HADDAM NECK NUCLEAR POWER PLANT, SCREENWELL HOUSE
(Connecticut Yankee Nuclear Power Plant, Screenwell Structure/Screen House)
362 Injun Hollow Road
Haddam
Middlesex County
Connecticut

HAER CT-185-A
HAER CT-185-A

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
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HISTORIC AMERICAN ENGINEERING RECORD

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(Connecticut Yankee Nuclear Power Plant, Screenwell Structure/Screen House)
HAER No. CT-185-A

Location:	362 Injun Hollow Road Haddam, Middlesex County, Connecticut U.S. Geological Survey Haddam & Deep River Quadrangles UTM Coordinates 18.708748.4595057
Date of Construction:	Original construction 1964-1966. De-icing line modification ca. 1968
Engineers:	Stone & Webster Engineering Corporation
Present Owners:	Connecticut Yankee Atomic Power Company (CYAPCO) 362 Injun Hollow Road Haddam Neck, CT 06424-3022
Present Use:	Decommissioned and demolished, with some foundations filled in place
Significance:	The Haddam Neck Nuclear Power Plant was one of the earliest commercial scale nuclear power stations in the United States, and was eligible for the National Register of Historic Places. Located on the Connecticut River, the Screenwell House supported four pumps feeding the Circulating Water System which provided cooling water to the main condensers in the Turbine Building (HAER No. CT-185-C), four pumps for the Service Water System which cooled all other plant components and served additional secondary foundations, a pump for washing of traveling intake screens, and two fire pumps serving the entire plant. Chemical controls in the Screenwell House inhibited marine bacterial growth in the plant equipment using river water.
Project Information:	CYAPCO ceased electrical generation at the Haddam Neck plant in 1996 and began decommissioning operations in 1998, subject to Nuclear Regulatory Commission (NRC) authority which brought the project under the purview of federal acts and regulation protecting significant cultural resources from adverse project effects.[1] This documentation was requested by the Connecticut State Historic Preservation Office to preclude the possibility of any adverse project effects.

[1] National Historic Preservation Act of 1966 (PL 89-655), the National Environmental Policy Act of 1969 (PL 91-190), the archaeological and Historical Preservation Act (PL 93-291), Executive Order 11593, Procedures for the Protection of Historic and Cultural Properties (36 CFR Part 800).

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Note: Letter designations of Haddam Neck Power Plant structures and facilities.

Letter designations for structures A through W were assigned when the project started. Research and detailed knowledge of the plant acquired during the recordation process indicated that some facilities could logically be combined with others. In addition some facilities were described in the overview of CT-185, or briefly in Appendix B. The following lists which facilities were combined, included in another section or not considered part of the project.

CT-185-E Terry Turbine Building is included in CT-185-C Turbine Building

CT-185-K Ion Exchange Area is described in Appendix B - Summary of Structures, Primary Functions and Major Equipment

CT-185-N Radwaste Reduction Facility is included in CT-185-L Waste Disposal Building

CT-185-Q Service Boiler Room is included in CT-185-F Service Building

CT-185-S Information Center is described in Appendix B - Summary of Structures, Primary Functions and Major Equipment

CT-185-T Health Physics Facility is described in Appendix B - Summary of Structures, Primary Functions and Major Equipment

CT-185-U Health Physics Count Module is described in Appendix B - Summary of Structures, Primary Functions and Major Equipment

CT-185-V Steam Generator Mock-up is described in Appendix B - Summary of Structures, Primary Functions and Major Equipment

CT-185-W Emergency Operations Building is described in Appendix B - Summary of Structures, Primary Functions and Major Equipment. A reference to the facility will also be found in the CT-185 Overview.

Summary Building Description and Plant Design Factors

Located on the Connecticut River and known by many alternate names, the Screenwell House was — like most structures at the Haddam Neck Nuclear Power Plant — oriented on a northwest-southeast axis with the northwest end "called north" on plant drawings. Figure 1 shows the location of the Screenwell House in relation to other plant facilities. Because the most critical equipment in this structure was the set of circulating pumps which fed the main condensers in the Turbine Building, the Screenwell House was located approximately 120-feet directly "west" of the Turbine Building, in line with the condensers. Built on bedrock excavated to an elevation of -20- feet,[b] the Screenwell House had two major components: a screenwell section which served as a gatehouse to control river water flow to the pumps in the structure; and the pumpwell section housing the pump intakes, pumps and water treatment facilities. Both components had a common, reinforced concrete mat with an upper elevation of -18, resting on concrete fill and tied to bedrock. This base floor level was approximately 64.8-feet north-south and 57-feet east-west, and supported reinforced concrete walls up to 5-feet thick which rose to elevation 21.5 at the plant ground level.

All facilities in the 29-by-64.8-foot screenwell section were built into the concrete walls, other than the upper sprockets for the traveling screens and some sections of the de-icing line described below. The pumpwell section included a floor level at elevation 8 for all the Screenwell House pumps, an approximately 31-by- 64.8-foot floor at elevation 21.5 for pump motors and a variety of controls, and a steel-framed, 15-foot-high superstructure with insulated Galbestos siding, aluminum louvers, and a reinforced-concrete roof deck penetrated by covered roof hatches for equipment removal. The superstructure extended approximately 14-feet north of the foundation, with a concrete floor at an elevation of 22.2, as a 31-foot-long room housing the tanks, pump, and controls for the Hypochlorination System discussed below. There were four 7-foot-high single or double man doors on the north, east, and west sides of the superstructure, a 4-foot-wide concrete walk along the north side, and a 12-foot-wide concrete roadway along the south side above the de-icing line (Figures 3).[1]

The design and location of the Screenwell House, and the capacities of its components, were dictated largely by the "once through" or open circulating water system for exhaust steam condensation chosen by plant designers. As described in HAER NO. CT-185-C, the Haddam Neck plant pumped Connecticut River water through the tubing in the four condenser shells in one pass and then returned to the river.[2] Aside from localized river heating issues discussed in HAER No. CT-185-A, this design introduced ambient river temperature factors into plant operations. High cooling water temperatures in the summer reduced the amount of heat that could be pulled from the exhaust steam, lowering the plant efficiency.[3] Winter icing could restrict coolant ingress with the same effect. In addition, the intake had to be sited far

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[b] All elevations are in feet relative to mean sea level.

enough upstream to prevent the warmed discharge from being taken back in. By the mid 1960s, many large fossil-fueled power stations (over 500 mw) used a more efficient "closed loop" cooling system, in which cooling water was taken from a basin rather then a natural body of water, and the heated discharge was cooled in large concrete towers [c] to provide a long-term coolant flow within a close temperature range.[4] A "closed loop" system eliminated the plant efficiency issues associated with fluctuating water source temperatures, and required only a small screening and pumping station at the local water source to provide make-up water for system losses. The complex screening and trash removal system described below for the Screenwell House was not needed.

Connecticut Yankee's single-pass condensation system also used approximately 30% more water, and larger pumps and pipes, than designs in which the cooling water made two passes through the condensers before discharge to pull more heat. The two-pass condenser design facilitated internal backwashing to reduce fouling.[5] Cooling water flow could also be reduced by installing condensers in series with flow from one unit to a second before discharge. The large steam volume resulting from the low initial pressure out of the steam generators, and the use of single pass condensers, required a 372,000-gpm capacity for the Connecticut Yankee intake system, circulating pumps, and piping to the condensers. In contrast a 900 mw high pressure coal fired station with series condensation only needed 280,000 gpm of cooling water.[6]

Screenwell Section Components

Normal river water levels fluctuate approximately 5.5-feet, from elevations 4.5 to -1. Between elevations -3 and -18, the intake entrance was divided into four separate passageways protected by fish frighteners, trash racks and traveling screens, and equipped with crane-operated stop logs at inboard and outboard ends to allow for de-watering the intake passageways or the pumpwell areas inboard of the screenwell section. A concrete curtain wall at the riverside edge of the passageways, extending from elevations 21.5 to -3, prevented floating debris and warm surface water from entering the Screenhouse. Five 3-to-3.4-foot-wide concrete platforms extended 8.7-feet beyond the curtain wall between the passageways with top elevations of 4.5, accessed from above by ladder and used for manual removal of trash from the trash racks.[7] Each intake passageway narrowed from approximately 12-feet wide at the outboard end to 11-feet wide at the traveling screens centered approximately 11.3-feet from the end of the curtain wall. Fish frighteners located at the mouth of each intake passageway, between the ends of the narrow platforms, limited fish entry into the intake structures and diminished the numbers of fish trapped on the travelling

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[c] An alternative to towers was the use of natural or man made lakes to supply the cooling water and receive the heated discharge. They provided a large enough "heat sink" that supply temperature was consistent enough for overall efficiency. In addition, their controlled environment could reduce the amount of foreign matter that had to be screened from the cooling water inlets (Bergstrom 1965: 562).

screens. Each fish frightener was mounted on the concrete base of the Screenhouse House at elevation -18, and consisted of three rows of fifteen vertically-mounted, 20-foot-long, 1-inch-diameter aluminum conduit piping, with the rows set 18-inches apart. The pipes were set in oak timbers, hard-mounted at the bottom and allowed to rattle and vibrate at the tops as water flowed past the pipes. The resultant noise and vibration were designed to frighten the fish (Figure 3).[8]

Immediately outboard of the screenwall curtain wall, vertical concrete guides approximately 1.3-feet wide accommodated trash racks and the upstream stop logs for each intake passageway. The bar-type trash racks, designed to keep large pieces of debris from reaching the traveling screens, were built of 4-by-3/8- inch metal bars, set on 4-inch centers and mounted at a slight angle toward the traveling screens from the vertical position. The trash racks extended from elevation -18 to -3. Dewatering an intake passage required removal of a trash rack by a crane and installation of stop logs which consisted of quadrangular-section timbers. The trash racks were usually cleaned by contract divers (Figure 3). The differential pressure across the center two trash racks, indicating the extent of blockage, was monitored by indicators on either side of the wall of the Screenwell House superstructure.[9] The four rotating-type traveling screens, designed to remove all small particles and debris greater than 3/8 of an inch in diameter from the incoming river water, were each 10-feet wide with sprockets centered 41-feet apart at the top and bottom of the traveling screen assembly. Each screen, which extended the full height of the screenwell section, had a capacity of 100,000 gpm at an extreme low-water river elevation of -2 (a screen submergence of 16-feet). The traveling screens were normally stationary, but were periodically rotated to allow a screen wash system described below to backwash any debris collected on the screens to a trough which directed backwash water and debris into the Connecticut River (Figure 3).[10]

Circulating water warmed by passage through the condensers in the Turbine Building (HAER No. CT-185-C) was used to prevent formation of ice on the traveling water screens during winter months. A 4-foot-diameter concrete de-icing line, controlled by a 4-foot manually-operated butterfly valve operated from the 345-kv transformer yard, ran from the discharge tunnel in the Turbine Building to the south side of the Screenwell House just below the normal river level. As first built, the pipe transitioned to a 4-by-3-foot, rectangular steel distribution header which ran across the outer end of the intake passageways at elevation -3. Several years after the plant opened, the distribution component of the de-icing line was evidently rebuilt as a 4-foot diameter steel pipe which dropped 20-feet on the north side of the intakes, turned 90 degrees to run along the intake bottoms outboard of the foundation floor, and fed five evenly-spaced, approximately 21-foot-high vertical pipes located directly in front of the intake passageway partitions. The two outside pipes were 16-inches in diameter with 8-inch-diameter holes along one side to direct the de-icing water into the adjacent intake passageway. The three middle lines were each 24-inches in diameter with similar holes. The de-icing system could re-circulate a maximum of 10-per cent of total Circulating Water System flow. The control valve was closed when freeze protection was not needed, because the recirculation of warm circulating water would raise system temperature and lower plant efficiency.[11]

Pumpwell Section and Screenwell House Operating Systems

Below the floor level at elevation 8, the pumpwell section was divided longitudinally into two equal-sized areas: an open or common pump well, closer to the river, from which the four service water pumps and two fire pumps took suction; and an inboard area of four individual 13-foot-wide suction wells for the circulating water pumps, divided by three 15-foot-long concrete walls. A 10-foot-high, 1-by-8.8-foot stop log guide divided the common pump well in half, and along with the two sets of stop log guides in the screenwell section allowed for dewatering of each individual intake passage for access to the traveling screens, and for dewatering all or half of the common pump well. Dewatering either half of the pump well, using two duplex pumps on the lower floor, allowed for one of the two fire pumps and two of the four service water pumps to remain in service.[12]

Service Water Pumps and Components

Within the Screenwell House, Service Water pumps supplied water to backwash the traveling screens, dilute and inject sodium hypochlorite into the circulating water system, supply cooling and lubrication filters for the circulating water pumps, prevent freezing in the fire pump discharges, and run emergency showers to rinse workers of any spilled sodium hypochlorite.[13] The four pumps took suction at elevation -10.5 and discharged at elevation 10.5, with the motors located on the upper floor. Each pump was a vertical, two-stage, turbine type (mixed flow) design, incorporating the more desirable features of both centrifugal and axial-flow pump types to provide a 6000-gpm flow with a 150-foot head at 1185 rpm, and a 75-80-psig normal discharge pressure with a shutoff head of about 110-psig. A packed stuffing box provided shaft sealing. The lower pump shaft bearing was lubricated by the pumped water, and the upper shaft bearing had a drip-feed oil lubricator with a local reservoir and with a solenoid-operated outlet valve. The 250-hp, 480-v, vertical, solid shaft induction pump motors had oil-lubricated motor bearings, and were powered from 480v AC buses on the upper Screenwell House floor.[14]

Discharged water from each pump passed through a stop-check valve, full-flow strainer, double-disc check valve and a manual-discharge-isolation valve before reaching the two normally cross-connected, 24-inch main service supply headers. Supply taps off the headers fed Screenwell House components as described below. Both headers traveled underground to the main plant complex, resurfacing in the northeast corner of the Turbine Building. As river temperatures rose each year, plant components cooled by the Service Water System required increased water volume. With a maximum river water design temperature of 90-degrees F, three of the four pumps were required to supply station cooling demands, and in practice all four were operated in summer months.[15]

Circulating Water Pumps

Each of the four, approximately 44-foot-high circulating water pumps was a vertical, axial-flow (propeller type) pump with a rated capacity of 93,000-gpm at a head of 25-feet, with the suction located below the level of water at elevation -15, and horizontal pump discharge centered at elevation 12 through a 66-inch-diameter carbon steel pipe to an associated condenser water box in the Turbine Building.[16] As described in HAER No. CT-185-C, each condenser had two separate tube bundles, each with a separate non-divided water box supplied by one of the four circulating water pumps. There were no valves or interconnecting cross ties in the circulating water piping, and no provision for condenser backwash. When operating on fewer than four circulating water pumps, at least one pump per condenser had to remain in operation. When starting up, the circulating water pumps could not pump water all the way from intake elevation to the tops of the condenser tubes at elevation 35.5.[17] The circulating water pumps were augmented by a vacuum priming system including two vacuum priming pumps on the Turbine Building ground floor and vacuum priming tanks attached to each of the four condenser water boxes.[18]

Each circulating water pump motor was connected to its associated pump through a mechanical shaft coupling located above the pump shaft seal. Due to the extremely long distance between the pump motors and circulating water pumps, the pumps were built with mechanically-coupled multiple shaft pieces. The high flow requirement and relatively small elevation between the intakes and the condenser shells allowed the use of axial flow pumps (water flowing along the axis of the rotating shaft as opposed to centrifugal types with water flow at right angles to the shaft) with cantilevered blades resembling ship propellers which were well suited to that situation.[19] Internal vanes at the top of the discharge column directed water flowing through the pump to make the 90- degree turn to the horizontal pump discharge. This type of pump design had extremely high flow rates with a very small discharge head. Pump operation was similar to that of a vane axial fan. As fluid entered the pump suction propeller, rotation energy caused the water to flow upward toward the pump discharge. The propeller-type pump design had unique operating characteristics: as back pressure increased and flow decreased, the brake horse power increased due to an increased amount of work done by the pump. This characteristic allowed pump amperage to be used as an indication of the state of cleanliness of the condenser tubes. As the condenser tubes became fouled with biological growth, the pumps registered more back pressure with a corresponding decrease in system flow and an increase in pump amperage.[20] However, if circulating water flow tended to equalize because of the leaking condenser tubes discussed in HAER No. CT-185-C, pump amperage could have remained lower and provided false indications of less tube fouling. Monitored water chemistry changes in the Condensate System detected leaking condenser tubes.

The discharge flange of each circulating water pump was surrounded with a rubber lining for leak detection. If a leak occurred in the discharge flange, the rubber lining would swell to provide a visible indication. Between the Screenwell house and the Turbine Building foundation, the underground piping was 66-inch inside-diameter precast concrete with an internal steel liner. As described in HAER NO. CT-185-C, the piping beneath the Turbine Building floor was also carbon steel. Each pump was driven by a 700-hp, 4000-V, three-phase AC motor rated at 393-RPM. Controlled from the main plant control room and powered by switchgear on the main Screenwell House floor, the pumps operated continuously except during plant shutdown and maintenance periods (Figure 3). A pressure gauge installed on the discharge of each circulating water pump provided local discharge pressure indication. Each gauge had a range of 0 to 15-psig and normally read from 4 to 6-psig. In addition to the pressure gauge, a pressure transmitter installed in each pump discharge sent a signal equivalent to pump discharge pressure to the plant process computer for use in the "Condenser Performance" program which estimated levels of condenser tube leakage.[21]

The air-cooled pump motors had an upper thrust and radial bearing and a lower sleeve bearing. The upper and lower bearing supplied radial support to the motor shaft. The upper bearing also supported the entire weight of the motor and pump; the pump had no thrust bearings. Both motor-bearing assemblies sat inside internal oil sumps with oil level indicators (sight glasses) external to the motor. Both the upper and lower motor bearing had temperature indicators with a range of 100 to 220 degrees Fahrenheit which normally read between 120 and 150-degrees when a pump was running. The upper bearing also had a resistance temperature detector indicating upper bearing temperature on the Plant Process Computer (Figure 4).[22]

Each circulating water pump was radially supported by four sleeve-type bearings. The lowest bearing, located at the pump suction, was cooled and lubricated by the flow of pumped liquid flowing through the pump. The upper three bearings were inside a shaft sleeve, and were cooled and lubricated by an external source of clean water. A packing gland around the pump shaft at the top of the pump casing prevented air entry into the pump and limited the amount of water leaking out of the pump. Filtered bearing supply water entered the pump sleeve section below the pump packing gland, and flowed downward to cool and lubricate the upper three bearings. There was sufficient leakage out of the shaft sleeve into the main flow path of the pump to allow for sufficient cooling flow past the bearings. The packing gland was cooled and lubricated by a small amount of the filtered bearing supply water seeping upward through the packing gland.[23] The Service Water System supplied the bearing water through two motorized, self-cleaning (Kinney) filters from 2-inch-diameter supply lines coming from the service water pump discharge header. The Kinney filters were located on the lower level of the pumpwell section near the north wall. Each filter could supply all four circulating water pumps, and one was usually manually isolated and de-energized. If both filters were out of service, a backup supply of clean water was tapped from the plant Well Water System.[24] One-inch supply lines tapping off the bearing supply headers provided flow to each of the four circulating water pumps, via 1-inch-diameter manually-operated isolation and throttle valves, and a pressure with a range of 0 to 30 psig. The supply line throttle valves were manually throttled to maintain 6 to 10 psig bearing supply pressure to their associated circulating water pumps.[25]

Hypochlorination System

Sodium hypochlorite was intermittently injected automatically into the circulating water to prevent the buildup of bacterial slime and Asiatic clams on the traveling water screens, condenser tubes, and piping, usually three times a day for 15 minutes at a rate of 4-7 gpm, with manual adjustment as necessary to maintain approximately 0.5 to 1 ppm residual chlorine in the circulating water at the condenser outlet during the period of injection. The injection system was controlled and largely housed in the room at the north end of the Screenwell House. Two tanks held sodium hypochlorite containing approximately 13.5-percent by weight of available chlorine. Service water controlled by an air-operated valve diluted the solution as necessary, and powered an injector which pushed the solution through polyvinyl chloride pipes to diffusers located between the trash racks and the traveling water screens. Each of the four traveling water screen passages was served by two 2-inch diameter hypochlorite diffusers. Automatic controls on the chemical solution precluded release of excessive sodium hypochlorite into the marine environment, to minimize or eliminate harm to fish and other marine life.[26]

Washing of Traveling Screens

The Service Water System provided water for backwashing the traveling water screens. Available information suggests that when the plant opened, water for this process came only from the discharge of two of the two service water pumps. Pump discharge pressure proved inadequate for effective cleaning of more than one screen at a time, and a screen wash booster pump was installed on the lower floor level by c1970, with the valve controlling flow from the service water pump discharges maintained for back-up supply. This horizontal, single-stage, centrifugal pump took suction from the south service water header and operated with sufficient pressure to backwash all traveling screens simultaneously. A traveling screen was activated manually if an alarm actuated by a bubbler-type differential level controller indicated an increase in level differential across the screens of from 3 to 6-inches. The pump pressurized the screen wash header, which automatically opened the screen wash control valve allowing flow to a selected traveling screen whose rotation had been manually switched on. After the booster pump operated for a prescribed time period, the pump automatically stopped, the screen wash control valve closed, and the selected traveling screen stopped, completing the wash cycle. The procedure was subsequently repeated on the remaining screens.[27]

The pump had a capacity of 1200-gpm at a discharge pressure of 150-psig and a suction pressure of 60-psig, and was driven by a 100-hp motor. An orifice on the pump discharge provided for an optimum operating discharge pressure of 120-psig. The pump bearings were oil lubricated using a constant-level oiler system. A 100-hp electric motor, powered from the 480-v Screenwell House motor control center and controlled from a panel on the upper floor, drove the screen wash booster pump.[28]

Fire Pumps

On the upper floor level, two vertical, turbine-type, 2500-gpm fire pumps, each with a 115-psi gage discharge pressure, pumped river water to an underground piping system serving exterior and interior plant fire protection systems. One pump was motor driven, powered from a local 480-v bus, while the second was driven by a diesel engine with its own fuel oil supply and starting equipment. Pressure in the water distribution piping system was maintained at 110-100-psi gage by a pressure maintenance system located on the upper floor level, consisting of a hydro-pneumatic tank, an air compressor, a 30-gpm vertical turbine-type make-up pump and a control system. The control system was an automatic combination pressure-level controller which maintained pressure in the piping header and compensated for minor water leakage from the piping.[29] The two fire pumps were controlled from pressure switches in the discharge piping. One switch was set to start the motor driven pump if system pressure dropped to 90-psi gage. The second switch started the diesel driven pump if the pressure continued to drop to 80-psi gage. The pumps continued to operate until shut down manually. Taps from the two service water headers provided discharge column de-icing for the fire pumps.

A 10-inch-diameter line from the fire water header provided an emergency supply of service water from the diesel-driven fire pump if a complete loss of AC power made the service water pumps inoperable.[30]

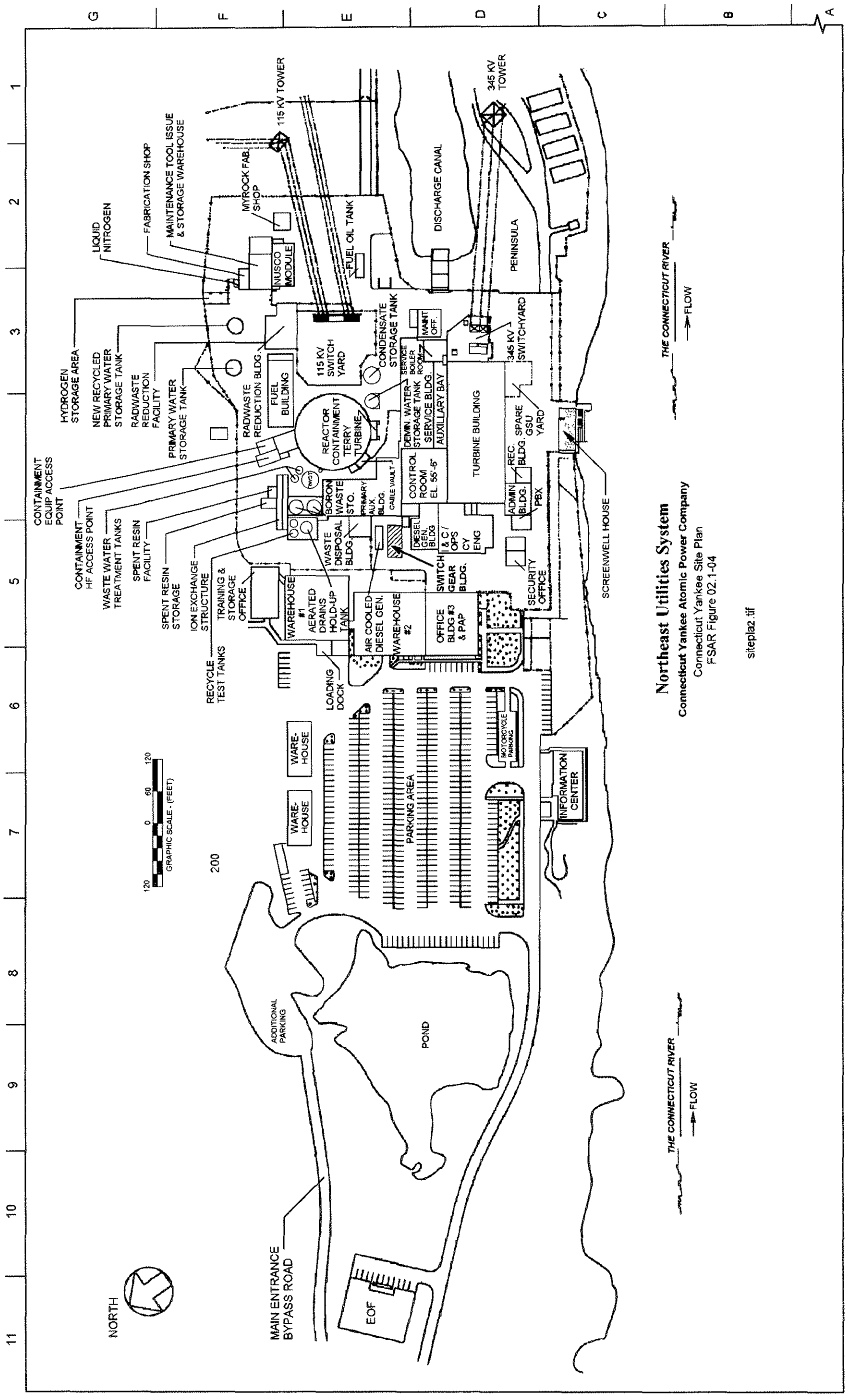

Figure 1. SITE PLAN SHOWING LOCATION OF SCREENWELL HOUSE

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Notes

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[1] Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964, 1964-*1996a*, b [drawings]; Connecticut Yankee Atomic Power Company 1987-1993: Chapter 41, pages 6-7.

[2] Power 1982a: 225.

[3] Ibid: 361.

[4] Mc Vay and Fiehn 1966: 361.

[5] Miller and Kolflat 1965: 551, Jonelis and Scheibel 1966: 370.

[6] Estrada and Smith: 395.

[7] Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964-1996a, b [drawings]. Connecticut Yankee Atomic Power Company 1966-1974: 8.5-2; 1987-1993: Chapter 41, pages 6-7.

[8] Connecticut Yankee Atomic Power Company 1987-1993: Chapter 41, pages 7-10.

[9] Ibid: pages 10-11; Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964- 1996a, b [drawings].

[10] Connecticut Yankee Atomic Power Company 1966-1974: 8.5-2; 1987-1993: Chapter 41, pages 11-12.

[11] Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964-1996a, b; 1968 [drawings]; Connecticut Yankee Atomic Power Company 1966-1974: 8.5-5.

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[12] Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964-1996a, b [drawings]; Connecticut Yankee Atomic Power Company 1966-1974: 8.5-2.

[13] Connecticut Yankee Atomic Power Company 1987-1993: Chapter 43, page 2.

[14] Ibid: pages 11-13; Connecticut Yankee Atomic Power Company 1966-1974: 8.9-1.

[15] Connecticut Yankee Atomic Power Company 1987-1993: Chapter 43, page 16.

[16] Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964-1996a, b [drawings]; Connecticut Yankee Atomic Power Company 1987-1993: Chapter 41, page 12. The statement on page 16 of the latter source that the discharge pipes were stainless steel is erroneous, per rust visible in historic construction photographs and a November 25, 2003 personal communication from Peter Clark.

[17] Connecticut Yankee Atomic Power Company 1987-1993: Chapter 42, page 1.

[18] Ibid: page 3.

[19] Power 1982b: 68.

[20] Connecticut Yankee Atomic Power Company 1987-1993: Chapter 41, pages 14-15.

[21] Ibid: page 14.

[22] Ibid: pages 13-14.

[23] Ibid: pages 15-16.

[24] Ibid: pages 17-18

[25] Ibid: page 18.

[26] Ibid: page 3; Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964-1996a, b [drawings]; Connecticut Yankee Atomic Power Company 1966-1974: 8.5-5; 1987-1993: Chapter 43, pages 2, 18.

[27] Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964-1996a, b [drawings]; Connecticut Yankee Atomic Power Company 1966-1974: 8.5-2, 3; 1987-1993: Chapter 43, pages 18-19.

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[28] Ibid.

[29] Connecticut Yankee Atomic Power Company/Stone & Webster Engineering Corp. 1964-1996a, b [drawings]; Connecticut Yankee Atomic Power Company 1966-1974: 8.11-8.

[30] Connecticut Yankee Atomic Power Company 1966-1974: 8.11-8; 1987-1993: Chapter 43, pages 5-6.