bellows Falls Dam spans the river near the head of the falls, diverting the river into the Canal and creating a “pond,” or impoundment, that extends 30 miles upstream and covers 2,804 acres. The Canal cuts northwest to southeast across the peninsula formed by the curve of the river and Bellows Falls, dividing portions of the Village of Bellows Falls in Rockingham to create a 30-acre “island” before terminating at the Wilder Powerhouse at the south end of the island. The Dam and Canal provide a combined 62 feet of head, and the impounded water flows through three 18,000-hp turbines connected to generators to provide a total of 40,800 kW of generative capacity (TransCanada Hydro Northeast Inc. 2013c).

The 12 individual resources of the Bellows Falls Project are arranged in a linear grouping that trends on a northwest to southeast axis across the Connecticut River from North Walpole to Bellows Falls (Table 5-1). The Red Barn, Crew Shack, Gauge House, and the bulk of the Dam lie in North Walpole, while the Canal, Six-Man Garage, Powerhouse, Line Shed, Visitors’ Center, two Switchyards, Fish Ladder, and Tailrace are located in Bellows Falls. The resources are described below beginning with the Dam, Canal, and Powerhouse; then moving south to north to describe the ancillary buildings and structures.

The Bellows Falls Project infrastructure is surrounded by the densely built-up urban environs of North Walpole and Bellows Falls. Many of the adjoining commercial, residential, industrial, and transportation resources of Bellows Falls are included in the Bellows Falls Downtown Historic District and/or Bellows Falls Island Multiple Resource Area, both historic properties listed in the National Register (Henry 1981; Mulholland and Peebles 1988).

Bellows Falls Dam

The Bellows Falls Dam (1927) crosses the Connecticut River on a northwest-southeast axis beginning at the Church Street-Kileen Street intersection in North Walpole and terminating at the upstream end of the Canal near Canal Street in Bellows Falls (Photo 5-3, see Photo 5-2 and Figure 5-2). A New England Central (Boston & Maine) Railroad bridge crosses the river immediately east of and parallel to the Dam. With the exception of its south abutment, the Dam lies entirely within North Walpole, New Hampshire.

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[4] Descriptive information is derived from field survey data, the Deerfield and 1999 *Deerfield and Connecticut River Documentation* (Doherty and Kierstead 1999), *Bellows Falls: Project Description* (New England Power Company 1990), and project plans on file with TransCanada (New England Power Company 1984a, 1984b, 1984c, 1984d, 1984e, 1984f; New England Power Construction Company 1926).

Table 5-1. Bellows Falls Project Existing Resources and Status within the Recommended Bellows Falls Hydroelectric Development Historic District.

Resource Name	Location	Construction Date	Recommended National Register Status*
Red Barn	Pine Street at CT River, North Walpole, NH	1894–1901	C
Six Man Garage	Bridge Street, east of Canal, Bellows Falls, Rockingham, VT	1875–1880	C
Gauge House	Intersection of Church and River Sts., North Walpole, NH	ca. 1927	C
Bellows Falls Dam	Intersection of Church and River Sts., North Walpole, NH	1927	C
Canal	Canal Street, between Green Mountain RR Bridge and Powerhouse, Bellows Falls, Rockingham, VT	1927	C
Bellows Falls Powerhouse	12 Mill Street, Bellows Falls, Rockingham, VT	1928	C
115-kV Switchyard	12 Mill Street, Bellows Falls, Rockingham, VT	1928	C
46/69-kV Switchyard	12 Mill Street, Bellows Falls, Rockingham, VT	1928	C
Tailrace	CT River, south of Powerhouse, Bellows Falls, Rockingham, VT, and North Walpole, NH	1928	C
Crew Shack	Intersection of Church and River Sts., North Walpole, NH	ca. 1930	C
Line Shed	Mill Street, Bellows Falls, Rockingham, VT	ca. 1955	C
Visitors' Center	17 Bridge Street, Bellows Falls, Rockingham, VT	1984	NC
Fish Ladder	17 Bridge Street, Bellows Falls, Rockingham, VT	1984	NC

*C = Resource that contributes to the significance of the recommended district.
NC = Resource that does not contribute to the significance of the recommended district.

The Dam is a 643-ft-long, 30-ft-high, linear, poured concrete, gravity-type structure built on the bedrock river bed. It is divided by concrete pylons into five ogee-profile spillway sections, three with wood flashboards and two with roller-type gates. North to south, the spillway sections consist of two 13-ft-high needle beam type flashboards of 100 ft and 121 ft in width; two 115-ft-wide sections containing 14-ft, 9-inch-diameter roller-type gates; and a 121-ft-wide section with 13-ft-high needle beam type flashboards.

Figure 5-1. Plan of the Bellows Falls Hydroelectric Project showing the location of the recommended Bellows Falls Hydroelectric Development National Register Historic District.

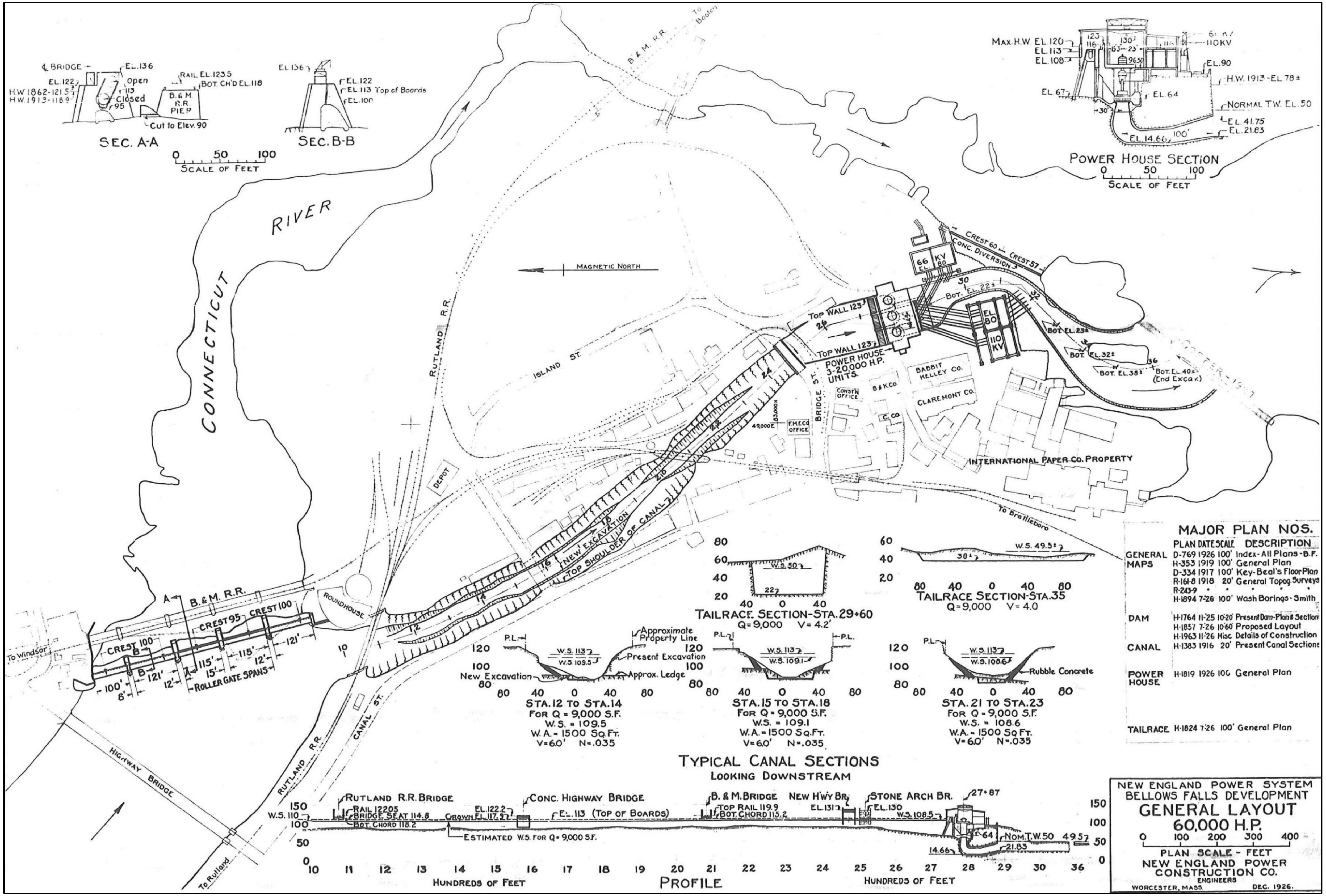

Figure 5-2. General layout of the Bellows Falls Project.

Photo 5-1. Bellows Falls Project, general view of Dam, impoundment, and Canal intake at north end of divided-fall facility, looking east from Vermont.

Photo 5-2. Bellows Falls Project, general view of Powerhouse, Tailrace, and Switchyards at south end of Bellows Falls Island, looking west from New Hampshire shoreline.

Each of the two roller gates is a riveted steel drum with a semicircular gate panel on its lower upstream arc that rests on the top of the spillway when closed. A semicircular toothed gear at each end of the gate drum meshes with an angled rack on the flanking piers. Each gate is raised by a gear chain at the end of the drum driven by an electric motor and reduction gear cluster housed in a polygonal, sheet steel housing atop two adjacent piers at the center of the Dam. Raising the rolling drum allows the water to flow between the but shorter spillway and the bottom of the roller drum. A 12-x-10-ft ice and trash sluice is at the south end of the Dam between the southern-most spillway and south Dam abutment.

A built-up, riveted, steel Pratt truss bridge runs across the top of the Dam pylons and abutments. On the bridge's lower chord, an expanded steel mesh deck (installed at an unknown date after 1999 as a replacement for a wood deck) provides personnel access to the roller gate drive mechanism housings atop the piers. A second open deck atop the bridge's upper chord supports rails for rolling gantry crane. The gantry is equipped with a hoist to pull the flashboard needle beams from their vertical shafts along the top of the spillway and to remove and install the flashboards.

Canal

The pondage upstream of the Dam is diverted to the Wilder Powerhouse via the Canal (1927), which is entirely in Bellows Falls (Photos 5-4 through 5-6, see Figure 5-2). The Canal begins immediately southwest of the Dam and terminates approximately 1,700 ft to the south at the Powerhouse, where it acts as a forebay and supplies water to the Powerhouse. The waterway has a capacity of 12,000 cubic ft per second and flows at 6 ft per second. As the waterway crosses through Bellows Falls on its slightly sinuous course, it is flanked by Canal Street and commercial buildings on the west and by parking lots and railroad infrastructure to the east and is crossed by several railroad and road bridges. The bridges, from north to south, are the Green Mountain Railroad's single-span, skewed Warren through truss bridge; the Depot Street Bridge, an early reinforced concrete, single-span, elliptical arch bridge; Guilford Rail System's former Boston & Maine Railroad single-span, skewed, riveted pony girder bridge; and the Bridge Street Bridge, another early reinforced concrete, elliptical arch structure. The majority of the Canal has a tapered, trapezoidal prism with typical dimensions of 100 ft wide at the top, 36 ft wide at the bottom, and 29 ft deep. The walls and floor are cut granite blocks stabilized with poured concrete ribs and coping. The sloping canal banks are lined with gravel and riprap and guarded by a chain link fence. At the forebay, the prism becomes rectangular, widening 130 ft and deepening to approximately 50 ft where it intersects with the Powerhouse. Due to grade changes, the vertical concrete side walls of the forebay are partially exposed; they are topped in places by an ornamental paneled concrete parapet and have steel walkways and stairs bolted to their outside faces.

Bellows Falls Powerhouse

The Bellows Falls Powerhouse (1928) is in Bellows Falls at the south end of the Canal and on a sloping site east of Mill Street and south of Bridge Street, between the former White Mountain Paper Company Mill Building to the west and the former Moore & Thompson paper mill complex to the east (Figures 5-3 and 5-4; Photos 5-7 through 5-11, see also Photo 5-6). An asphalt driveway runs east from Mill Street past the south side of the Powerhouse and across the Tailrace, then curves north, running back up to Bridge Street along the east side of the Powerhouse and Canal. The Powerhouse is a large, two-story, 185-x-105-ft building executed in the Renaissance Revival Style and having an elongated cruciform plan. It has a steel frame, stepped flat roof with ornamental parapets, Flemish bond brick walls with prominent arched window bays and buttresses, and a reinforced concrete foundation that incorporates the turbine scroll cases and draft

Photo 5-3. Bellows Fall Project, Dam spillway looking south from New Hampshire abutment.

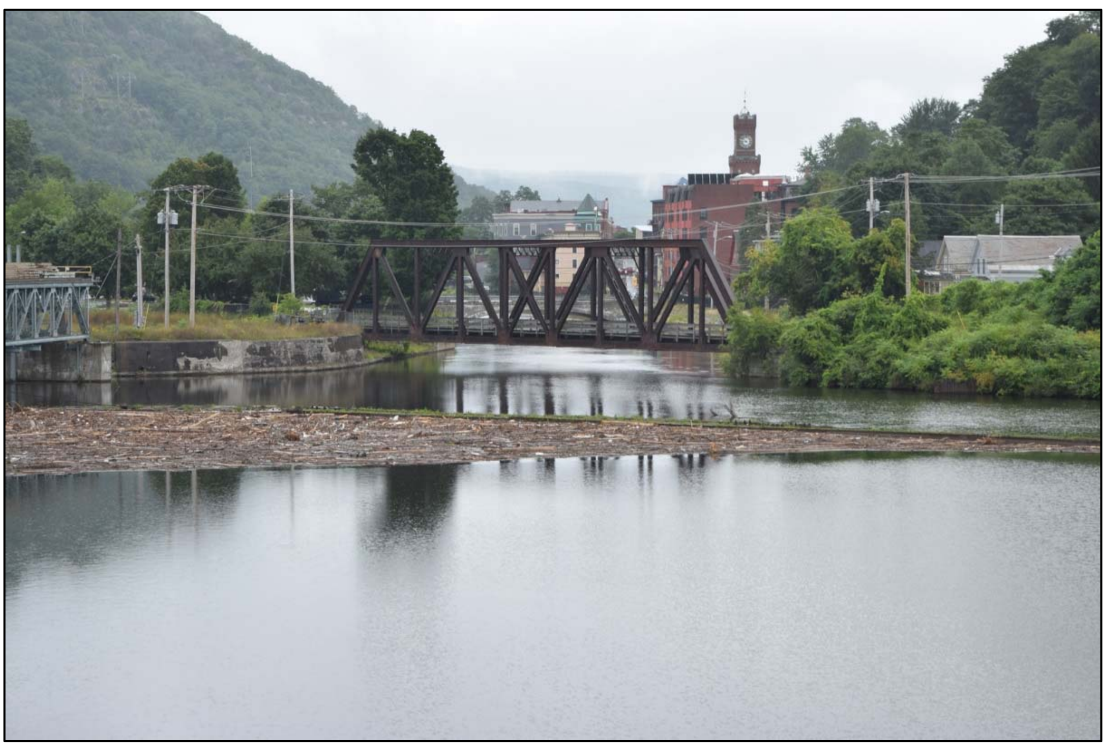

Photo 5-4. Bellows Falls Project, upstream end of Canal, looking south.

Photo 5-5. Bellows Falls Project, downstream end of Canal, looking north.

Photo 5-6. Bellows Falls Project, forebay of Canal and Powerhouse headworks building, looking south.

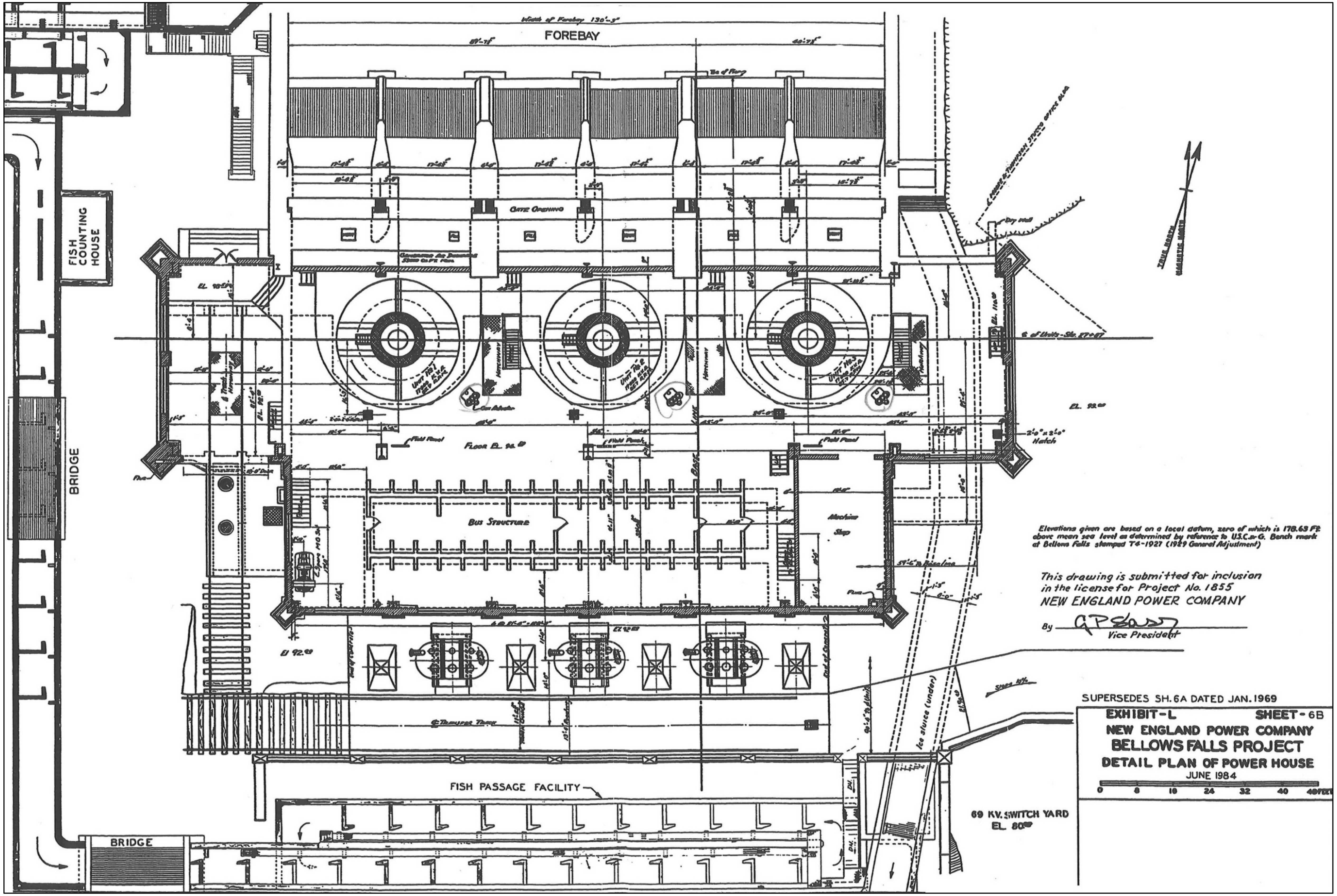

Figure 5-3. Plan of the Bellows Fall Project Powerhouse and Fish Ladder.

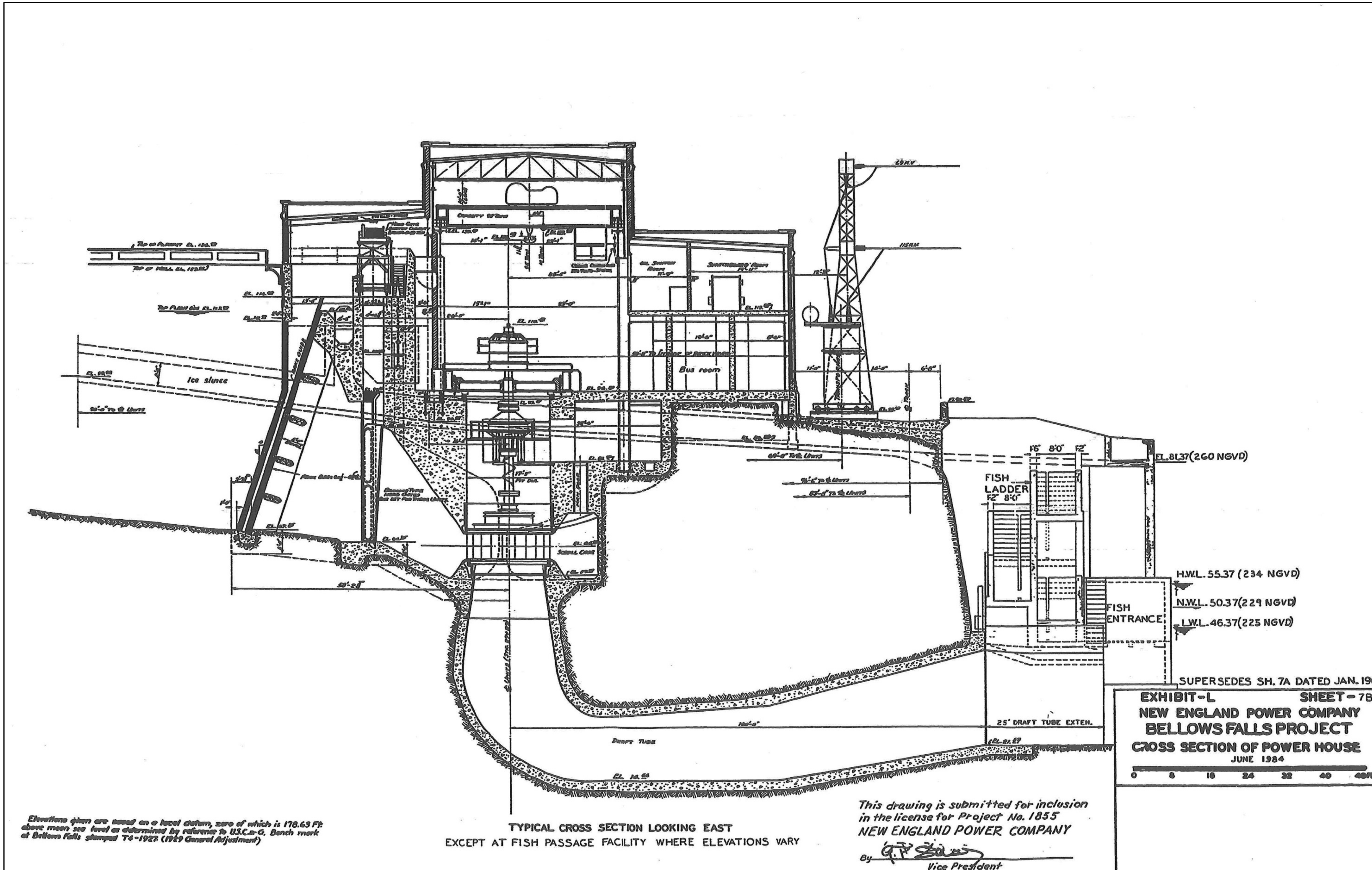

Figure 5-4. Cross-section of the Bellows Falls Project Powerhouse.

Photo 5-7. Bellows Falls Project, Powerhouse, looking northwest.

Photo 5-8. Bellows Falls Project, Powerhouse, looking north.

Photo 5-9. Bellows Falls Project, Powerhouse, looking east.

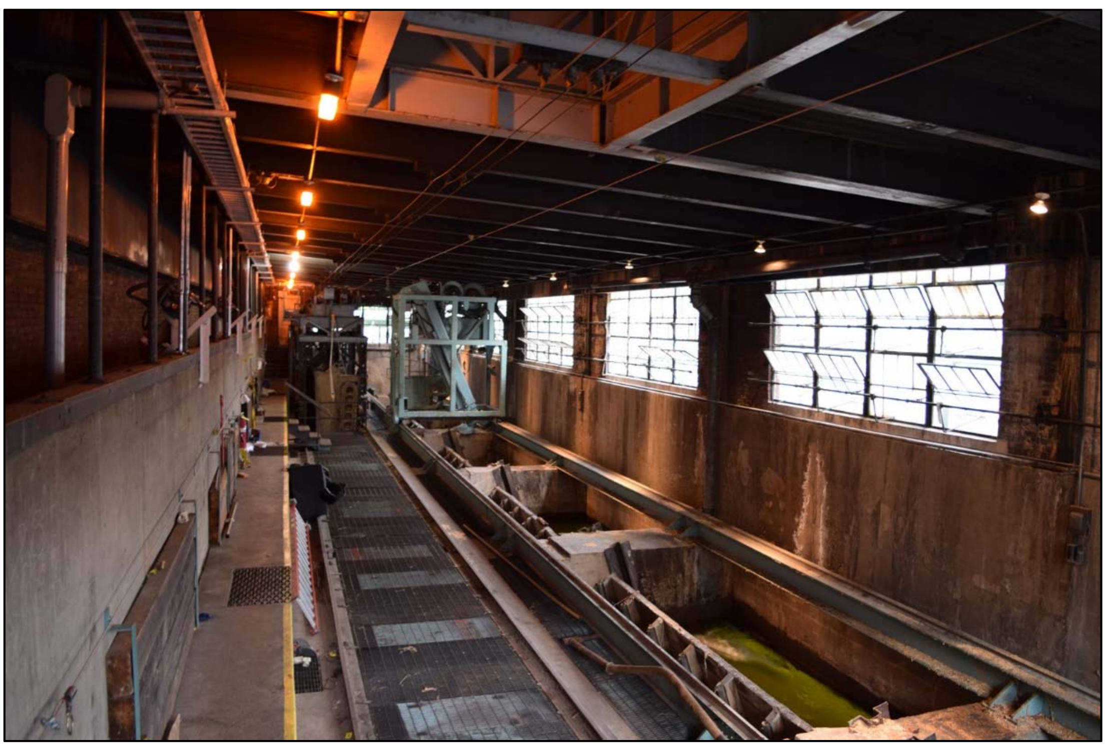

Photo 5-10. Bellows Fall Project, interior of Powerhouse headworks.

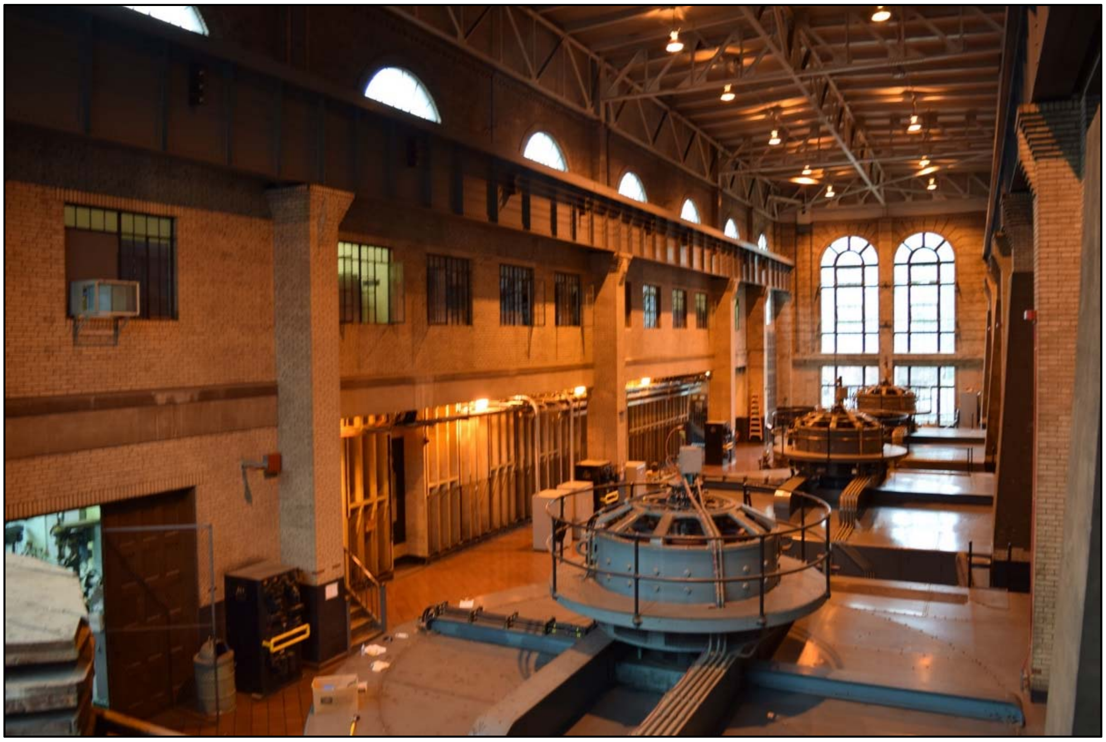

Photo 5-11. Bellows Falls Project, interior of Powerhouse generator hall.

tubes. A large poured concrete equipment pad and pylons that formerly held generator step-up (GSU) transformers (removed in 2013–2014) projects from the building's south foundation.

In plan, the building consists of three parallel, attached, rectangular sections with each long axis running east-west. The 8-by-2-bay central section is referred to as the generator building and is 51 ft high, 185 ft long, and 42 ft wide. It is flanked to the north by the 24-ft-high, 135-ft-long, 30-ft-wide headworks building (aka intake house) and the 33-ft-high, 130-ft-long, 33-ft-wide electrical building to the south. Both flanking buildings are 6-by-1-bay structures centered on the elevations of the central generator building and with lower rooflines. The roofline of the headworks building is 11 ft lower than the generator building roofline, and the roofline of the electrical building is 17 ft lower than the generator building roofline.

The Renaissance Revival Style ornamental scheme incorporates brick piers dividing the bays; prominent cast stone string and belt courses and window spandrels; a high, molded concrete foundation; skewed buttresses with cast stone trim at the corners; and decorative cornices, window mullions, and entrance surrounds. All four elevations of the central generator building have floor-to-ceiling, arch-topped, multi-pane, steel-sash windows broken by the cast stone belt course and topped with volute keystones. Windows on the flanking sections are rectangular and of similar construction, but with splayed lintels and sills of cast stone. Other cast stone embellishments include carved bases and capitals on the window piers and lions' heads on the east and west elevations of the generator building. The parapet on the north elevation is broken by a rectangular cast stone panel bearing the legend "NEW ENGLAND POWER SYSTEM," flanked by volute brackets and capped with a small shield. This elevation overlooks the Canal forebay, where a steel catwalk with pipe railing spans the watercourse. Large coffered bronze equipment doors are set into the northeast and southwest corners of the generator building. The primary personnel entrance is located in the west bay of the north elevation. It has a heavy paneled wood door flanked by paneled brick piers and a rectangular lintel incised with a Greek key pattern. Transom windows with diagonal mullions are set above the door and bronze light sconces with white glass globes are mounted to the piers.

The interior of the Powerhouse contains three vertical-shaft turbine-generator units and associated water control and electrical distribution and control equipment. The headworks section is a single large gallery resting over the south end of the forebay, with multiple cut-outs in the floor above the waters of the forebay. Its substructure contains three short tapering penstocks leading to the turbines in the generator building. Trash racks extend from the headworks floor to the base of the forebay prism. Two gantry cranes run on two sets of tracks running longitudinally through the gallery. The northern gantry crane carries a trash rack rake. The southern gantry crane lifts gate leaves to open and close each penstock. The headworks interior is unfinished, with raw concrete on the ceiling, walls, and floor.

Water passing through the headworks penstocks is carried to three generating units located toward the north wall of the generator building. The generating units, which are numbered 1–3 from west to east, consist of three S. Morgan Smith, 18,000-hp, 85.7-rpm, vertical-shaft, 129-inch-diameter, single-runner, Francis-type, fixed-blade turbines, each connected to a General Electric 13,600-kW alternating current generator with a top-mounted exciter and painted sheet metal cooling shroud. The turbines are set deep below the building in specially cast spiral scroll cases. A concrete-lined draft tube excavated from bedrock extends down and curves south from beneath each unit, exiting in the tailrace south of the building. Above the turbine level is the generator building’s basement level, which contains three large concrete footings for the generators and access to the turbine shaft and thrust bearings. Ancillary spaces in the basement, which is entirely of concrete construction, contain a boiler room and rows of turbine governor oil pumps and oil reservoirs

The main floor of the generator building is a large, clear-span, high-bay generator hall, with the three generators and their S. Morgan Smith speed governors dominating the space. The concrete slab ceiling rests on exposed steel purlins and roof trusses. The walls are sheathed in yellow brick and ornamented with coursed voussoirs and blank arches on the north wall, red brick string courses, window and door bands, tapestry panels in the bays, rough-split black slate wainscoting, and piers with corbelled brackets. The floor is clad in red quarry tile, except in the western-most bay, which has a sunken floor so that the equipment door threshold matches the exterior grade. A 95-ton motorized horizontal traveling crane rides on wall-mounted rails running the length of the building. A curving tile stair accesses the main personnel door at the west end of the north elevation, and a steel stair and landing access the entry at the east and of the north elevation.

The first floor of the electrical building opens onto the south side of the generator hall and contains a machine shop at its east end and an aisle of compartments for the 6.9-kV bus structure in the remainder. The second (operating) floor of the electrical building is accessed by a metal staircase at its west end and contains an office at its west end; store room, battery room, and crew room at its east end, and a long central switchboard room with a long, narrow, freestanding row of panels containing an array of meters, switches, and monitoring equipment for the units. Ceilings are a combination of concrete slabs and acoustic tile; walls are painted brick; and floors are vinyl tile. Heavy paneled oak doors are set in the room entries.

Switchyards

Two switchyards (1928) are located just south of the Powerhouse on level terraces east and west of the Tailrace where it empties into the Connecticut River. On the west bank of the tailrace is the 115-kV Switchyard (aka 115-kV Substation) (Photo 5-12). This fenced compound is approximately 160-x-100 ft in plan and contains switches and bus bars mounted atop 60-ft-tall and 40-ft-tall bolted steel lattice towers. A modern, Butler-type equipment shed is set within the compound. Five electrical distribution lines are supplied by the yard and run from towers to various Vermont locales.

Photo 5-12. Bellows Falls Project, 115 kV Switchyard looking southwest.

On the east bank of the tailrace is the 46- & 69-kV Switchyard (aka 46/69-kV Substation) (Photo 5-13). This fenced compound is approximately 90-x-120 ft in plan and contains switches and busbars mountedatop 56-ft-tall towers similar to those in the 115-kV Switchyard. Four electrical transmission lines exit the compound.

Photo 5-13. Bellows Falls Project, 6 & 69 kV Switchyard, looking southeast.

Tailrace

The Tailrace (1928) is a channel excavated into bedrock south of the Powerhouse that carries water expelled from the turbine draft tubes away from the Powerhouse and minimizes backwater moving from the river into the draft tubes (Photo 5-14). It runs southwest on a curvilinear course for approximately 700 ft and has widths varying from approximately 90 to 300 ft. The walls of the channel are poured reinforced concrete with a concrete diversion weir separating the east side of the structure from the run of the river.

Photo 5-14. Bellows Falls Project, Tailrace, looking south from Powerhouse.

Fish Ladder

The Fish Ladder (1984) is a poured concrete structure that climbs with multiple switchbacks from the Tailrace to the Canal in Bellows Falls (Photo 5-15). It begins on the east side of the Tailrace, south of the Powerhouse, then angles around the west end of the Powerhouse. At the northwest corner of the Powerhouse, the Fish Ladder makes multiple turns to climb the slope just below the Visitors' Center, then continues east to empty into the Canal at the forebay. A sheet metal fish counting house and steel frame elevator are connected to the ladder where it passes the northwest corner of the Powerhouse. The fish ladder is approximately 750 ft long and its sloping portions are divided by concrete baffles into 67 8-ft-square pools.

Visitors' Center

The Visitors' Center (1984) is located off the northwest corner of the Powerhouse in Bellows Falls, accessed via an asphalt driveway that extends north to Bridge Street, and set at the crest of a slope looking south over the Fish Ladder (see Photo 5-15). The one-story, rectangular building has a viewing porch running the full length of the south wall set under the building's shed roof, which is clad in standing seam metal. A brick facade wraps around the north, west, and east sides of the building and has minimalist Renaissance Revival architectural details to harmonize with the adjacent Powerhouse. A Roman-arched window and door are set off-center on the north wall, and arched openings lead onto the porch at the south ends of the east and west walls. A cast concrete string course wraps around the facade parapet. The south building elevation is fully occupied by a glass curtain wall looking onto the porch and fish ladder, where the building roof is supported by a row of brick piers between which runs a wood and composite porch railing. The interior's lower level has a viewing window the looks into the fish ladder pools.

Photo 5-15. Bellows Falls Project, Visitors' Center and Fish Ladder, looking northwest.

Line Shed

The Line Shed (ca. 1955) is approximately 150 ft west of the Powerhouse on a terrace cut into the natural slope on the north side of the facility driveway (Photo 5-16). Stone and brick retaining walls wrap around the north wall and portions of the east building walls. The one-story, three-by-three-bay, end-gable building has a square plan, a wood frame, a corrugated metal roof and walls, and a concrete slab foundation. The south wall faces the driveway and includes a paneled metal personnel door and two paneled wood roll-up garage doors and a four-light metal sash window. A combination of four-light and six-light, fixed, metal-sash windows are on the west, north, and east elevations. Louvered metal vents are set high on the gable ends.

Photo 5-16. Bellows Falls Project, Line Shed looking northeast.

Six-Man Garage

The Six-Man Garage (ca. 1875–1880) is in Bellows Falls immediately east of the Canal forebay on a constrained site between that structure, Bridge Street, and a driveway leading to the Bellows Falls Powerhouse (Photo 5-17). The long, narrow, rectangular brick building is divided into two blocks of unequal height that rest on fieldstone and concrete foundations and the east wall of the Canal. The two-story, nine-by-two-bay north block has a shallow-pitch, built-up gable roof and tapered ornamental rafter tails. The bays on the long, windowless east and west sides are divided by brick piers reinforced with vertical steel I-beams bolted to the pier's external faces. On the north elevation, the building's upper floor is accessed by a pair of paneled wood garage doors set under a steel lintel. Two entries on the east elevation access the north block's lower level and are fitted with a steel-clad fire door and a wood door, each with narrow wood jambs and steel lintels. The four-by-two-bay, one-story south block has a built-up shed roof and open soffits with exposed beveled rafter tails. An entry on the south wall of the block contains a pair of paneled, windowed doors set under a steel lintel and accessed via a poured concrete stair. Two small window openings with segmental arch brick lintels and quarry-faced stone sills are set high on the east wall of the block and contain four-over-four, double-hung, wood sash. The garage interior is divided into several large storage areas, and the heavy timber framing is exposed.

Photo 5-17. Bellows Falls Project, Six-Man Garage, looking southwest.

Gauge House

The Gauge House (ca. 1927) is built into the concrete north abutment of the Dam in North Walpole facing east toward the parking and staging area (Photo 5-18). The small, one-by-one-bay equipment hut has a hipped roof and rectangular plan. The roof is clad in asphalt shingles and has shallow wood plank eaves and a plank fascia. The brick walls are laid in Flemish bond and rest on a concrete slab foundation that is integrated into the Dam abutment, which wraps around the north, west, and south sides of the building to create a high water table. The single entrance, a paneled wood door that is now missing its window, is on the east elevation and the other three walls are blank. The interior is a single unfinished room with a Homasote or similar pressboard ceiling, painted brick walls, and a concrete floor. An original gauge display and circuit breaker panel, now unused except for the gauge, are mounted to the north wall of the interior. In front of this is a newer equipment rack with computer circuitry and telecommunications equipment that allows remote control of the Dam gates.

Photo 5-18. Bellows Falls Project, Gauge House, looking west.

Crew Shack

The Crew Shack (ca. 1930) and Gauge House are immediately south of the intersection of Church and River streets in North Walpole in an asphalt-paved and fenced parking and equipment laydown area at the north end of the Bellows Falls Dam (Photo 5-19). The Crew Shack faces east onto the parking lot from the side of a low, earth embankment, with its south end adjoining a concrete retaining wall. The small, three-by-two-bay, one-story, side-gable building rests on a concrete slab foundation with a high water table on the south, west, and north sides. It has an asphalt shingle roof with asymmetrical roof slops, vinyl siding (added at an unknown date after 1999), and an external brick chimney on the north wall. The entry is set at the south end of the east elevation and has a wood plank door and plank surround. The north, south, and east elevations have six-over-six, double-hung, wood-sash windows with shutters. The interior consists of one open room.

Photo 5-19. Bellows Falls Project, Crew Shack, looking northwest.

Red Barn

The Red Barn (1894–1901) is on a land parcel that is non-contiguous with the rest of the project, approximately 0.60 mile northwest of the Dam (Photo 5-20). It is sited at the west end of Pine Street in North Walpole and on the east bank of the Connecticut River at what is currently designated TransCanada's Pine Street Boat Launch. The Greek Revival Style industrial building has a rectangular plan with an irregular bay count and is two stories in height. It has an end-gable, slate clad roof with a louvered cupola; common brick walls; and a mortared rubblestone foundation that is reinforced with concrete on the rear (river facing) elevation. The walls are topped with corbelled brick cornices and gable rakes that terminate at returns. The four entries, all of which have wide freight and vehicle openings, are on the north, east, and west elevations and have segmental arch brick sills and concrete lintels. The vehicle entry on the east elevation is fitted with a replacement vertical lift roll door. The north freight entry is fitted with a heavy wood plank door leaf with diagonal cross bracing and wood plank jambs. The south freight entry is covered with plywood. A loft door is located on the east wall above the vehicle door and fitted with a door leaf similar to, but shorter than, that of the north entry. Window openings with segmental arch brick sills and quarry-faced granite lintels are on the north, east, and south elevations. The sash is now removed and the openings are covered in plywood and sheet metal. The interior, which is used for storage, has exposed wood timber framing, brick walls, and unfinished plank floors. A staircase clad in beaded paneling leads to the attic.

Photo 5-20. Bellows Falls Project, Red Barn, looking northwest.

Historical Development

The Bellows Falls Project is one of six hydroelectric facilities built by the New England Power Company and related corporations on the Connecticut River in 1909–1957. Completed in 1928, it was a redevelopment of existing industrial and transportation infrastructure with a history extending back to 1792, when the Bellows Falls Canal was chartered to construct a navigation waterway around Bellows Falls.[5] The canal was completed in 1802 on the same general alignment of the present Canal. The same year, Bellows Falls' (and Vermont's) first paper mill opened on the canal and papermaking became the village's most important industry. As of the early twentieth century, the transportation company existed primarily to bring water to the Fall Mountain Paper Company (owned by International Paper Company), which, along with other firms, occupied a dense complex of mills running across the south end of Bellows Falls Island and immediately adjacent areas to the west. In 1912, Chace & Harriman purchased the canal company and two small hydroelectric companies and reorganized them into a subsidiary, the Bellows Falls Power Company. A dispute soon arose between the paper company and power company over the proper distribution of water; this was resolved in 1918 when Chace & Harriman enlarged the canal and erected a new and larger power station with a share of the resultant electricity to be guaranteed to the paper mills. The acquisition of the necessary land and water rights from other industries continued from 1918 until 1925, when construction commenced on the new development. In 1926, Fall Mountain Paper decided to shut down and sell its land and water rights to the power company. This timing coincided with the paper company's parent International Paper Company merging with Chace & Harriman to become NEPA (Henry 1981; Landry and Cruikshank 1996:59–60).Included in the 1918–1926 acquisitions of paper company facilities were two buildings currently owned by TransCanada as part of the Bellows Falls Project: the Red Barn and the Six-Man Garage.[6] The Six-Man Garage was built at an unknown date before 1886 as the No. 2 Stock House for the Fall Mountain Paper Company, and enlarged by the addition of the south block between 1885 and 1891 to achieve its current footprint. It is currently used for equipment storage. It is typical of the utilitarian, brick industrial buildings constructed in Bellows Falls and elsewhere in New England in the mid- to late nineteenth century (Burleigh 1886; Doherty and Kierstead 1999; Mulholland and Peebles 1988; Sanborn Map Company 1885–1891).

The Red Barn was built between 1894 and 1901 as part of the expansion of the Bellows Falls' paper industry under the White Mountain Paper Company or Fall Mountain Paper Company. It is located at the point on the Connecticut River where the paper companies placed a log boom across the river during each spring's snowmelt freshet to catch the logs placed on the ice by winter loggers. The Fall Mountain Paper Company's North Walpole Sawmill was located on the premises until it burned in 1894. By 1906, the International Paper Company owned the building and adjacent lands, where it stockpiled pulp logs along a railroad siding before they were converted to paper. The Red Barn is supposed to have functioned as a stable, sheltering horses used by the companies to retrieve logs from the river banks. The building, which is currently used for storage, is a good example of a small, Greek Revival Style brick industrial building (Ashcroft 2000; Burleigh 1886; Doherty and Kierstead 1999; Landry and Cruikshank 1996:60; Sanborn Map Company 1885–1950; *The Woodworker* 1894:34).

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[5] The canal corporation was chartered as the "Company for Rendering the Connecticut River Navigable by Bellows Falls" and was the earliest transportation canal chartered in the United States (Landry and Cruikshank 1996:258).

[6] Two additional pre-1925 industrial buildings in Bellows Falls were also purchased by New England Power Company, but are now removed from TransCanada ownership: the White Mountain Paper Company Mill Building (ca. 1873), just west of the Powerhouse, and the Frank Adams & Company Grist Mill (1831), southwest of the White Mountain Paper Company Mill Building. These are listed in the National Register of Historic Places as contributing elements of the Bellows Falls Historic District (Henry 1981) and were included in previous documentations and evaluations of the Bellows Falls Hydroelectric Development Historic District. Neither building was used for hydroelectric generation or related activities, although the paper mill building was used for equipment storage. For these reasons, both are excluded from the current survey (Doherty and Kierstead 1999).

Construction of the original project's components (the Dam and Gauge House, Canal, Powerhouse, Switchyards, and Tailrace) proceeded from 1925–1928, with heavy rains and flooding in the fall of 1927 causing great damage to the project, as well as creating delays and budgetary overruns. The New England Power Construction Company, an arm of the New England Power Company, built the development. When the project was finally completed in 1928, it had a generating capacity of 40,800 kW from three 13,600-kW generating units operating off 62 ft of head (Figure 5-5). By comparison, the similar Harriman Development (1924), the largest on the Deerfield River, produced 33,600 kW from three 11,200-kW generators running on 345 ft of head (Bowers 1992: E-22; Doherty and Kierstead 1999; Landry and Cruikshank 1996:59-62, 72).

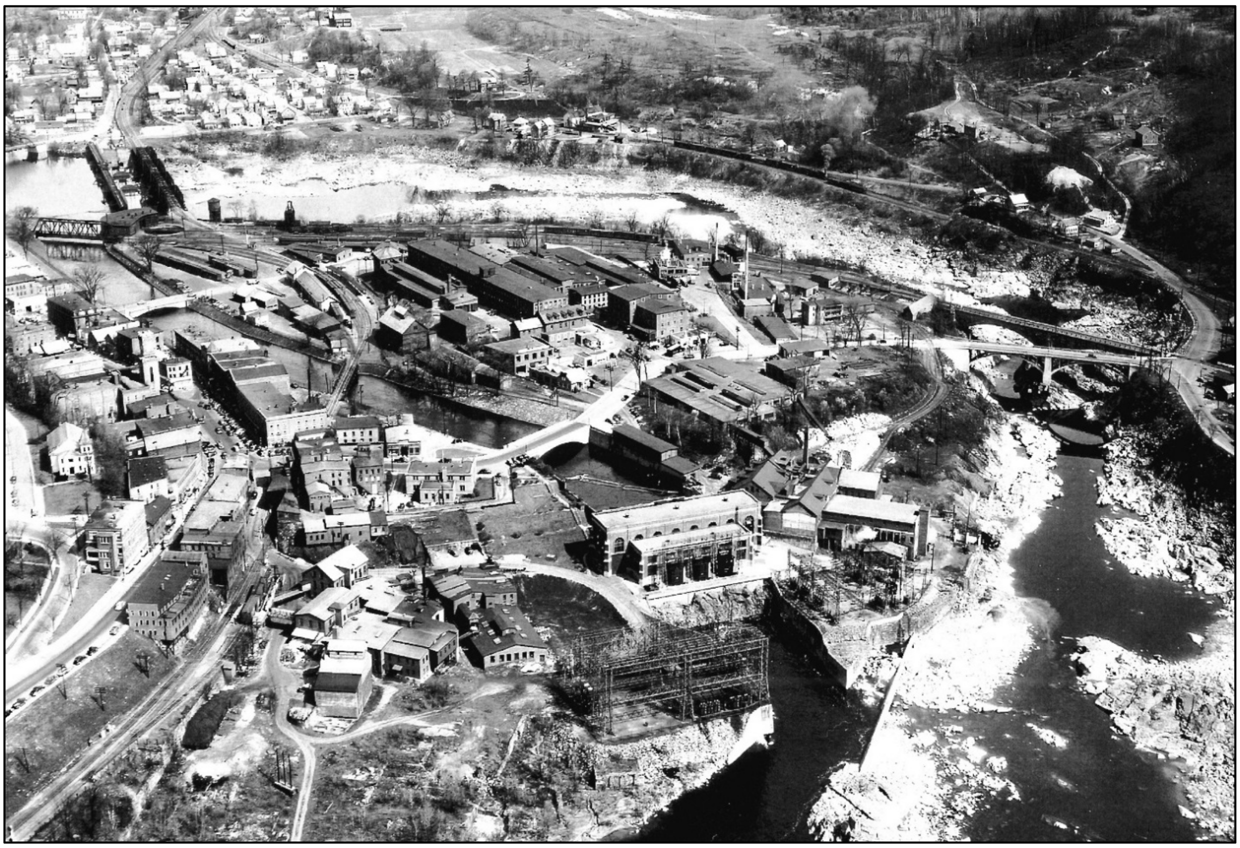

Figure 5-5. Circa 1932 aerial view of the Bellows Falls Project, looking north. Dam is at upper left and Canal extending from Dam to Powerhouse is at lower center.

The Dam and Gauge House were built on the site of earlier dams that had been used to manipulate the flow of the Connecticut River for the Bellows Falls Canal and the White Mountain/International Paper Company paper mills. The dam was replaced with a new structure whose crest was 11 feet higher. As a concrete gravity dam, the structure relies on its own weight on its bedrock foundation to hold back the water behind it. The first concrete gravity dam was built in San Mateo, California, in 1887. This type of dam was a departure from the rock-filled wooden crib dams that were typical in New England at the time and came into standard use in the region during the first quarter of the twentieth century. The Dam is typical of early twentieth century in its linear form, ogee profile, and use of gates and flashboards to regulate flow and pond height; however, its roller-type gates differentiate it from the dams at other Connecticut River facilities built by TransCanada predecessors, which incorporate tainter-type gates. The Gauge House contains equipment used for measuring the height of the water passing over the dam. It is typical of the utilitarian buildings erected by the New England Power Association for the construction and operation of their hydroelectric facilities (Doherty and Kierstead 1999; Cook 1991:18–19; Hay 1991:xix; Henry 1981; Landry and Cruikshank 1996:33–34).

Substantial excavations were required for construction of the Canal, Powerhouse foundations, and Tailrace. The Canal was widened and deepened to provide the 4.2 million gallons per minute needed by the turbines under the new power generation scheme. In addition, the waterway had to be re-graded so that it would be level for most of its course, with a fall just as it entered the Powerhouse. The Tailrace was created by blasting approximately 10,000 cubic yards of rock at the foot of the canal below the Powerhouse site. Spoil from the excavation was moved to the land area to the north to level the Powerhouse and Switchyard sites (Landry and Cruikshank 1996:59–62).

The Powerhouse, prominently located in the village of Bellows Falls, provided a highly visible corporate showpiece. Architecturally, the building features the elaborate Renaissance Revival scheme and "erecting shop" configuration that typifies powerhouses of the period and other large-scale public and transportation buildings such as libraries and train stations. It provided a high-style, dignified appearance that power companies used to legitimize and dignify the industry by conveying a positive public image. The building is the only one of the TransCanada predecessor developments on the Deerfield and Connecticut rivers that was located in dense urban surroundings, making its appearance particularly important. In addition, the building is practically designed to provide the open interior spaces and massive structural supports necessary to house and maintain the large, heavy power generation equipment and ancillary devices (Doherty and Kierstead 1999).

Technologically, Bellows Falls' power generation infrastructure represented the culmination of the progress made in hydroelectric generating during the first quarter of the twentieth century, which was characterized by the combination of a variety of water management techniques and standardized equipment configurations that were interconnected to provide electricity to larger areas. The Powerhouse incorporates the major elements that characterize the mature expression of large-scale hydroelectric generating technology, including multiple, vertical-shaft, single-runner, high-horsepower, large-diameter, low-rpm turbines with scroll cases cast into their foundations; oil-pressure vertical thrust bearings; and improved tailrace draft arrangements. The configuration of the generator room and foundation substructure of the Powerhouse are directly related to the vertical-shaft turbine and generator arrangement, which had first been practically implemented in 1905 and improved by the introduction of the pressure-wedge thrust bearing in 1912. The adaptive reuse and modification of preexisting industrial waterpower infrastructure for hydroelectric development, in this case the International Paper Company's mill rights and power canal, was not unusual for New England. Other examples of this phenomenon at TransCanada predecessors' hydroelectric developments include the Deerfield No. 3 Development's utilization of a preexisting industrial water privilege and the utilization of a former paper mill power canal at the Deerfield No. 5 Development at Monroe Bridge, Massachusetts (Cook 1991:4; Doherty and Kierstead 1999; Hay 1991:xi–xii, 71–83).

Following the completion of the Bellows Falls Project in 1928, New England Power Company and successive owners modified and added to it for purposes of technological and operational efficiency and to address environmental concerns. The Crew Shack was built about 1930 to provide shelter for personnel working on the Dam in inclement weather and is still used for that function. The Line Shed was added about 1955 for use by transmission line crews to house vehicles, equipment, and supplies. Like the Gauge House, these service buildings use simple designs and robust construction materials (Doherty and Kierstead 1999; Historic Aerials 1956; Sanborn Map Company 1885–1950).

During the 1970s and 1980s, there was increased attention paid by environmental activists to the impacts of hydroelectric facilities on the upstream migration fish such as Atlantic salmon and shad for spawning. Therefore, state wildlife officials requested that NEES construct fish ladders and other bypass mechanisms to route fish around dams and turbines. In 1978, FERC approved a settlement among the States of Massachusetts, Connecticut, New Hampshire, and Vermont, the U.S. Fish and Wildlife Service, and four non-governmental organizations to install upstream fish passage facilities at Bellows Falls and two other projects. The fish ladder, along with the Visitors' Center, was constructed at Bellows Falls in 1984, with the draft tube extended slightly to accommodate the new ladder (Doherty and Kierstead 1999; Landry and Cruikshank 1996:242; New England Power Co. 1988; TransCanada 2013c).

In 1998, New England Power Company transferred the Bellows Falls Project to U.S. Generating, Inc., a non-regulated generation subsidiary of Pacific Gas and Electric Corporation (PG&E Corp). The same year, nationwide energy deregulation resulted in the separation of power generation from transmission companies and, consequently, National Grid acquired the 69/46-kV Switchyard, the 115-kV Switchyard, and the three GSU transformers on the south side of the Powerhouse. TransCanada acquired the Bellows Falls Project in 2005 (Doherty and Kierstead 1999; TransCanada 2013c).

In 2013, National Grid completed the multi-year Bellows Falls Revitalization Project, which replaced transformers, meters, and breakers within the substation yards. A small brick oil pump house was also demolished and two new Butler-type buildings were added to the yards. Three original GSU transformers and associated steel lattice towers sited on the south wall of the Powerhouse were removed. TransCanada, in order to minimize the impacts of the National Grid project on its operations, constructed in 2008 a new GSU switchyard just north of the 115 kV yard (Olausen and Kierstead 2008; PAL 2007; Welch, personal communication, 2014).

National Register Eligibility

The buildings and structures that constitute the Bellows Falls Project have previously been determined eligible for listing in the National Register as the Bellows Fall Hydroelectric Development Historic District through consultation with the VTSHPO and NHSHPO, and the historic district currently remains eligible for listing. The district possesses significance as defined in *Hydroelectric Generating Facilities in Vermont MPS* (Bowers 1992) under National Register Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture.

Under Criterion A, the district derives its primary significance from its contribution to the broad patterns of Vermont and New Hampshire economic and social history. Bellows Falls was an important component of the system of six hydroelectric facilities designed to serve the southern New England electrical market and built by the New England Power Company and related corporations on the Connecticut River in 1909–1957. Vermont hydroelectric stations historically served as the principal source of electric power in the state and thus have contributed to its industrial and economic development. From the time that the facility commenced power generation, the Bellows Falls Project has provided an important source of electricity that was distributed over long distances to multiple locations in Vermont and New Hampshire.

Under Criterion C, the district is significant for its embodiment of early twentieth-century hydroelectric project engineering, specifically as a divided-fall project that incorporated a concrete ogee-profile dam with roller gates, a steel and brick powerhouse, and vertical-shaft turbine and generator configuration using 1920s Francis-type, single-runner, fixed-blade turbines set in specially cast concrete spiral scroll cases and draft tubes. The development of this type of purpose-built hydroelectric project represented a significant step in the evolution of modern, large-scale electrical generation facilities.

The three primary contributing resources in the district are the Dam, Canal, and Powerhouse that are associated with the facility's function as a hydroelectric power generating facility. Various ancillary structures also contribute to the significance of the district: the Red Barn, Gauge House, Six-Man Garage, Line Shed, two Switchyards, Crew Shack, and Tailrace (see Figure 5-1). The Fish Ladder and Visitors' Center, both completed in 1984, do not contribute to the significance of the district. They are less than 50 years of age and are not functionally related to the electrical generation activities and infrastructure from which the district derives its significance.

The Bellows Falls Project retains its integrity. Its setting in the Village of Bellows Falls is maintained, as are the locations and physical and functional relationships of all the contributing resources that convey its design as a divided-fall hydroelectric facility. Technologically, all of the water control and power generation components remain intact, with the exception of the GSU transformers and related switches and busses in the Powerhouse. The property expresses its feeling as an early twentieth-century hydroelectric project and its associations with the development of the hydroelectric power generation industry during that era.

CHAPTER SIX

VERNON HYDROELECTRIC PROJECT

Description

The Vernon Hydroelectric Project is the southernmost of TransCanada's Connecticut River facilities and spans the river at river mile 141.9 between Vernon, Vermont, and Hinsdale, New Hampshire, six miles south of Brattleboro, Vermont (Figures 6-1 and 6-2, Photos 6-1 and 6-2).[7] It is located on the upstream arm of a sharp, mile-long westward horseshoe bend in the river, approximately 1,600 feet (ft) downstream from the Vermont Yankee nuclear power plant. The Powerhouse is built into the Vermont (west) bank of the river, with the New Hampshire-Vermont state line passing diagonally through the building and the Dam extending almost due east to the New Hampshire shore, which is unpopulated. All of the project's buildings and structures are accessed from Vermont along Governor Hunt Road in Vernon, which is sparsely populated in the immediate project vicinity. An asphalt-paved, horseshoe-shaped driveway extends from the road past the Powerhouse and is lined with grass and mature deciduous trees. A small pump house, added to the project about 1970 and set partially below grade, is adjacent to the north end of the driveway. A chain link fence surrounds the project's yard around the driveway. A secondary driveway accesses a parking lot and staging area above the Fish Ladder, immediately south of the Powerhouse. A modern gazebo is on the north edge of this driveway for portages-goers and fish ladder observers.

The Vernon Project is a concentrated-fall type hydroelectric project, where the Dam and Powerhouse are integral and the pondage behind the Dam acts as a forebay that provides water directly to the Powerhouse. The Vernon impoundment extends approximately 26 miles upstream and covers 2,550 acres. It supplies water at 34 ft of head to power 10 turbine-driven generators with a combined 32,400 kW capacity. Nine resources make up the project: the Dam, Powerhouse, Crew Shack, Switchyard, Pump House, Hoister House, Fish Ladder, Superintendent's House, and Superintendent's Garage (Table 6-1). Most of these resources are clustered around the west end of the Dam, with a few ancillary buildings and structures to the northwest along Governor Hunt Road. The nine resources are described below, beginning with the Dam and Powerhouse, then moving to ancillary resources in New Hampshire and Vermont (New England Power Company 1992: "Vernon Development"; New England Power n.d.: "Vernon Station").

Vernon Dam

Vernon Dam (1909 and 1986) is a 956-ft-long, 58-ft-high, concrete gravity structure that runs east-west across the Connecticut River, with most of the structure in New Hampshire (Photos 6-3 and 6-4, see also Photos 6-1 and 6-2). West to east, it is made up of an approximately 100-ft-long earth berm northwest of the Powerhouse on the riverbank in Vermont, the 356-ft-long concrete Powerhouse substructure, and a 600-ft-long spillway section that terminates at a concrete abutment on the Hinsdale riverbank. The earth berm section of the Dam is armored with a vertical concrete wall on its upstream side, and the upstream

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[7] Descriptive information is derived from field survey data, the 1999 *Deerfield and Connecticut River Documentation* (Doherty and Kierstead 1999), *Vernon Station: Project Description* (New England Power Company 1991) and project plans on file with TransCanada (New England Power Company 1987b, 1987c, 1987d, 1992a, 1992b, 1992c).

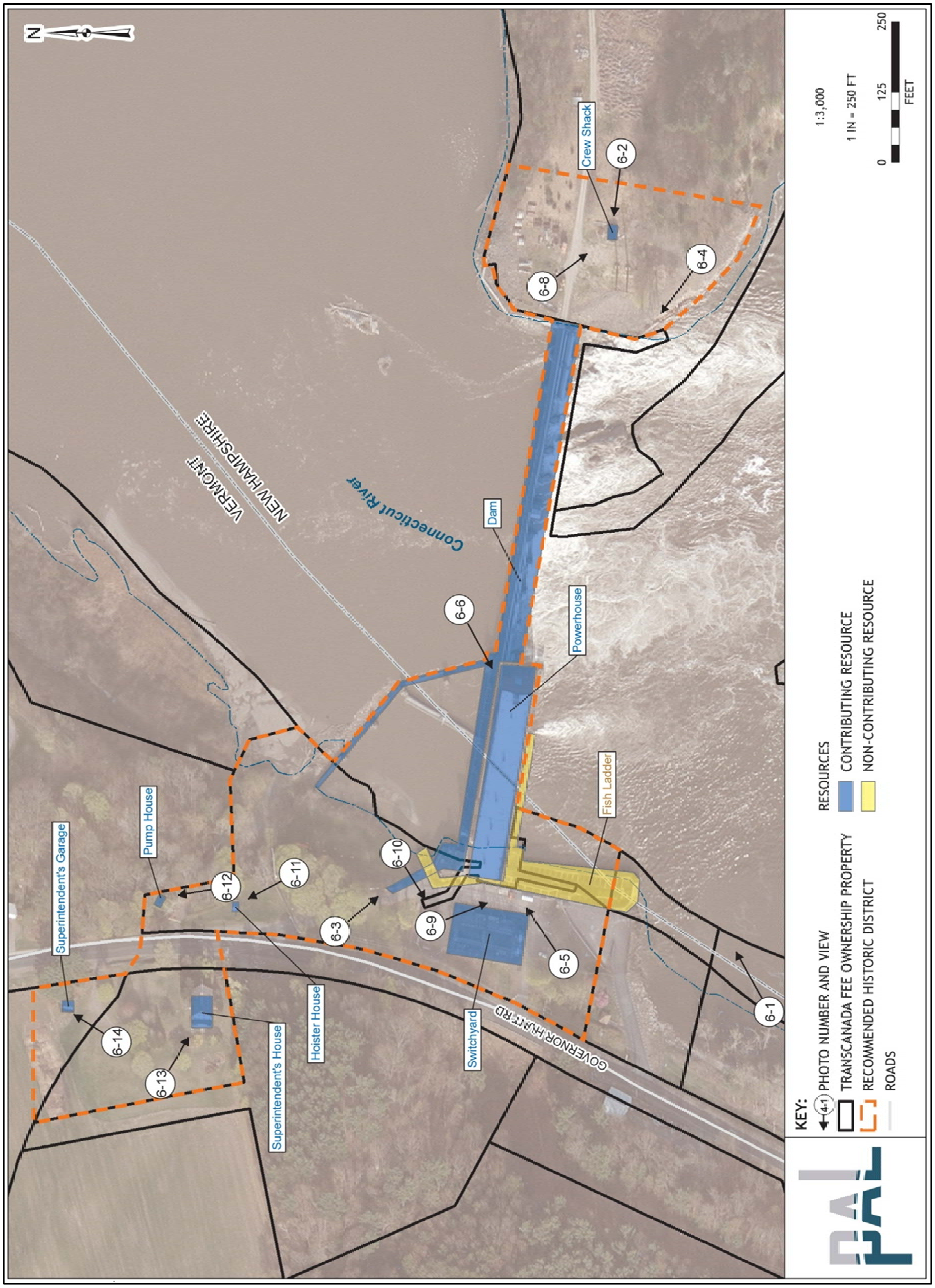

Figure 6-1. Plan of the Vernon Hydroelectric Project showing the location of the recommended Vernon Hydroelectric Development National Register Historic District.

Table 6-1. Vernon Project Existing Resources and Status within the Recommended Vernon Hydroelectric Development Historic District.

Resource Name	Location	Construction Date(s)	Recommended National Register Status*
Superintendent's House	255 Governor Hunt Road, Vernon, VT	1907	C
Superintendent's Garage	255 Governor Hunt Road, Vernon, VT	1907	C
Crew Shack	East end of Vernon Dam, Hinsdale, NH	1909	C
Vernon Powerhouse	152 Governor Hunt Road, Vernon, VT	1909 and 1920	C
Vernon Dam	152 Governor Hunt Road, Vernon, VT	1909	C
Hoister House	Governor Hunt Road, Vernon, VT	1909	C
Pump House	Governor Hunt Road, Vernon, VT	1909	C
Switchyard	152 Governor Hunt Road, Vernon, VT	1909 and 1920	C
Fish Ladder	152 Governor Hunt Road, Vernon, VT	1981	NC

*C = Resource that contributes to the significance of the recommended district.
NC = Resource that does not contribute to the significance of the recommended district.

end of the fish ladder cuts through this portion of the Dam. The concrete portion of the Dam rises to a maximum structural height of 58 ft above the underlying bedrock and is divided into multiple sections by means of piers that rise an additional 20 ft above the spillway crest.

The Dam's pondage acts as the forebay and supplies water directly to the Powerhouse via the Powerhouse substructure, or headworks, at 34 ft of head. The Powerhouse substructure consists of multiple intake bays for the turbine penstocks, divided by vertical concrete walls and guarded by a combination of vertical lift gates with the operating mechanisms mounted atop the Dam and flap gates below the water level. Submerged trash racks protect the intakes and are cleaned by a trash rack rake gantry crane that rides on a steel bridge (added in 1986) over the turbine intakes. A concrete trash and ice boom extends from the east end of the Powerhouse to the Vermont shore approximately 250 ft north of the building.

East of the Powerhouse, the Dam's ogee-profile spillway extends to the New Hampshire shore. This spillway structure begins with a 15-x-13-ft trash and log sluice gate adjacent to the Powerhouse. The remainder is divided into eleven 50-ft-wide sections by piers. These sections consist of (west to east) four 10 ft-tall tainter gates, two panels of 10-ft-tall hydraulic flashboards, three sections of stanchion-type wood flashboards, and two 20-ft-tall tainter gates (piers, gates, and flashboards added in 1986). Eight flood gates (aka sluices) with a 9-x-7-ft section are located near the base of the Dam, below the four 10-inch tainter gates. A concrete abutment and boulder rip-rap are located at the east end of the Dam. A passageway to provide access to the flood gate mechanisms extends from the Powerhouse about 250 ft into the Dam. The flood gates are 16,000-pound cast iron plugs operated by oil pressure cylinders. A 12-ft-wide roadway with a steel I-beam and grating deck crosses the Dam on its piers (New England Power Company 1992: "Vernon Development"; New England Power n.d.: "Vernon Station").

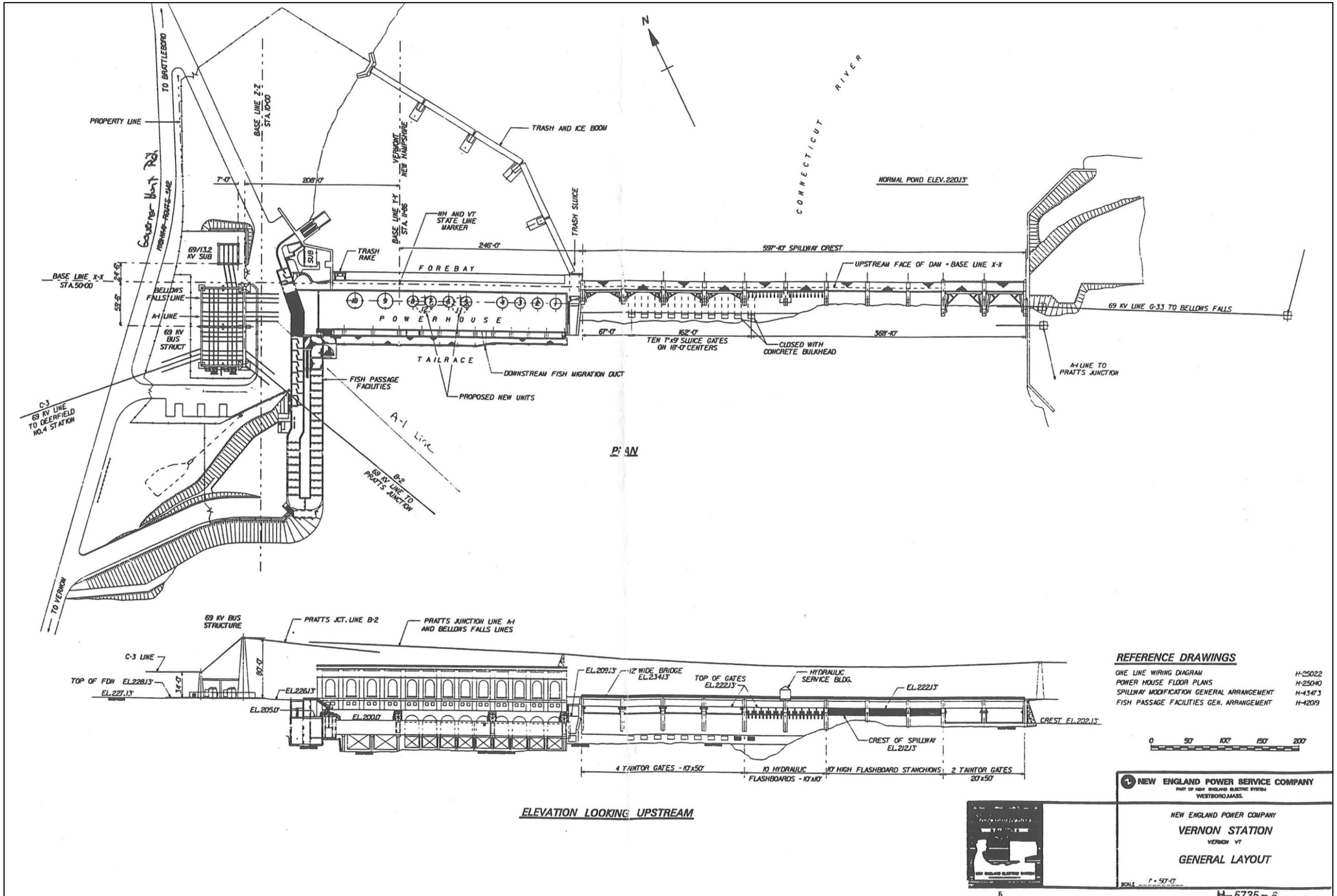

Figure 6-2. General plan of the Vernon Project.

Photo 6-1. Vernon Project, general view looking north from Vermont riverbank.

Photo 6-2. Vernon Project, general view looking west from New Hampshire riverbank.

Photo 6-3. Vernon Project, Dam and Powerhouse looking southeast.

Photo 6-4. Vernon Project, Dam spillway looking northwest.

Vernon Powerhouse

The Powerhouse (1909 and 1920) is a two-story Renaissance Revival Style building built on a 336-x-55-ft rectangular plan that extends from the Vermont riverbank across the southwest face of the Dam (Figures 6-3 and 6-4; Photos 6-5, 6-6, and 6-7). The 13-by-1-bay building has a steel frame, brick walls, and a high concrete foundation that incorporates the turbines and associated penstocks and draft tubes. Six cylindrical metal ventilators, a flat-roofed stairwell headhouse, and a pair of electrical transmission towers project from the shallow pitched "flat" concrete slab roof, which is surrounded by a brick parapet topped with cast concrete coping.

The Renaissance Revival decorative scheme consists of tall arch-topped windows in rectangular bays divided by flat piers. From the top down, all elevations share a thin tile roofline coping, second-story corbel table, and wide cast stone first story belt course. On the long west and south elevations, each bay contains triple machicolations at the cornice. The arched windows, excepting the window at the building's east end, retain their original multi-pane steel and wood sash with cast stone spring and keystones, window sills, and wide intermediate mullions at the spring line. The east window is replaced with a louvered vent. On the south (downstream) elevation, the area below the belt course contains two small, rectangular, multi-pane windows with cast stone sills, and the concrete foundation is visible and includes nine arched tailrace openings occupying the eastern two-thirds of the building. Additional square tailrace openings are present at the western end of the building, but hidden below the normal water line. A steel-frame bus structure extends across the easternmost and westernmost four bays of the building's south wall between the cornice and the windows. The building's north (upstream) belt course and water table are obscured by the Dam's headworks structure and equipment. The west elevation contains the primary entrance and is divided into three bays. The entire width of the center bay is nearly filled with an arched entry that contains a tall, rectangular, multi-paneled, wood plank equipment door with a personnel door set into the left side, set under an arched transom window. The coursed brick arch has cast stone key and spring stones, the latter with metal light sconces with round white glass globes. A corbelled, recessed brick panel is located above the corbel table over the door. This center bay is flanked by multi-pane, arched windows on the ground floor.

The Powerhouse contains 10 vertical-shaft turbine-generator units, their mechanical and electrical control equipment, and maintenance facilities. The interior is divided horizontally into a generator floor, with a gallery level above and pump room/low tension bus room below. Interior finishes at the generator floor and above are concrete ceilings and floors and painted brick walls. Finishes in the lower levels are primarily raw concrete. The generator floor is divided into two sections longitudinally. The north half of the generator floor is occupied by an open, full-height, full-length generator room. The generator room contains the upper portion of 10 vertical-shaft generating units numbered units 1 to 10 from east to west and having a total alternating current generative capacity of 32,400 kW. Units 1–4 (replaced in 1923–1925) have turbines manufactured by S. Morgan Smith. These are 4,190-hp, 133.3-rpm, 62.5-inch-diameter, single-runner, Francis-type, fixed-blade wheels equipped with specially cast concrete spiral scroll cases and draft tubes connected to 2,000-kW alternating current generators manufactured by General Electric. Units 5–8 (replaced in 2006–2008) have vertical-shaft 144-rpm Saxo-type propeller turbines manufactured by the Slovenian company Litostroj that are attached to Koncar 4,000-kW alternating current generators. Units 9–10 (added in 1920) also use S. Morgan Smith turbines. These are of the same configuration as Units 1–4, but are 6,000-hp, 75-rpm, 110-inch-diameter units connected to 4,200-kW General Electric generators (for installation and modification chronology, see Historical Development section below). Units 9–10 are larger than units 1–8 and have top-mounted exciters accessed by railed galleries.

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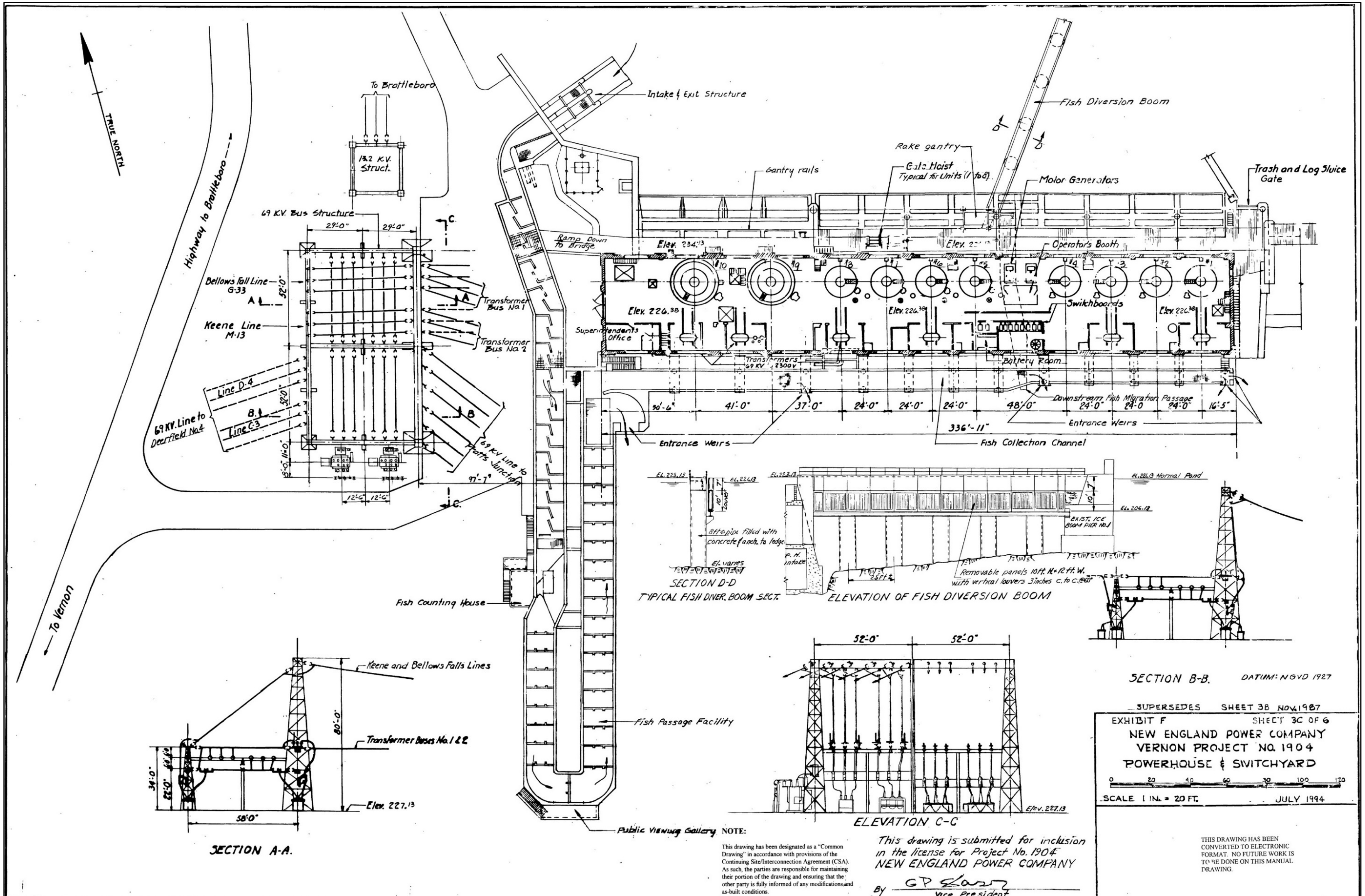

Figure 6-3. 1994 plan of the Vernon Project Powerhouse and environs (before 2006–2008 repowering project) (New England Power Co. 1994).

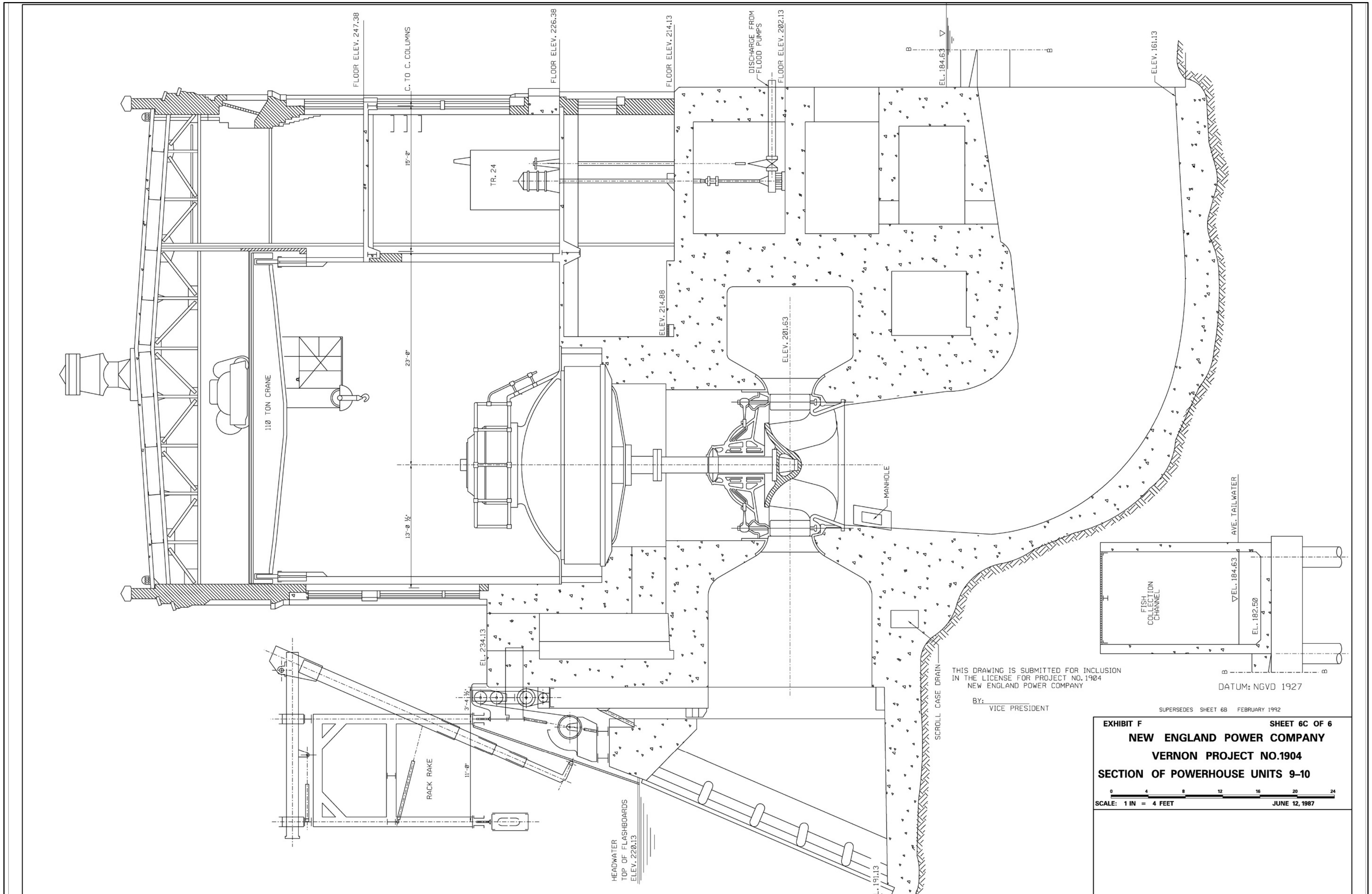

Figure 6-4. 1987 cross-section of the Vernon Project Powerhouse at generation units 9–10 (New England Power Co. 1987e).

Photo 6-5. Vernon Project, Powerhouse looking northeast.

Photo 6-6. Vernon Project, Powerhouse looking southwest from dam.

Photo 6-7. Vernon Project, Powerhouse generator hall, looking west.

In the generator room, units 1–4 have original S. Morgan Smith hydraulic governors located to the southeast. The operator's booth is located between units 4 and 5 and consists of a small wood-frame shack with half-height windows and a flat roof. The main switchboard is immediately east of the operator's booth and consists of a free-standing wall of multiple panels containing an array of meters, switches, and monitoring equipment for the units. Flights of stairs leading down to the pump room/low tension bus room are in the northwest corner and between several of the units. The entire floor is serviced by a 46-ton motorized horizontal traveling crane (replaced in 2006–2008) that rides on wall-mounted rails that run the length of the long axis of the building (Don Dionne, TransCanada, personal communication, 2014).

The south half of the generator floor contains an enclosed superintendent's office in the southwest corner, compartments for transformers and switch gear, and a set of stairs leading up to the gallery level. The office has been recently remodeled with gypsum board partitions and new drop ceilings and tile floors. The gallery, running along the entire length of the downstream side of the building, contains a locker room and wash room for the use of the station operators. The 66-kV bus equipment, including transformers and oil switches, is now removed from this area. Large banks of steel sash windows line the north side of the gallery, overlooking the generator room.

The pump room/low tension bus room is located below the generator floor and is longitudinally divided into two sections. The upstream side of this level, under the generators, houses the thrust bearings and associated oil pump equipment; the 2,300-volt busses, low-tension oil switches, and storage batteries are on the downstream side. In the west end of this level, a machine shop is has been fitted out to handle plant maintenance work, and a 57-x-12-ft storage gallery is on the downstream side of the substructure. Both of these spaces can be reached directly by the crane through removable panels in the generator room floor (New England Power Company 1992: "Vernon Development"; New England Power n.d.: "Vernon Station").

Crew Shack

The Crew Shack (1909) is in Hinsdale on a level, grassy terrace above the east abutment of the Vernon Dam (Photo 6-8). It is accessed via a gravel driveway extending off the Dam, and the area immediately surrounding the building is used as an equipment laydown area. The small, two-by-one-bay, one-story, wood-frame building has an end gable configuration facing west toward the Dam. Its asphalt-shingle roof has shallow overhanging eaves with plank soffits and gable rakes, and an interior chimney is set on the ridgeline at the rear (east) end of the building. The asbestos shingle-clad walls are blank on the north and east elevations. A wood panel door with a plank surround is centered on the west elevation, and a pair of six-over-six, double-hung, wood-sash windows with plank surrounds are set in the south elevation. The building is founded on wood sills. The interior is unfinished, with exposed ceiling rafter and stud bays and a rough plank floor. A pot belly stove is the only fixture. The building is currently vacant and used for storage.

Photo 6-8. Vernon Project, Crew Shack looking southeast.

Fish Ladder

The Fish Ladder (aka Fish Passage Facility, 1981) is a poured concrete structure that occupies approximately 400 linear ft of the west riverbank in Vermont, passing the west side of the Powerhouse (Photo 6-9). The ladder intake (aka collection gallery) runs across the south wall of the Powerhouse, passing along the front of the tailrace arches. The total length of the ladder is 984 ft and it incorporates 51 pools and a fish counting house, which is a flat-roofed concrete block hut.

Photo 6-9. Vernon Project, Fish Ladder, looking southeast.

Switchyard

The Switchyard (1909 and 1920) is owned by National Grid and is located approximately 75 ft west of the Powerhouse, between the project's driveway and Governor Hunt Road (Photo 6-10). The fenced, approximately 75-x-100-ft compound is surfaced with crushed gravel and contains transformers, busses, and other electrical appurtenances that step up and isolate the voltage incoming from the Powerhouse generators and exit through the five transmission lines that leave the Switchyard and the project. These devices are mounted on and below riveted steel lattice towers 34 to 80 ft in height.

Photo 6-10. Vernon Project, Switchyard, looking southwest.

Hoister House

The Hoister House (1909) is in Vernon at the north end of the project's driveway, approximately 400 ft north-northwest of the Powerhouse and just outside the project's fenced area (Photo 6-11). This small, one-by-one-bay, wood-frame shed has an end-gable orientation facing east toward the river. It has an asphalt shingle roof, clapboard walls with plank corner boards, and a concrete slab foundation. The entry has a rolling, wood plank door set in a plank surround and accessed by a low wood ramp. Windows are set off-center on the south, west, and north elevations and consist of two-over-two wood sash in plank surrounds. The roof, clapboard, and windows are all new material, added at an unknown date in the last five years. The interior is vacant and has exposed rafter and stud framing on the ceiling and walls and a rough wood plank floor.

Photo 6-11. Vernon Project, Hoister House, looking northwest.

Pump House

The Pump House (1909) is at the bottom of a deep wooded gulley in Vernon, approximately equidistant between the river and Governor Hunt Road and about 400 ft north of the Powerhouse (Photo 6-12). The small, one-by-one-bay hut is accessed by a decayed wood plank staircase with a steel pipe railing. The Pump House is in ruinous condition with a collapsed gable roof clad in slate, brick walls that are partially collapsed, and a high concrete foundation set into the slope of the gulley. The interior contains pipes and footings for the water pump.

Photo 6-12. Vernon Project, Pump House, looking northwest.

Superintendent's House

The Superintendent's House and Superintendent's Garage are on the west side of Governor Hunt Road, on a level, landscaped plot that overlooks the Powerhouse approximately 600 ft to the southwest. Farm fields and woodlands surround the plot to the north, west, and south. The House is south of the Garage, and a gravel driveway curves south from its turnout near the Garage to the rear of the House. Mature deciduous and evergreen trees line the driveway and ornament the lawn.

The Superintendent's House (1907) is a 2½-story, five-by-four-bay, wood-frame, vernacular duplex dwelling with a side-gable orientation and modest Colonial Revival architectural details (Photo 6-13). The two identical entries are set off-center on the north and south walls under projecting hip roof porches with turned columns and railing balusters. A one-story ell extends across the rear (west) side of the house and incorporates two small entry porches in its north and south corners. The slate roof has two brick chimneys set near the ends of the peak and ogee-profile eaves and gable rakes that continue as full returns across the gable ends, where the resulting pediments are shingled. Walls are clapboard, with wide plank fascia, corner boards, and door and window surrounds. The windows have double-hung, two-over-one, wood sash, and semicircular carved wood fans cross the gap between the paired, east first-floor windows, giving them the appearance of Palladian windows. The foundation is brick. The Superintendent's House is in poor condition and the interior is not accessible.

Photo 6-13. Vernon Project, Superintendent's House, looking southeast.

Superintendent's Garage

The Superintendent's Garage (1907) is about 250 ft north of the Superintendent's House, facing south from the north edge of the lawn (Photo 6-14). The wood-framed, one-by-one-bay, one-story, end-gable building has an asphalt shingle roof with plank soffits and gable rakes. The single vehicle door has two hinged wood plank door leaves set in a plank surround. The walls are clad in a combination of novelty siding and clapboard with plank corner boards and window surrounds. Six-over-six, double-hung wood windows light the building on the east and west sides. The building rests on poured concrete footings. The interior is unfinished, used for storage, and has exposed rafter and stud bays and a dirt floor.

Photo 6-14. Vernon Project, Superintendent's Garage, looking northeast.

Historical Development

The Vernon Project, completed in 1909, was the first of Chace & Harriman's hydroelectric projects on the Connecticut and Deerfield rivers and was a pioneering New England electrical generation facility. In the early part of the twentieth century, several bankers and merchants in Brattleboro, Vermont, had obtained New Hampshire and Vermont charters to develop hydroelectric power along the Connecticut River which, with its many waterfalls, had attracted mills since the Colonial Period. In 1907, when the charter holders identified Vernon as a potential site for development, Chace & Harriman took control of the project, convincing the local investors to sign over their charters in exchange for a share of the power. Chace & Harriman's ambitious plan was to build a facility that could send power over high-voltage lines to industries in north-central Massachusetts, a great deal further than the maximum 35 miles recommended by engineers at the time. Chace and Harriman founded the Connecticut River Power Company and received special permission to enter the Massachusetts market, provided that they establish a Massachusetts-based company as well. Thus they established the Connecticut River Transmission Company of Massachusetts.

The project's original resources were the Dam, Power House, Crew Shack, Hoister House, Switchyard, Pump House, and Superintendent's House and Garage. A second staff house was adjacent to the Superintendent's House. Construction began at the Vernon site in 1907, after Chace & Harriman had obtained the land and flowage rights to raise the river 30 ft and flood all or parts of 150 farms. The design of the facility was largely the work of the engineering firm of Charles (Chas.) T. Main, Inc., of Boston. Main was a major designer of hydroelectric projects in Vermont and a mechanical engineer who graduated from the Massachusetts Institute of Technology in 1876. After working in Massachusetts textile mills and publishing a work on mill construction, he opened his own consulting practice and developed substantial expertise in hydroelectric facility construction. He published numerous articles on the subject and his firm designed approximately 80 hydroelectric projects before Main died in 1943. Experienced hydroelectric contractors J. G. White & Company of New York acted as design consultants and built the project with 450 workers in two years (Bowers 1992; Landry and Cruikshank 1996:26–36; NEES 1949).

Work on the Vernon Project proceeded from east to west across the river, with extensive coffer dam systems used to dry portions of the river bed. The Dam, which was completed first, used a concrete gravity design that relied on its own weight and its bedrock foundation to hold back the water behind it. This type of dam was a departure from the rock-filled wooden crib dams that were typical in New England at the time and came into standard use in the region during the first quarter of the twentieth century. (Landry and Cruikshank 1996:33–34; Cook 1991:18–19). Substantially altered in 1986 (see below), the Dam was typical in its linear form and ogee profile, but differed from later developments on the Connecticut and Deerfield rivers because of the passive spillway design that used wood flashboards mounted on iron pins (Hay 1991:xix).

The first generator in the Vernon Powerhouse went on line July 27, 1909, supplying electricity to the Estey Organ Works in Brattleboro, Vermont. The facility's eight generating units produced 20,000 kW, dwarfing the output of all other hydroelectric stations east of Niagara Falls. Transformers at Vernon raised the line voltage to 66 kV, enabling it to be transmitted over 60 miles to Gardner and Fitchburg, Massachusetts, a voltage and distance unprecedented in the northeast (Landry and Cruikshank 1996:26–36, 54, 72; Cook 1991:18–19).

Technologically, the Vernon Project is typical of hydroelectric projects constructed during the first quarter of the twentieth century, when rapid advances in hydropower technology allowed the development of geographically remote sites using a variety of water management techniques and equipment configurations that were interconnected to provide electricity to larger areas (Cook 1991:4; Hay 1991:xi–xii). Today the Vernon Powerhouse operates with a variety of turbine types and substructures representing the transition from early open-flume settings to later scroll-case arrangements. The variety of turbines and substructures is evidence of efforts to keep Vernon's equipment in line with industry advances over time.

Initially, the generation infrastructure at the Vernon Powerhouse incorporated the latest direct connected vertical-shaft turbine and generator configuration that had been pioneered by Gardner S. Williams in his 1905 Sault Ste. Marie, Michigan, hydroelectric plant (Hay 1991:71). This configuration offered increased efficiency over horizontal-shaft configurations, but incorporated new bearing types that were prone to rapid wear. In their original, as-installed configuration, the first eight units installed at Vernon incorporated 2,000-kW General Electric vertical-shaft generators directly connected to triple-runner S. Morgan Smith waterwheels set in open flumes. The turbines consisted of two 60-inch-diameter fixed-blade runners in a duplex "camelback" case for operation during times of normal water flow, and a single 57-inch-runner with a quarter-turn draft tube above the duplex set to compensate for backflow power loss during high water conditions (Hay 1991:86-87). The 60-inch-diameter runners were designed to be controlled by Lombard governors, and the 57-inch-diameter runners were controlled by hand. The weight of the water in the open flume pressing against the turbine blades spun them by force of gravity. These generating units were a hybrid of new and old technology. They incorporated new, but maintenance-prone bearing technology with open flumes and stock pattern turbines, which were typical of lower-efficiency, late nineteenth-century mill waterpower technology (Hay 1991:65–67).

In 1920, the New England Company added two new generating units (9 and 10) to the Vernon Powerhouse. The building was extended 112 ft west (the westernmost four bays) into Vermont to house the new General Electric 4,200-kW vertical-shaft generators (Figure 6-5). These were directly connected to S. Morgan Smith 6000-hp, 75-rpm, Francis-type, fixed-blade, single-runner turbines with Lombard governors. Unlike the original Vernon turbines, the new units were set into scroll cases, specially-cast concrete substructures that directed incoming water into the turbine in a spiral motion, and had modern draft tube tailraces. These new units and substructures offered considerable improvements in efficiency, as evidenced by comparison of these units' specifications with the earlier triple-runner units, and nearly doubled the station's capacity at peak periods. As part of the 1920 expansion, the Powerhouse gallery's high-tension line switches were re-located to the Switchyard and the 66-kV bus in the gallery was continued through the main building and extension to the Switchyard, where it ties onto a double bus (Cook 1991:18–19; Doherty and Kierstead 1999; New England Power Company 1992: "Vernon Development"; Landry and Cruikshank 1996:26–36, 54, 72; New England Power n.d.: "Vernon Station").

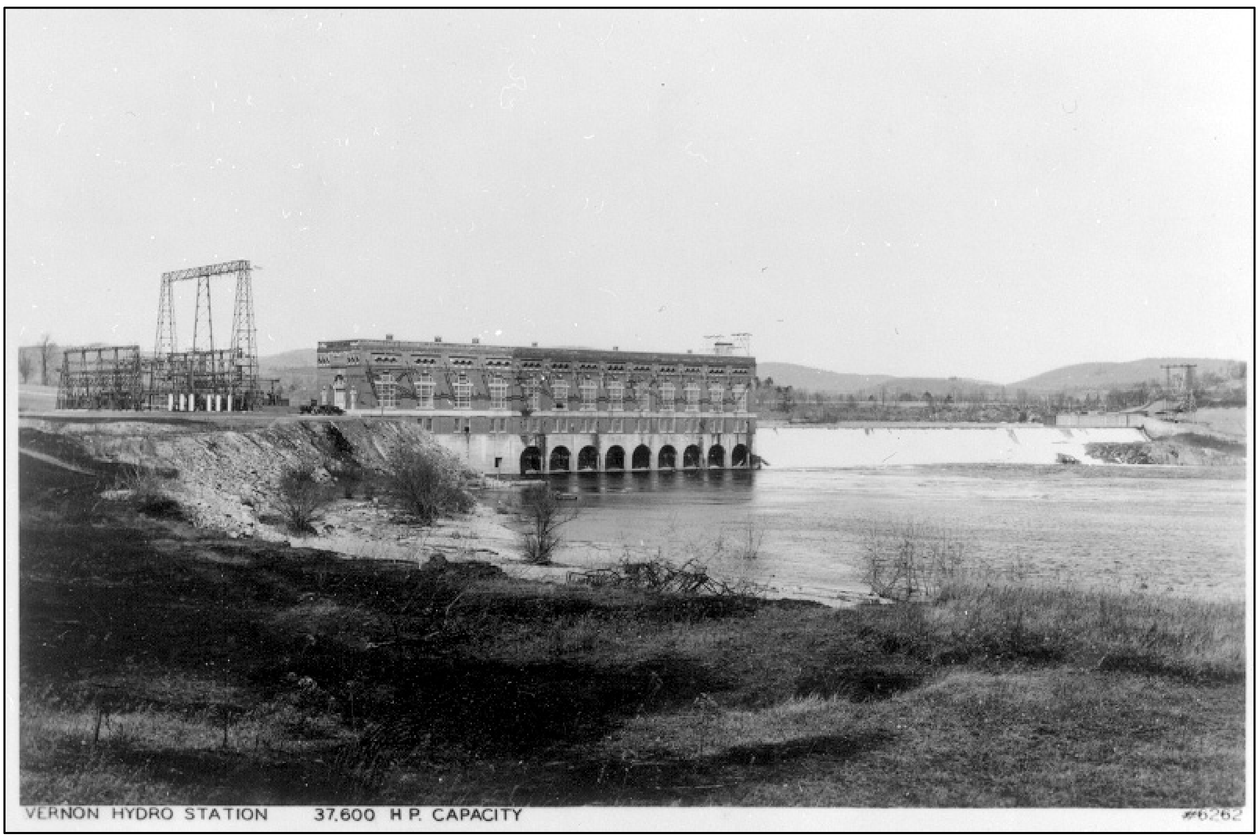

Figure 6-5. Undated historical view of the Vernon Project looking northeast from the Vermont bank of the Connecticut River and showing the facility after the 1920 expansion of the Powerhouse (visible as a lighter section of brick at the left end of the building) and before the completion of the 1986 crest control redevelopment project.

The improved efficiency of the new technology used in units 9 and 10 prompted the New England Company to reequip units 5–8 with improved wheel cases and runners to improve efficiency in 1921-1922. Between 1923 and 1925, units 1–4 were radically redesigned; their triple-runner turbines were replaced with 4,190-hp, single-runner units with rebuilt substructures incorporating cast concrete scroll cases. The development of more reliable and durable pressurized oil-film vertical thrust bearings just before World War II led to the installation of improved Gibbs-type oil pressure vertical thrust bearings in all units (Hay 1991:71–75; New England Power n.d.: “Vernon Station”). These expansions and improvements brought Vernon’s generating capacity to 24,400 kW. (New England Power Company 1992: “Vernon Development’; New England Power n.d.: “Vernon Station”).

Like the powerhouses of the Wilder and Bellows Falls projects, the Vernon Powerhouse typifies the synthesis of functional and structural requirements with architectural historicism that was the common approach to design of such infrastructure in the early twentieth century. The Vernon Powerhouse demonstrates a restrained Renaissance Revival Style scheme similar to that of the Bellows Falls Powerhouse and common for large utility and industrial buildings of its period. Its decorative scheme includes elements of the Romanesque, notably the triple machicolations repeated in the cornice in the west and south elevations (Doherty and Kierstead 1999).

The Hoister House, Crew Shack, Pump House, and Superintendent’s House and Garage were built in 1907–1909 and are typical of the utilitarian, ancillary buildings erected by Chace & Harriman and its successors for the construction and operation of their hydroelectric facilities. The Hoister House, completed in 1907, is the last remaining vestige of construction activities at the facility. It housed a compressed air-powered hoist that hauled construction railroad cars up the grade from the Powerhouse. The Crew Shack was constructed ca. 1909 to accommodate power company personnel, particularly those working on the dam in bad weather. Housing for permanent workers at remote projects in the pre-automobile era was often necessary, and the Superintendent’s House, Garage and Pump House were all built to meet this need.

Various trends combined to eliminate housing-related resources from the Connecticut and Deerfield rivers’ hydroelectric projects. Improved equipment reliability and automation reduced the number of employees required to operate the plant, and the widespread adoption of automobiles and good roads made it easier for employees to commute to formerly remote locations. The Superintendent’s House was one of two residences originally constructed at Vernon; the other was demolished at an unknown date. Now vacant, the Superintendent’s House is the only known surviving example of a power station official’s dwelling that survives on TransCanada-owned land on the Connecticut and Deerfield rivers’ systems. The Pump House was built concurrently with the houses to provide potable water to the Powerhouse and the company-built employee dwellings (Doherty and Kierstead 1999).

NEES added the Fish Ladder for spawning of Atlantic salmon, shad, and other saltwater fish past the Vernon Project in 1981. The fish passage was a product of the same 1978 agreement that resulted in similar installations at the Wilder and Bellows Falls projects, and was the first of the Connecticut River projects to receive such an installation (Landry and Cruikshank 1996:242; NEES 1990).

In 1986, NEES completed a major crest control redevelopment project to increase the efficiency of water control and attendant power generation capacity during fall and spring freshets. The Dam spillway, which had been controlled with passive flashboards running across the crest of the structure, was modified with the addition of the current system of powered boards and gates mounted to piers rising from the spillway’s crest and downstream face. The current rack rake gantry crane and bridge were added at that time. Collectively, these modifications substantially changed the appearance of the structure, although the original spillway shape is still discernable below the additions (New England Electric System 1990; TransCanada 2013d).

In 1998, New England Power Company transferred the Vernon Project to USGen New England, Inc., a non-regulated subsidiary of PG&E Corp. The same year, nationwide energy deregulation resulted in the separation of power generation from transmission companies and, consequently, National Grid acquired the Switchyard (Doherty and Kierstead 1999; TransCanada 2013c).

TransCanada acquired the Vernon Project in 2005 and, in 2006, initiated the Vernon Repowering Project. Completed in 2008, the repowering project replaced the turbines, governors, generators, and exciters for units 5–8. The turbine's associated concrete wheel pits and draft tubes in the Powerhouse foundations were demolished and replaced. The travelling crane in the generator hall was replaced with a new unit to accommodate the heavier replacement units. On the Powerhouse exterior, the bus structure extending across the five central bays of the building's downstream wall was removed. The replacement Saxo-type turbines are a relatively recent hydropower innovation and represent the continued evolution of propeller turbines. The Saxo-type turbines are similar to Kaplan turbines, but water is supplied to the turbine with an elbow containing deflector vanes rather than a spiral casing. The new generators increased the facility's electrical generation capacity to its current 32,400 kW (Gale et al. 2013; Olausen and Cherau 2008; TransCanada 2013d).

National Register Eligibility

The buildings and structures that constitute the Vernon Project have previously been determined eligible for listing in the National Register as the Vernon Hydroelectric Development Historic District through consultation with the VTSHPO and NHSHPO, and the historic district currently remains eligible for listing. The district possesses significance as defined in *Hydroelectric Generating Facilities in Vermont MPS* (Bowers 1992) under National Register Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture.

Under Criterion A, the district derives its primary significance from its contribution to the broad patterns of Vermont and Massachusetts economic and social history. Vernon was the first large-scale hydroelectric development constructed in New England. Developed by Chase & Harriman, which went on to form the largest power generating concern in the region, Vernon dwarfed the output of any hydroelectric plant east of Niagara Falls at the time of its completion in 1909. It was the first hydroelectric plant in the Northeast built to deliver energy via long-distance transmission lines and therefore contributed substantially to the economic development of central Massachusetts and southeastern Vermont.

Under Criterion C, the district is significant for its embodiment of early twentieth-century hydroelectric project engineering, specifically as a concentrated-fall development incorporating a concrete ogee-profile dam, connected steel and brick powerhouse with Renaissance Revival Style detailing and vertical-shaft turbine and generator configuration using 1920s Francis-type, single-runner, fixed-blade turbines set in specially cast concrete spiral scroll cases and draft tubes. The development of this type of purpose-built hydroelectric development represented a significant step in the evolution of modern, large-scale electrical generation facilities. The Vernon Hydroelectric Development Historic District Powerhouse and Dam also possess significance under Criterion C in the area of engineering as a work of the significant hydroelectric designer Charles T. Main, Inc. The period of significance for the project under Criterion A begins in 1909, when electrical generation commenced, and terminates in 1941, the end of the period of significance as defined in *Hydroelectric Generating Facilities in Vermont MPS*.[8] Under Criterion C, the period of significance extends from 1909, when the original electrical generation resources were completed, until 1925, when the last historic period turbines and generators were installed.

[8] As noted in Chapter 4, the 1941 end date is arbitrary, and it is likely that the significance of the Bellows Falls property under Criterion A continues to the present.

The district consists of two primary resources: the Powerhouse and Dam that are associated with the project's function as a hydroelectric power generating facility. Six ancillary structures also contribute to the significance of the district: the Switchyard, Crew Shack, Hoister House, Pump House, Superintendent's House, and Superintendent's Garage (see Figure 6-1). The Fish Ladder does not contribute to the significance of the district. It was added in 1981, outside the period of significance, and is not functionally related to the electrical generation activities and infrastructure from which the district derives its significance.

Although the Vernon Project has been subject to substantial modifications of its Dam and power generation units, the historic district retains the essential physical features (as defined in *Hydroelectric Generating Facilities in Vermont MPS*) to demonstrate its associations with early twentieth-century hydroelectric power generation and its engineering and architectural significance. The development retains its location and setting on the Connecticut River. The facility's overall design, materials, and workmanship as a concentrated-fall facility with vertical-shaft generation infrastructure within a Renaissance Revival Powerhouse is preserved, with the spatial and functional relationship among the development's principal components readily discernible. The property expresses its feeling as an early twentieth-century hydroelectric development and its associations with the development of the hydroelectric power generation industry during that era.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

PAL has completed a survey and evaluation of historic architectural resources on behalf of TransCanada in fulfillment of the Cultural and Historic Resources Study 33 of its Revised Study Plan for the relicensing of the Wilder, Bellows Falls, and Vernon hydroelectric projects. PAL recommends that each of the three projects contains a historic district eligible for listing in the National Register. Recommendations for a newly identified Wilder Hydroelectric Development Historic District are provided. The survey confirms that the previously identified Bellows Falls Hydroelectric Development Historic District and the Vernon Hydroelectric Development Historic District continue to be eligible for listing in the National Register and has refined the boundaries and contributing and non-contributing resources of these districts.

Wilder Hydroelectric Development Historic District

Elements of the Wilder Project are eligible for listing in the National Register as components of the Wilder Hydroelectric Development Historic District under National Register Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. The district is significant due to its contribution to the broad patterns of economic and social history in Vermont and New Hampshire and for its embodiment of mid-twentieth-century hydroelectric project engineering. The district contains 6 contributing resources: the Dam, Powerhouse, Visitors' House, and Garage, and the TransCanada 13.8-, 47-, and 115-kV Switchyard and National Grid 115-kV Switchyard. Four resources are excluded from, or do not contribute to, the significance of the recommended district: the Connecticut River Office, Consolidated Control Center, Oil Storage Shed, and Fish Ladder.

Bellows Falls Hydroelectric Development Historic District

The Bellows Falls Hydroelectric Development Historic District is significant under National Register Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. Under Criterion A, the district derives its primary significance from its contribution to the broad patterns of Vermont and New Hampshire economic and social history and as an example of an early twentieth-century, as a divided-fall type project. The Bellows Falls Hydroelectric Development Historic District contains 11 contributing resources: the Dam, Canal, Powerhouse, Red Barn, Gauge House, Six-Man Garage, Line Shed, two Switchyards, Crew Shack, and Tailrace. Two resources do not contribute to the recommended historic district: the Fish Ladder and Visitors' Center.

Vernon Hydroelectric Development Historic District

The Vernon Hydroelectric Development Historic District is significant under National Register Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. Under Criterion A, the district is significant due to its contribution to the broad patterns of Vermont and Massachusetts economic and social history. Under Criterion C, the Vernon Hydroelectric Development Historic District is significant as a twentieth-century concentrated-fall hydroelectric project incorporating concrete ogee-profile dam, connected steel and brick powerhouse with Renaissance Revival Style detailing, and vertical-shaft turbine and generator configuration. The District Powerhouse and Dam are also significant in the area of engineering as a work of the important hydroelectric designer Charles T. Main, Inc. The Vernon Hydroelectric Development Historic District contains 8 contributing resources: the Powerhouse, Dam, Switchyard, Crew Shack, Hoister House, Pump House, Superintendent’s House, and Superintendent’s Garage. The Fish Ladder does not contribute to the significance of the recommended historic district.

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