VIII. Alternatives

VIII. ALTERNATIVES

A. INTRODUCTION

The Proposed Action described fully in Section IV.A. is to operate the Bowline Point Units 1 & 2, Indian Point Units 2 & 3, and Roseton Units 1 & 2 power plants to provide levels of protection for five taxa of fish (striped bass, white perch, Atlantic tomcod, bay anchovy, and river herring) at least equal to those ensured by the 1981 and 1987 SPDES permits, on average over the 10-year period 2001 through 2010. Alternatives to the proposed action can be defined that would directly reduce the effects of operating the stations' cooling water systems or would offset those effects. Such actions would entail modifications to water intake or discharge structures of the plants or alteration of operating practices. Consideration must be given to whether these actions would provide commensurate net environmental benefits.

Both the feasibility and desirability of mitigating a perceived reduction in a valued environmental attribute and the various alternatives for achieving such mitigation depend on site-specific circumstances. In evaluating the proposed action and alternatives to it, consideration must be given to: the specific nature of the environmental attributes affected by the underlying activity, i.e., the operation of the power plants; the extent of the effects that can be specifically associated with the activity; the various mitigative alternatives that might be adopted; the degree of improvement that might be realized by adopting each alternative; the feasibility and cost of implementing various alternatives, including any undesirable effects such as damage to other aspects of the environment; and the extent to which the reduction of desirable environmental attributes affected by the regulated activity would be alleviated. In the section below, various actions identified by DEC as potential alternative approaches to cooling water use on the Hudson River are described. Each alternative is described; its applicability at each station is evaluated; and potentially positive and negative direct and indirect environmental effects are identified. Economic costs and effects on electric power supply associated with implementing each option are also evaluated.

The alternatives to the proposed action include options that would reduce the volume of cooling water flow or that would physically exclude or deter aquatic organisms from entering power plant intakes, and other actions or combinations of actions selected by the DEC for evaluation. Alternatives that would reduce the volume of cooling water used include prescribed outages at times when aquatic organisms could be entrained, use of multiple-speed pumps or pump cycling to more closely reflect efficient cooling water flows, and installation of closed-cycle cooling systems. Alternatives that would exclude or deter aquatic organisms from entering power plant intakes include modified (Ristroph) vertical travelling screens, cylindical wedge-wire screens, fine-mesh screens, barrier nets, fine-mesh barrier nets, and behavioral deterrence systems. Other alternatives prescribed for evaluation by the DEC were district heating and cooling and a group of alternatives, collectively labeled the "Multiple Choice Alternatives". In addition, a number of actions that would directly or indirectly offset, rather than directly reduce, aquatic effects of power production are considered.

B. ALTERNATIVES THAT REDUCE COOLING WATER USE

1. Prescribed Outages

a. *Environmental Aspects of Prescribed Outages*

i. Entrainment Mortality Rates

The proposed action specifies levels of fish protection (reduction in fish mortality from that which would occur under baseline conditions) to be achieved at the Bowline Point Units 1 & 2, Indian Point Units 2 & 3, and Roseton Units 1 & 2 power plants without specifying combinations of outages and flow reductions that would be used to provide them. An alternative to the proposed action is to prescribe outages of fixed duration within periods of time when entrainment has historically occurred. This alternative action was embodied in the 1981 and 1987 SPDES permits. Those SPDES permits provided for two 1-unit outages at Bowline Point Units 1 & 2 (one for 30 days between May 15 and June 30 and one for 31 days in July); a 1-unit outage at Indian Point Units 2 & 3 (for an annual average of 42 days between May 10 and August 10); and a 1-unit outage at Roseton Units 1 & 2 (for 30 days between May 15 and June 30), annually.

The alternative that embodies prescribed outages is examined with four scenarios, three of which were based on the outage lengths and cooling water flow rates provided for in the 1981 and 1987 permits. The fourth involves more extensive outages at all four stations. The scenarios were evaluated using a modeling approach developed during technical workshops sponsored by the New York State Department of Environmental Conservation (DEC) to facilitate preparation of this DEIS. The outages in the 1981 and 1987 SPDES permits were intended to protect striped bass. The current model (Appendix VIII-1-A) considers the weekly entrainment conditional mortality rates (CMR) for the five taxa of fish (striped bass, white perch, Atlantic tomcod, bay anchovy, and river herrings) selected during the workshops and identifies the weeks during which CMR reduction objectives could best be met with scheduled outages of the selected duration. For the purposes of this DEIS, the objective was established to be the greatest possible reduction in the sum of the annual entrainment CMRs for all five fish taxa from that which would occur with no outages and efficient cooling water flow rates. The metric used (greatest overall reduction in total entrainment CMR for all taxa combined) affords greater protection to those taxa with higher annual entrainment CMR. The metric used during the technical workshops, i.e., greatest minimum percent reduction, would give

give equal importance to all taxa, regardless of the entrainment CMR value. Using that metric, a 20% reduction in the entrainment for a taxon with a CMR of 3% (from 3% to 2.4%) would be considered as important as a 20% reduction in the entrainment CMR for a taxon with a CMR of 30% (from 30% to 24%). As an alternative, using the metric of greatest overall reduction in total entrainment CMR, a reduction of 6% (from 30% to 24%) would be considered more important than a reduction of 0.6% (from 3.0% to 2.4%). Conditional mortality due to impingement was not considered in these analyses because it is relatively minor and is mitigated by other means at all stations.

For modeling purposes, it was assumed that outages at any unit would be taken as a single block of weeks and that the two Bowline Point Units 1 & 2 outages would not overlap in time. The outage length for Indian Point Units 2 & 3 in the 1981 and 1987 permits (42 days) is exactly equal to a 6-week outage. The outage lengths for Bowline Point Units 1 & 2 and Roseton Units 1 & 2 in the 1981 and 1987 permits (30 days and 31 days) are each approximated here by a 4-week outage.

In Scenario A, outages of the lengths provided for in the 1981 and 1987 permits were restricted to the calendar periods established in those permits. Reductions in CMR were calculated independently for each plant as the average reduction provided by all possible outage blocks within the periods established by the permits. An outage block was included in the calculations, if the following two conditions were met: 1) the first date of the outage period in the 1981 and 1987 permits occurred before or within the first week of the projected outage and 2) the last date of the outage period in the 1981 and 1987 permits occurred after or within the last week of the projected outage.

In Scenarios B and C, outages were not restricted to the calendar periods established by the 1981 and 1987 permits, but rather were allowed to occur at the most opportune time for saving fish at each plant during the entire 32-week period. In Scenario B, the timing of the outage or outages for each plant was established without consideration of operations at the other plants. The scenario represents the greatest overall reduction in total entrainment CMR for all five species that could be achieved by an outage at each plant independently of the others, i.e., assuming that outages would not be taken at the other plants. In Scenario C, the timing of the outage or outages at each plant was established dependently with the other plants. This scenario represents the greatest overall reduction in entrainment CMR that could be achieved collectively by all of the plants assuming that each plant would take an outage or outages and the timing of an outage at each plant could affect the timing of the outages at the other plants. In Scenario D, one unit at each of the plants was assumed to be offline with no cooling-water flow for the entire period during which some entrainment of the five target fish taxa occurs, a period of approximately 32 consecutive weeks from late February through mid-October.

This duration would totally eliminate entrainment mortality at the unit taking the outage and essentially reduce entrainment CMRs by 50% for all species.

Analyses were done using both estimated through-plant entrainment mortality rates and assumed 100% through-plant mortality rates. Results based upon estimated mortality rates are presented here; those based on assumed 100% through-plant mortality rates are presented in Appendix VIII-1-A. The annual sum of the annual entrainment CMRs for all plants and taxa combined ranged from 62% for Scenario A to 43% for Scenario D (Table VIII-1). The absolute reduction in the annual entrainment CMR from the maximum (77%) based on outages, efficient flows, and estimated through-plant mortality rates was approximately the same for Scenarios A (15%, i.e., 77%-62%), B (17%), and C (18%). It was greater for Scenario D (35%). The differences among the scenarios are primarily due to a slightly greater reduction in entrainment CMR for striped bass from Scenario A to Scenario C, and additional reductions for Atlantic tomcod and bay anchovy for Scenario D (Table VIII-2).

The sums of the annual entrainment CMR values for Scenarios A, B, and C are slightly lower than those that would be provided on average by the proposed action (Table VIII-3), but higher than those that would occur under Scenario D. If none of the units at any of the plants operated during the entire 32-week period during which entrainment mortality has historically occurred, total CMR would be 0%. However, the operating alternatives are unlikely to provide material benefits to any of the individual fish species or the fish community of the Hudson River (as described in Section VI).

ii. Air Emissions

The three subject stations, due to the fuels they use, are among the lowest in New York State for air emissions. The Indian Point Units 2 & 3 use uranium as a fuel, and thus do not emit products of fossil fuel combustion. Roseton Units 1 & 2 and Bowline Point Units 1 & 2 both burn either natural gas or low-sulphur oil and have relatively low emission rates.

The source of electric generation in the deregulated utility market cannot be forecast with certainty. Thus, the effect of curtailing the operation of Bowline Point Units 1 & 2, Indian Point Units 2 & 3 and Roseton Units 1 & 2 on air quality is difficult to forecast reliably. However, based on an analysis performed with the New York Power Pool production planning model (PROMOD) requested by the New York State Department of Environmental Conservation, there would be an increase in statewide emissions on an annual basis for a 32-week curtailment of one unit at Indian Point Unit 2, one unit at Bowline Point Units 1 & 2, and one unit at Roseton Units 1 & 2 (Scenario D). The analysis and results are fully described in Appendix VIII-1-B. Emission increases for

TABLE VIII-1

ENTRAINMENT CONDITIONAL MORTALITY RATE (%) FOR ALL PLANTS BASED ON, EFFICIENT FLOWS, AND ESTIMATED THROUGH-PLANT MORTALITY RATES. SCENARIOS A, B, AND C ARE BASED ON TWO OUTAGES OF 4 WEEKS DURATION AT BOWLINE, ONE OUTAGE OF 6 WEEKS AT INDIAN POINT, AND ONE OUTAGE OF FOUR WEEKS AT ROSETON. SCENARIO D IS BASED ON 32 WEEKS OF OUTAGE AT ONE UNIT AT BOWLINE POINT, ROSETON AND INDIAN POINT 2 OR 3

SCENARIO	ENTRAINMENT CMR (%)					ALL TAXA COMBINED
	ATLANTIC TOMCOD	BAY ANCHOVY	RIVER HERRING	STRIPED BASS	WHITE PERCH	
A	22	15	4	12	9	62
B	21	16	4	10	9	60
C	22	15	4	9	9	59
D	14	10	3	9	7	43

TABLE VIII-2

ABSOLUTE REDUCTION IN THE ENTRAINMENT CONDITIONAL MORTALITY RATE (CMR) FOR ALL PLANTS FROM THE MAXIMUM BASED, EFFICIENT FLOWS, AND ESTIMATED THROUGH-PLANT MORTALITY RATES. SCENARIOS A, B AND C ARE BASED ON TWO OUTAGES OF 4 WEEKS DURATION AT BOWLINE, ONE OUTAGE OF 6 WEEKS AT INDIAN POINT, AND ONE OUTAGE OF FOUR WEEKS AT ROSETON. SCENARIO D IS BASED ON 32 WEEKS OF OUTAGE AT ONE UNIT AT BOWLINE POINT, ROSETON AND INDIAN POINT 2 OR 3

	ABSOLUTE REDUCTION IN ENTRAINMENT CMR (%)					
SCENARIO	ATLANTIC TOMCOD	BAY ANCHOVY	RIVER HERRING	STRIPED BASS	WHITE PERCH	ALL TAXA COMBINED
A	2	5	1	4	3	15
B	3	4	1	6	3	17
C	2	5	1	7	3	18
D	11	10	2	7	5	35

TABLE VIII-3

COMPARISON OF ANNUAL ENTRAINMENT CONDITIONAL MORTALITY RATES (%) FOR THE PROPOSED ACTION (PA) AND THE ALTERNATIVE ACTIONS (SCENARIOS A, B, C AND D).

	ENTRAINMENT CMR (%)					
ACTION	ATLANTIC TOMCOD	BAY ANCHOVY	RIVER HERRING	STRIPED BASS	WHITE PERCH	ALL TAXA COMBINED
Proposed action Early	19	20	5	16	12	72
Proposed action Design	23	17	4	15	11	70
Proposed action Late	24	15	4	16	12	71
Scenario A	22	15	4	12	9	62
Scenario B	21	16	4	10	9	60
Scenario C	22	15	4	9	9	59
Scenario D	14	10	3	9	7	43

Scenario D were scaled back on a per week basis to estimate the values for Scenarios A, B, and C (Table VIII-4).

b. Economic and Reliability Considerations

Compared to the proposed action, prescribed outages would impose additional constraints on the operation of the Bowline Point Units 1 & 2, Indian Point Units 2 & 3, and Roseton Units 1 & 2 power plants and reduce the flexibility required by the operators of these facilities to provide electricity reliably and economically in an unregulated market.

Based on the PROMOD analysis requested by the DEC, the increase in statewide cost of power production, per week of forced outage, would be $2.28 million for an Indian Point Units 2 & 3, $0.24 million for Roseton Units 1 & 2, and $0.24 million for Bowline Point Units 1 & 2. If the outages required to satisfy the prescribed outage alternatives had to be taken exclusively for fish protection, then the increased costs could range from $16.59 million for Scenarios A, B, or C to $88.48 million for Scenario D (Table VIII-5). A loss of generation associated with 32 week curtailments of 1 unit at Indian Point Units 2 & 3, Bowline Point Units 1 & 2 and Roseton Units 1 & 2 (Scenario D) could severely impair system reliability in the bulk transmission system and consumers of electricity in southeastern New York.

2. Efficient Cooling Water Flow Rates

a. Technology Review

In steam cycle power plants such as the Hudson River plants, steam produced in boilers or steam generators flows through turbines, providing the energy required to rotate them and produce electricity. Immediately after passing through the final stage of the turbine, steam must be cooled and condensed in order to reduce its volume and pressure, allowing additional steam to flow through the turbine. The cooling takes place in large heat exchange vessels called condensers which contain thousands of metal tubes. As steam flows around the outside of the tubes, it is cooled and condensed as the heat from the steam is transferred to water flowing inside the tubes.

The temperature and volume of cooling water entering the condensers determine the temperature and pressure at which the steam condenses. The condensing pressure influences flow of steam through the turbine, thereby affecting the amount of power that can be generated and the thermal efficiency with which it is generated. Electric power is

TABLE VIII-4

POTENTIAL ANNUAL INCREASE IN STATEWIDE AIR EMISSIONS (TONS/YEAR) EXPECTED AS A RESULT OF PRESCRIBED OUTAGES FOR ALTERNATIVE SCENARIOS A, B, C, AND D.

SCENARIO	NOX	SO2	CO	CO2	PARTICULATES
A, B, C	1,148	4,651	76	512,74	487
D	6,150	24,545	385	2,728,42	2,596

TABLE VIII-5

POTENTIAL ANNUAL INCREASE IN STATEWIDE ELECTRICAL PRODUCTION COSTS OF PRESCRIBED OUTAGES FOR ALTERNATIVE SCENARIOS A, B, C, AND D.

SCENARIO	MILLIONS OF DOLLARS			
	BOWLINE POINT	INDIAN POINT	ROSETON	TOTAL
A, B, C	1.9	13.69	0.97	16.59
D	7.71	73.00	7.77	88.48

produced most efficiently when the cooling water flow rate is at the minimum needed to condense exhaust steam from the turbines. The minimum flow rate is a function of ambient cooling water temperature; the volume, temperature, and pressure of the steam to be condensed; and the heat transfer characteristics of the condenser. Use of more than the minimum flow rate is undesirable because the condensed steam may be cooled below the saturation temperature, thus requiring more fuel energy to reheat it. The steam turbines in large power plants, including the Hudson River plants, are carefully engineered so that each of the many stages operates efficiently in relatively narrow ranges of pressure and temperature. Operating beyond these ranges can lead to substantial equipment damage and reduced performance. As explained in Chapter IV, cooling water flow rates through the condensers affect both the efficiency of steam electric generating facilities and the number of aquatic organisms involved.

Cooling water pumps are selected to provide the flow required to operate the condensers and turbines at high efficiency when the generating unit is operating at full power at the high end of the expected ambient temperature range. Pumps originally installed in older plants operate at only one speed, providing maximum flow for the size of the pump. Cooling systems are generally designed so that more than one pump provides flow to each condenser. Redundancy ensures that, in the event of a pump failure, some flow is still provided to each condenser to avoid abrupt unit shutdown. This redundancy also provides some flexibility in matching cooling water flow to changing ambient water temperatures and power levels to achieve high generating efficiency. However, the range of flow rates available is limited by the flow path and the number of pumps available and the number required for safe operation. At reduced power levels and/or low ambient water temperatures, more flow may be provided by the minimum number of pumps that can be operated than is required for efficient generation. Under these conditions, generating efficiency may be reduced. In addition, pumping more water than is necessary uses electric power that might otherwise be saved.

Several options are available to better match cooling water flow rates to power generation requirements. These include: installing pumps that operate at more than one speed (dual flow or variable speed pumps); restricting (throttling) the flow of water through the condensers; and turning redundant pumps on and off as generating conditions change. The use of multiple speed pumps is the most efficient over the longer term, but the cost of replacing or modifying single-speed pumps with variable speed controls or motors is high. The flow reductions possible with throttling alone are limited and, since the pumps continue to operate at full power, there is no reduction in auxiliary power use when flows are reduced in this fashion. Depending on the flow path and the number of pumps available, simply turning pumps on and off as cooling water requirements change may provide approximately efficient flows. However, the stresses associated with frequently turning pumps on and off may cause the very large motors of circulating water pumps to fail. Therefore, pump cycling is used to accommodate gradual seasonal changes in ambient water temperatures, but is not considered good operating practice to accommodate changes in plant operating levels that may occur several times over the course of a day.

b Applicability, Costs, And Environmental Considerations

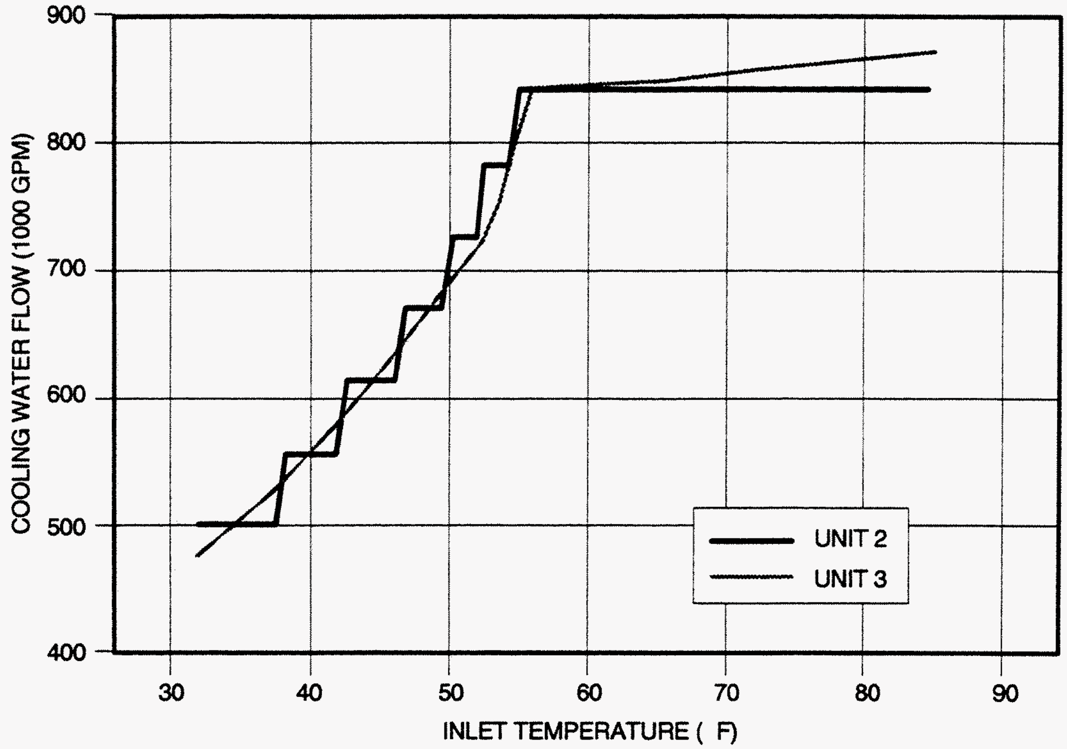
The cooling water flow rate schedules established for the 1981 and 1987 SPDES permits were designed to keep cooling water volumes at or below the minimum required for efficient operation at full power without increasing temperature-related mortality of entrained fish. Although these rates approximate "efficient" flows at Bowline Point Units 1 & 2 and Roseton Units 1 & 2, they are sometimes below those required to operate Indian Point Units 2 & 3 efficiently. As alternatives to these cooling water flow rates at Indian Point Units 2 & 3, efficient water flows are considered below.

c. Indian Point Units 2 & 3

The Indian Point Units 2 & 3 Stations have installed multiple speed pumps to better maintain efficient cooling water flows. Unit 2 has pumps that can be operated at two speeds, while those at unit 3 can be operated at continuously varying speeds. These stations generally operate at full power whenever they are in service, so flow rates are usually changed only gradually in response to seasonal changes in ambient water temperatures.

Figure VIII-1 presents the relationship between the temperature of the cooling water as it is withdrawn from the estuary and the volume required for efficient operation at full reactor power at Indian Point Units 2 & 3. Ambient water temperatures on any calendar date vary among years and among points in the estuary; therefore, so does the amount of cooling water required for efficient operation. To evaluate the effects on entrainment of operating at efficient flows, a predictive equation was developed for Hudson River water temperatures near Indian Point Units 2 & 3. Figures VIII-2 and VIII-3 present the cooling water volumes required for efficient operation throughout the year based upon predicted water temperatures.

The volumes required for efficient operation differ between the two units primarily because of differences in cooling water pump design. The continuously variable speed pumps at Unit 3 provide greater flexibility in matching flows daily to ambient temperature, while dual-speed pumps at Unit 2 provide less flexibility.



Source: Consent orders.

Figure VIII-1. Relationship between river temperature and volume required to achieve efficient operation of Indian Point.

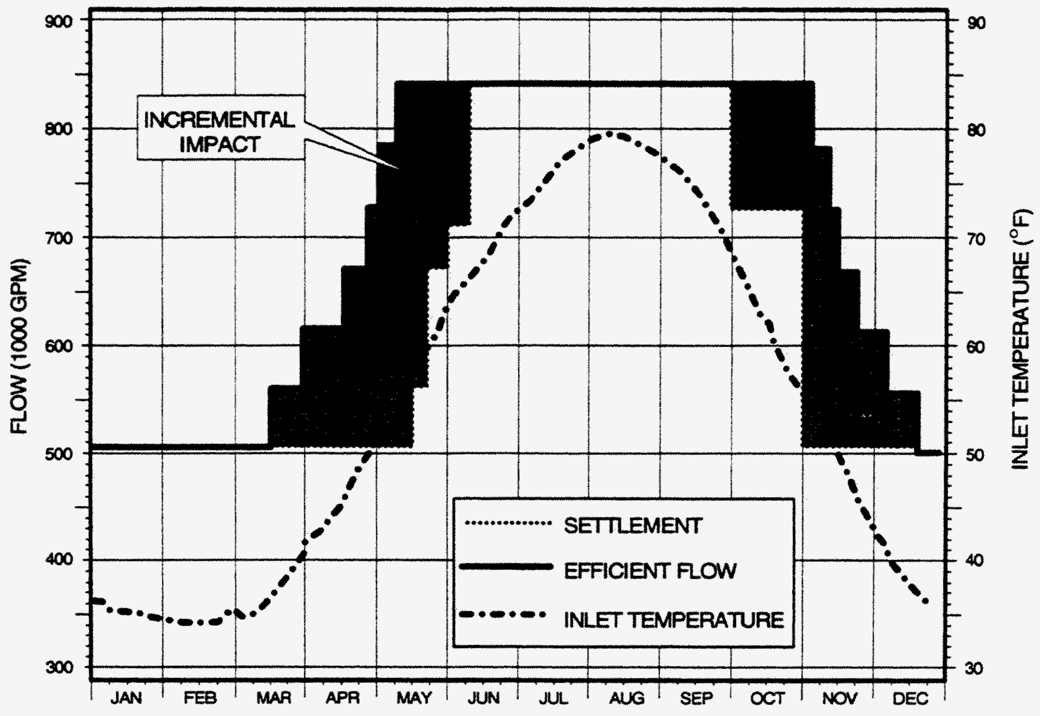


Figure VIII-2. Predicted condenser cooling water flow rate schedules to achieve efficient operation of Indian Point Unit 2.

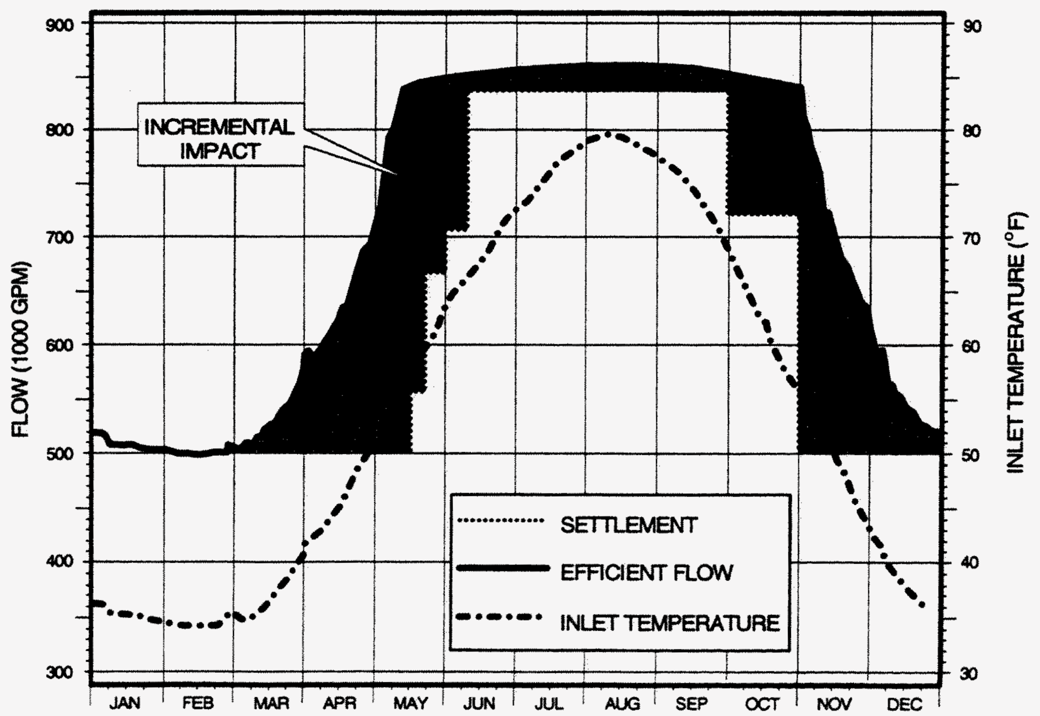


Figure VIII-3. Predicted condenser cooling water flow rate schedules to achieve efficient operation of Indian Point Unit 3.

The conditional mortality rates due to entrainment and impingement of selected species would be slightly higher for efficient flow rates compared to the flow rates in the proposed action (Table VIII-6). For comparison the units were assumed to operate without outages. To the extent outages take place during periods of restricted flow, the differences would be reduced.

If Indian Point Units 2 & 3 operated at the flows provided in the proposed action rather than those that allow for efficient operation, it would reduce their annual electric output by 19,696 MWh on average and revenues by $ 590,000 (Table VIII-7). These numbers would be reduced if outages occurred during reduced-flow periods.

d. Bowline Point Units 1 & 2 and Roseton Units 1 & 2

Electric power production at fossil plants, may be curtailed during off-peak hours when demand is reduced and electric power can be produced as, or more, economically elsewhere. These off-peak periods occur most often during the late night and/or early morning hours and on weekends. When electric generation is reduced, cooling water use can also be reduced without negatively affecting unit efficiency or causing higher thermal mortality among entrained organisms.

Power generation levels are sometimes reduced at the Bowline Point Units 1 & 2 and Roseton Units 1 & 2 Stations in response to reduced demand. In 1995, Central Hudson and Orange and Rockland conducted preliminary assessments of means to reduce aquatic impacts related to cooling water flows at Roseton Units 1 & 2 and Bowline Point Units 1 & 2, respectively (Appendices VIII-2- A and B). The focus of these studies was on reducing aquatic impacts, rather than achieving efficiency, and the scenarios examined would result in some operating penalties. Both concluded that cooling water volumes might be reduced by about 16% over the course of a year based upon historical operating patterns for the stations. To accomplish flow reductions of this magnitude, flows would sometimes be reduced during periods of high power production and result in inefficiencies in electric production. The net costs would differ among the means examined to reduce flow, including pump cycling, installation of multiple-speed pumps, and condenser throttling. They are dependent upon unpredictable future demand for electricity and station operating levels.

Central Hudson examined the costs of installing two-speed and variable speed pumps at the Roseton Units 1 & 2 Station. The cost of modifying an existing pump with a new two speed motor would be on the order of $400,000 and the cost of modifying an existing pump by installing a new variable speed drive and a new motor would be on the order of $700,000 for each pump (1996 cost estimates). If the existing motors could be operated

TABLE VIII-6

POTENTIAL INCREASE IN ENTRAINMENT CONDITIONAL MORTALITY DUE TO USE OF EFFICIENT COOLING WATER FLOW RATES AT INDIAN POINT UNITS 2 AND 3 COMBINED[a]

SPECIES	CMR @ PERMIT FLOW	CMR @ EFFICIENT FLOW	INCREASE
Striped bass	0.1160	0.1242	.0082
White perch	0.0475	0.0520	.0044
American shad	0.0020	0.0023	.0003
Bay anchovy	0.1462	0.1486	.0024
Herring	0.0089	0.0106	.0018
Atlantic tomcod	0.1439	0.1597	.0158
Spottail shiner	0.0372	0.0381	.0009

[a]Efficient flows at average river temperatures (Figures VIII-2 and VIII-3).

TABLE VIII-7

PREDICTED MONTHLY INCREASE IN ELECTRIC POWER OUTPUT AND TOTAL COST REDUCTIONS DUE TO USE OF EFFICIENT COOLING WATER FLOW RATES AT INDIAN POINT UNITS 2 AND 3[a]

	UNIT 2	UNIT 3
MONTH	ΔMWh	ΔMWh
January	0	0
February	0	0
March	156	0
April	1842	1173
May	4528	3593
June	467	568
July	0	468
August	0	554
September	0	298
October	1023	773
November	2421	1650
December	182	0
Total MWh	10,619	9077
Total $	320,000	270,000

[a]Efficient flows at average river temperatures (Figures VIII-2 and VIII-3).

at variable speeds, the costs of installing a new drive alone would be on the order of $530,000 for each pump. These cost estimates are conservative and do not take into account other capital improvements, i.e. motor control centers, that may be required. Further evaluation of the existing motors would be needed to determine whether they would be compatible with new drives. Multiple speed pumps would reduce operating costs relative to pump cycling, but the difference in net costs would be dependent upon future operating conditions.

The levels to which entrainment and impingement might be reduced by flow reductions depend upon the times during which flow can be reduced, as well as the frequency with which reduced cooling water flows would result in discharge temperatures exceeding the tolerance limits of entrained organisms.

Future electric demand and market conditions cannot be predicted accurately as deregulation of the electric utility industry develops. Future operations at Bowline Point Units 1 & 2 and Roseton Units 1 & 2 may differ enough from the past to make it impossible to accurately quantify the costs of implementing alternative means of achieving flow reductions or the environmental effects. If the stations were to become base-load stations and operate at full power nearly continuously in the future, the entrainment reductions projected on the basis of the Roseton Units 1 & 2 Study discussed above would not be realized.

3. Closed Cooling Water Systems

a. Introduction

Typically the source of cooling water for steam electric power stations is a large water body where heated water can be discharged after it is used and additional cooler water can be withdrawn (open-cycle cooling). In situations where the heated effluent may cause environmental problems, or there is no large source of water available, a closed-cycle system may be employed. In closed-cycle systems, the heat removed from the steam by the cooling water is transferred directly to the atmosphere by means of cooling towers or ponds and the water is then recirculated for additional condenser cooling. Closed cycle cooling through use of cooling towers is evaluated below as an alternative to the open-cycle cooling systems in place at the Bowline Point Units 1 & 2, Roseton Units 1 & 2 Indian Point Units 2 & 3 Stations.

b. Cooling Tower Technology Review

Cooling towers may be wet or dry, or a combination of the two, and use natural circulation or mechanically impelled air flow to cool the water. With wet cooling towers, the majority of the heat transfer from the water to the atmosphere occurs through evaporation. In dry towers, which have no direct contact between the air and water, cooling occurs entirely through convection. Wet towers may circulate air using natural drafts created by the warmed air, or by mechanical fans. Dry towers use only mechanical draft. In a few special situations, systems have been built with both wet and dry cooling elements. The wet components provide the majority of the cooling, while the dry components can be used in conjunction on occasions when atmospheric conditions warrant.

i. Wet Towers

A typical wet tower consists of a base section about 45 to 60 feet high supporting fill material and a large array of baffles. Headers with spray nozzles are arrayed above the fill. Water is pumped up to the headers and sprayed along the top of the fill. It then flows in thin films down over the thousands of square feet of fill surface to a basin located beneath the tower. The collected water is channeled to a sump where recirculating pumps are located (Figure VIII-4). A large space that allows air to enter is provided between the bottom of the fill and the basin. Air flows upward through the fill, making close contact with the extensive water surface. A large air flow is required to provide adequate cooling. Air flow is increased either by the use of fans or towers that create a "chimney" effect. Towers using fans are called mechanical draft towers and those using a chimney effect are called natural draft towers.

Natural draft towers are usually circular with a large hollow hyperbolic structure (the "tower") built above the fill. Natural draft cooling towers of the capacity required for the existing Hudson River plants would range in height from nearly 400- to 600-ft. The chimney effect draws air through the fill, reducing the noise and eliminating the power loads associated with the fans that are required to increase air flow in mechanical draft towers (see below). The large hyperbolic towers add substantially to the cost of natural draft towers, so they normally have higher capital costs than mechanical draft towers for the same conditions and loads. However, the absence of fans with their associated power requirements reduces the operating costs of natural draft towers significantly, and natural draft towers may have lower total (construction and operation) costs over the life of a power plant. However, the shorter the life of a plant and the lower the cost of replacing electric power or generation capability, the less likely the natural draft tower is to prove the economic choice.

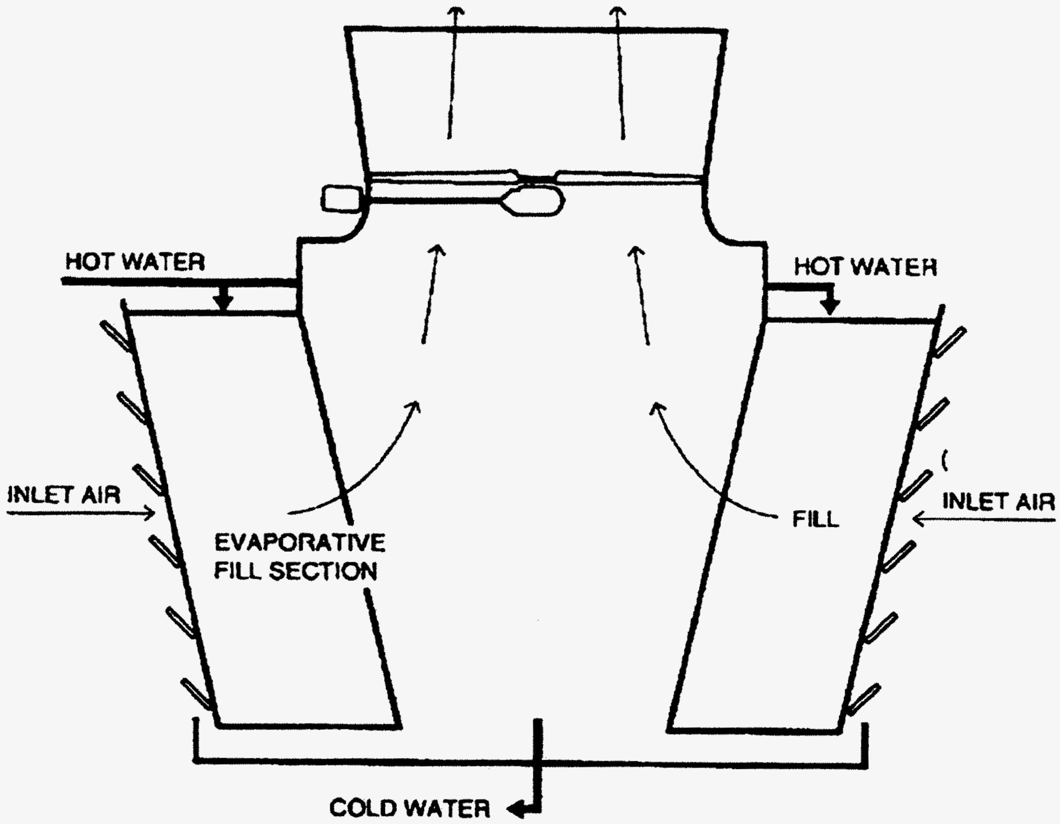


Figure VIII-4. Air and water flow in a typical mechanical draft cooling tower.
(Courtesy of The Marley Cooling Tower Company)

Mechanical draft towers are typically constructed as rows of separate cells. The center of each cell is open, and a large fan at the top of the cell draws air through the fill material. Mechanical draft cells are typically much lower than natural draft towers, usually 40-50 ft in height. However, they cover a much more extensive land area.

With wet cooling towers, the majority of the heat transfer from the water to the atmosphere occurs through evaporation. The evaporation leads to several factors that need to be evaluated including plume formation, drift, evaporative water loss, and concentrated discharges (blowdown). Plumes are the result of the vapor added to the air in the heat rejection process condensing into visible moisture droplets. They can cause fog, icing, and visual impacts. Drift is the entrainment of droplets of cooling water directly into the air. While the quantity of water contained in these droplets is orders of magnitude smaller than the quantity of vapor which results from the evaporation process, these droplets contain dissolved and suspended minerals in the makeup water and other substances that are absent from the vapor. Drift can result in the deposit of salts on surrounding vegetation and contribute to icing. Drift from mechanical draft towers is deposited over a much smaller area than that from the taller natural draft towers.

In settings where water is scarce, loss of water from evaporation could be a significant problem. Approximately ten gallons of water are evaporated per minute for each MW of plant output. The evaporation causes salts and other chemicals to concentrate in the closed cooling system. As these substances become concentrated, some of the cooling water may be discharged (blowdown) to the water source and replaced with new water to maintain concentrations below levels where they have deleterious effects on materials and operations. This blowdown may be warmer than the source water body and the heat and concentrations of salts and chemicals added to maintain water quality in the closed cooling system may have localized effects near the point of discharge. The total make-up flow to replace evaporation and blowdown is usually in the range of one and one-quarter to two times the evaporation rate.

Additional issues include visual impacts of the tower structures themselves, noise, and sludge disposal. The visual effects of mechanical draft towers are much smaller than those caused by natural draft towers, but may still be substantial because of their size and the additional ground cover that must be removed. The fans used to draw air into the mechanical draft towers generate noise. In the case of all evaporative cooling towers, suspended materials in the makeup water accumulate as sludge, which must be removed periodically from the basin. Environmental concerns related to wet cooling towers are discussed more fully in Appendix VIII-3-A.

ii. Dry Towers/Dry Condensers

Dry towers, which work like a large automobile radiator, keep the cooling water contained in tubes and do not expose it to the air. Air flows around the tubes and removes heat from the water inside the tubes. Thus, the air is heated without having absorbed any additional moisture. Heat transfer tends to be much less efficient per unit of surface area than that which occurs with the direct contact between water and air in wet towers. Therefore, dry towers are very much larger than their wet tower equivalents. Total reliance on convection requires much greater volumes of air for cooling, so more fans are required than with mechanical draft wet towers. Even so, the cooling provided by dry towers is less than that of wet towers and plant efficiency and output are compromised further.

Because of the large temperature drop required between the air and the cooling water, dry towers are not capable of providing suitably cool water for the condensers during the summer. The water temperatures produced by such towers would result in condensing steam temperatures greater than the turbines can tolerate. Major modifications would be required and losses of several tens of megawatts of capacity per unit would result. Because of these factors, the existing Hudson River plants would have to replace the present condensers with dry condensers to avoid evaporative cooling. With the use of dry condensers the intermediate loop of cooling water between the condenser and the cooling tower is eliminated and steam from the turbine is routed directly to the large radiator-like towers.

Due to higher capital costs, lower generation efficiency (a result of higher condensing temperatures), and higher power requirements (a result of more and larger fans being needed), dry towers are usually used only where water is in such short supply that the make-up water required for a wet tower would represent a significant environmental impact. Dry towers eliminate many of the impacts associated with wet towers (plumes, drift, blow-down). However, there is substantial noise associated with the fans and intrusive visual impacts because the extensive structures are typically much higher than mechanical draft evaporative towers. The dry condensers for this application would occupy approximately three times the area of wet (or wet/dry) mechanical draft towers and, at 120 ft high, would be more than twice as high as the mechanical draft wet/dry towers considered below.

Use of dry towers (condensers) on the existing plants would require removal of the existing condensers and the routing of four to six fourteen-foot-diameter ducts from under the turbines to large air-cooled condensers. While no detailed engineering investigations were made, the probability of being able to route such large lines in the congested area where structural members provide critical support to the turbine generator is believed to be small. The modifications, if feasible at all, would take several months of plant down time. Once the ducts left the turbine building they would have to traverse several hundred feet to open areas large enough for the dry condensers.

The construction cost for a dry condenser system would be approximately $80 to $120 million greater for each station then a wet/dry system. The extended shutdowns required for condenser removal and duct installation would impose further penalties of tens of millions of dollars and more than 4 MW of additional power beyond that needed for wet/dry tower systems would be required at each station.

No large power plant originally designed and constructed for once-through cooling has been backfitted to utilize dry towers and serious questions remain about the technical feasibility, and in the case of the Indian Point Units 2 & 3, Nuclear Regulatory Commission licensing issues involved.

iii. Wet-Dry Towers

Since the abundance of water in the Hudson River does not justify use of dry towers to reduce water consumption, but the issues associated with evaporative cooling need to be evaluated for the Hudson River Valley (See Appendix VIII-3-B), the alternative of wet-dry towers was examined in detail. Wet-dry towers combine evaporative and convective cooling to allow the higher efficiency of evaporative cooling, while reducing some of its environmental impacts. The formation of plumes and the associated icing and fogging events can be reduced but not entirely eliminated. Environmental concerns due to the structures, drift, blowdown, sludge formation and noise would remain essentially the same as those of the associated wet tower component

Since the plume produced by wet towers occurs when the moisture content of the air above the cooling tower exceeds the saturation level for the air temperature, two mechanisms may be invoked to reduce the frequency of plume formation. The amount of moisture transferred to the air can be reduced and the temperature of the air can be increased. Incorporating a dry heat transfer section into a mechanical cooling tower can accomplish both. A dry section in a wet tower, by providing a stream of relatively warm dry air to be mixed with the air from the wet sections, can reduce the tendency for droplet formation. However, these sections are space consuming and costly.

A system using a wet/dry tower designed to eliminate plumes under nearly all conditions in the Hudson Valley region would cost on the order of $15 million more than an equivalent mechanical draft wet tower for each Hudson River station. The slightly greater height of the towers and the use of tubes also add approximately 3 MW to the power consumed by the circulating water pumps for each station.

c. ***Wet-dry Tower System Design Descriptions***

i. General

Preliminary designs for wet-dry cooling towers for each of the individual plants are summarized in the following sections. A typical wet-dry tower of the design considered most appropriate for these stations appears in Figure VIII-5. Details for each of the stations appear in Appendix VIII-3-A.

ii. Bowline Point Units 1 & 2

The Bowline Point Units 1 & 2 are located on the west side of the Hudson River in the Town of Haverstraw. The plant comprises two essentially identical 606 MW units. The existing circulating water system is described in Section IV.B.3

The closed cooling water system design evaluated here includes four wet/dry mechanical draft cooling towers, two for each of the two units. The cooling towers would be located on a 13-acre site approximately 800 feet to the east of the units in a large level area between the units and the Hudson River. Each of the four cooling towers would be 432 ft long, 42 ft wide, and 50 ft high (from top of basin to the fan deck) and contain 8 cells. Each cell, comprised of an upper dry cooling element and a lower wet cooling element, would have a fan with a short vent stack located centrally at the top. The fans would be of low noise design, and the towers provided with inlet air baffles and splash shields expected to reduce noise to 50 dBA at 400 ft from the tower.

Each cooling tower would be located above a concrete basin that collects the water falling through the fill and flowing from the tubes of the dry cooling section. The water in the basins of each pair of towers would drain to a common sump where the cooling tower circulating pumps would be located. The three cooling tower circulating pumps in each basin would be capable of circulating 321,000 gpm to each unit's condensers through 120-in.-diameter, concrete-lined carbon steel pipes. A makeup system to withdraw up to 30,000 gpm of river water from the existing intake structure would include 3 pumps located behind stationary screens and racks. The maximum evaporation rate would be expected to be approximately 9,000 gpm. The normal 9,000 gpm flow of the blowdown system would result in a cooling water concentration factor of two, i.e., the concentration of nonvolatile substances in the water supplied from the river would be doubled in the cooling water as a result of evaporation. Cooling water to auxiliary loads would be provided by four 8,000 gpm service water pumps, two for each unit, which takes suction from the circulating water systems.

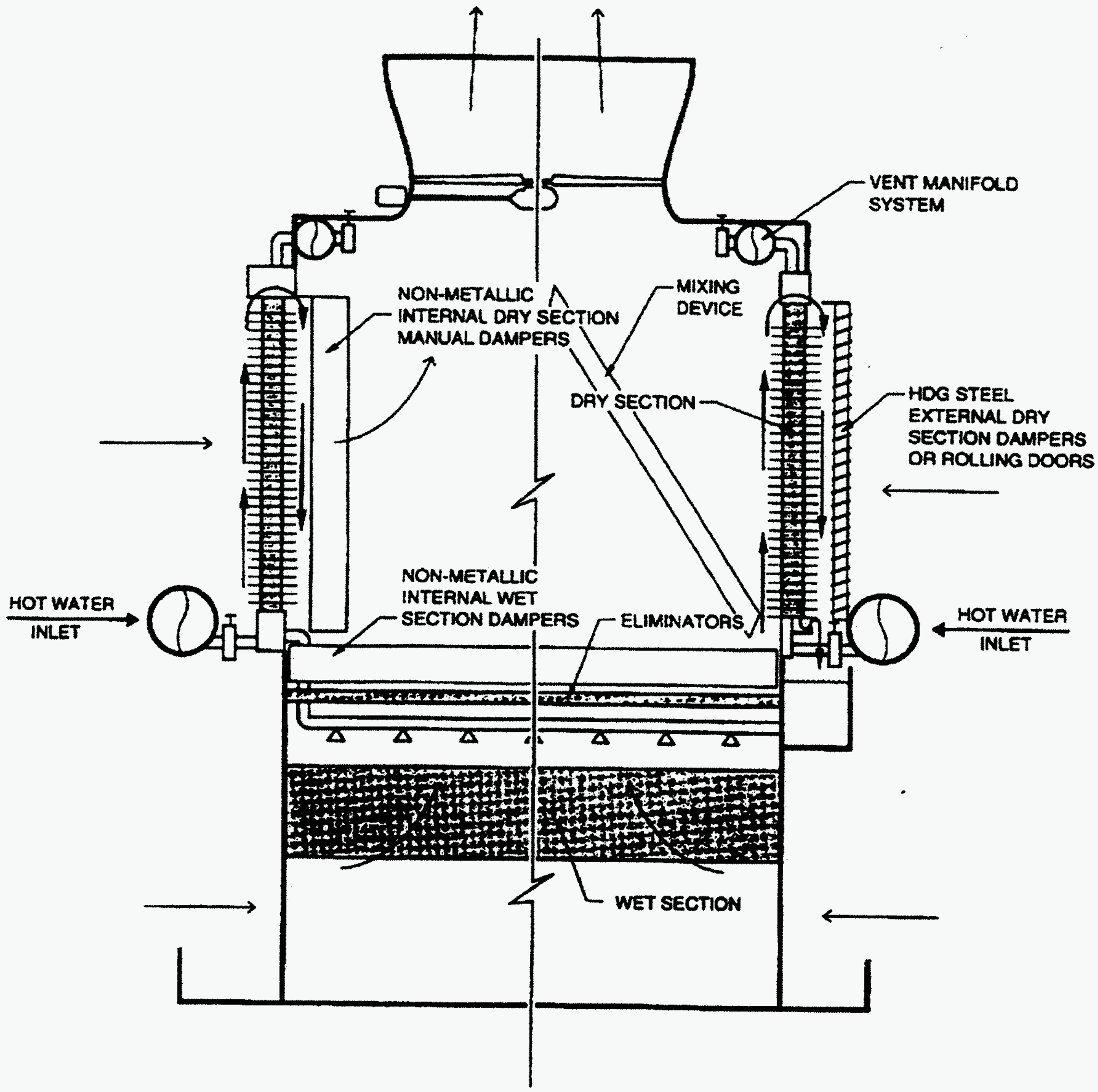


Figure VIII-5. Schematic diagram for wet-dry tower typical of the designs considered for the Hudson River Stations.
(Courtesy of The Marley Cooling Tower Company)

The closed system design would include the capability to return to once-through cooling if required.

iii. Indian Point Unit 2

The Indian Point Unit 2 Station is located on the east side of the Hudson River in the Village of Buchanan. Indian Point Unit 2 is a pressurized water reactor plant with a net capacity of approximately 940 MW. The existing circulating water system has a throughput of 870,000 gpm, including service water, and is described in Section IV.B.2.

The closed cooling-water system design evaluated here would include four wet/dry mechanical draft cooling towers. The cooling towers would be located on 15 acres along the river, approximately 1,000 ft to the north of the unit in a large wooded area.

Each of the four cooling towers would be 432 ft long, 42 ft wide, 50 ft from the top of the basin to the fan deck, and 60 ft high to the top of fan stacks. Each of the eight cells in each tower would be comprised of an upper dry cooling element and a lower wet cooling element and have a fan with a short vent stack located centrally at the top. The fans would be of low noise design, and the towers provided with inlet air baffles and splash shields expected to reduce noise to 50 dBA at 400 ft from the tower.

Each cooling tower would be located above a concrete basin that collects the water falling through the fill and flowing from the tubes of the dry cooling section. From each basin the cooled water would flow via a 90-in. pipe to one of the two 120-in. headers, which would collect all water in a common 13-ft wide, 15-ft high concrete tunnel to be recirculated to the condensers. A makeup system to withdraw river water from the existing intake structure would include three pumps located behind appropriate screens and racks sized to withdraw up to 24,000 gpm from the river. The maximum evaporation rate would be expected to be approximately 12,000 gpm. This evaporation rate, coupled with the 12,000 gpm capacity of the blowdown system, results in a cooling water concentration factor of two. Cooling water to auxiliary loads, including safety system loads would continue to be provided by the service water pumps of the existing once-through system.

The closed system design would include the capability to return to once-through cooling if required.

iv. Indian Point Unit 3

The Indian Point Unit 3 Station is located on the east side of the Hudson River in the Village of Buchanan, just south of Indian Point Unit 2. Indian Point Unit 3 is a pressurized water reactor plant with a net capacity of approximately 970 MW. The existing circulating water system has a throughput of 870,000 gpm, including service water, and is described in Section IV.B.2.

The closed cooling water system design evaluated here would include two wet/dry mechanical draft cooling towers. The cooling towers would be located on two sites to the south of the unit. Each site is approximately 6 acres in size and situated on a steeply sloping shoreline. One site, located along the river, is approximately 350 ft to the south of the unit. The second site is approximately 400 ft to the east of the first. Extensive excavation would be required and the tower site directly on the river would require substantial fill to provide a level area.

Each of the cooling towers would be 432 ft long, 90 ft wide, 50 ft from the top of the basin to the fan deck, and 60 ft high to the top of the fan stacks. Each of the 16 cells in each tower would be comprised of an upper dry element and a lower wet element and have a fan with a short vent stack located centrally at the top. The fans would be low noise design, and the towers provided with inlet air baffles and splash shields to reduce noise to 50 dBA at 400 ft from the tower.

Each cooling tower would be located above a concrete basin that collects the water falling through the fill and flowing from the tubes of the dry cooling section. The cooled water would flow from each basin to be recirculated to the six condenser water boxes. A makeup system would be provided to withdraw river water from the existing intake structure. It would include two pumps, located behind appropriate screens and racks, designed to withdraw up to 24,000 gpm from the river. The maximum evaporation rate would be approximately 12,000 gpm. This evaporation rate, coupled with the 12,000 gpm capacity of the blowdown system, would result in a cooling water concentration factor of two. Cooling water to auxiliary loads, including safety system loads would continue to be provided by the service water pumps of the existing once-through system.

The closed system design would include the capability to return to once-through cooling if required.

v. Roseton Units 1 & 2

The Roseton Units 1 & 2 Station is located on the west side of the Hudson River in the Town of Newburgh, NY. The plant comprises two essentially identical 600 MW units. The existing circulating water system is described in Section IV.B.1.

The closed cooling water system design evaluated here would include four wet/dry mechanical draft cooling towers, two for each of the two units. Each of the cooling towers would be 432 ft long, 42 ft wide, 50 ft high from top of basin to fan deck, and 60 ft high to the tops of the fan stacks. Each of the eight cells in each tower would be comprised of an upper dry element and a lower wet element and have a fan with a short vent stack located centrally at the top. The fans would be of low speed, low noise design and the towers provided with inlet air baffles and splash shields to reduce noise to 50 dBA at 400 ft from the tower.

Each cooling tower would be located above a concrete basin which collects the water falling through the fill and flowing from the tubes of the dry cooling section. The water in the basins would drain to a sump to be recirculated to each unit's condensers. A makeup system to withdraw river water from the existing intake structure would include three pumps located behind stationary screens and racks and be designed to withdraw up to 18,000 gpm from the river. The maximum evaporation rate would be expected to be approximately 9,000 gpm. The 9,000 gpm capacity of the blowdown system would result in a cooling-water concentration factor of two. Cooling water to auxiliary loads would be provided by six 6,000 gpm service water pumps, three for each generating unit.

The closed system design includes the capability to return to once-through cooling if required.

d. *Costs of Retrofitting Wet/Dry Cooling Towers*

Appendix VIII-3-A describes in detail the analyses carried out to develop preliminary estimates of the costs of retrofitting wet/dry cooling towers at Bowline Point Units 1 & 2, Roseton Units 1 & 2 and Indian Point Units 2 & 3 Electric Generating Stations. The costs of such projects include not only the direct construction costs, but also operating and maintenance costs associated with the additional equipment; replacement energy and capacity costs due to equipment-related deratings and replacement energy and capacity costs during cooling tower tie-in and other periods during construction when plant operation may not be allowed.

In calculating the costs it was assumed that design, permitting and other pre-construction activities for the Indian Point Units 2 & 3 could be completed in 40 months. Considering the potential for delays associated with placement of fill along the Hudson River and major modifications to nuclear power plants, this is considered aggressive. Similarly, the three-year construction schedule assumed is not conservative. Extensive delays would further reduce the period during which the cooling towers would provide any benefits. While extended delays would reduce the present value of the eventual major capital expenditures by postponing them to the future, legal, management, technical support and other licensing and procedural costs which are not included in these estimates can be expected to rise significantly.

The existing Roseton Units 1 & 2 and Bowline Points Units 1 & 2 plants were assumed to complete permitting and other pre-construction activities by mid 2003 and construction was estimated to be completed by the end of 2005. This is also considered non-conservative and assumes agreement is reached on implementing the towers early in 2000, a circumstance that is unlikely.

The total present value (1999) of retrofitting and operating wet/dry cooling towers at the four stations is estimated to range from $855,000,000 to $1,240,000,000, depending upon the number of years the facilities operate (Table VIII-8). Costs could be substantially higher if the tie-in or other shutdown periods are longer than those used for estimating purposes. For example, if the NRC were to require that the Indian Point Units 2 & 3 be off-line throughout the construction period, the costs would increase by approximately $600,000,000.

e. Environmental Considerations

i. General

Installing cooling towers at the existing Hudson River plants could reduce by about 97%, the volume of cooling water withdrawn from the Hudson River. The sum of entrainment and impingement conditional mortality (Table VIII-9) would be reduced to a somewhat lesser extent because all organisms entrained would be killed. With the existing cooling systems many entrained organisms are returned to the river alive. Above all, modeling of the population-level impacts on striped bass, American shad and Atlantic tomcod, the only three species to which population modeling could be successfully applied, indicates that the reductions in conditional mortality would not materially affect the size of these populations (Section VI).

Even with the selection of wet/dry mechanical towers for the existing generating units the aesthetic impacts require evaluation. For the purposes of the DEIS, previous environmental assessments have adequately documented the aesthetic values of the Hudson River Valley and the impacts that have resulted from, or could have been expected as a result of large scale utility proposal within it.

Therefore, it is appropriate to incorporate by reference several proceedings having applicability to this permit modification. They include the original 316 (b) proceeding (EPA Docket No. C/11-WP-77-01), as well as the Federal Energy Regulatory Commission

TABLE VIII-8

COSTS (MILLIONS OF 1999 DOLLARS) OF WET/DRY COOLING TOWERS CONSIDERED FOR THE HUDSON RIVER PLANTS

COST COMPONENT	BOWLINE POINT	INDIAN POINT 2	INDIAN POINT 3	ROSETON	TOTAL
Initial Costs (non-escalated value in year of occurrence)					
Construction	113	161	202	113	589
Interest during Construction	6	10	9	6	31
Energy & Capacity Loss During Construction	1	91	95	1	188
Initial Annual Costs					
Operation & Maintenance	0.7	1.0	1.1	0.7	3.5
Energy & Capacity Loss	3	11	8	3	25
Taxes, Ins, Cap Repl.	6	8	2	3	19
Total Life Cycle Costs (Present value in 1999)*					
For end of life (EOL) at 40 years after startup	138 for EOL at 2012	274 for EOL at 2013	310 for EOL at 2016	132 for EOL at 2014	855
For end of life (EOL) at 50 years after startup	183 for EOL at 2022	369 for EOL at 2023	366 for EOL at 2026	162 for EOL at 2024	1080
For end of life (EOL) at 60 years after startup	213 for EOL at 2032	439 for EOL at 2033	404 for EOL at 2036	184 for EOL at 2034	1240
Average Annual Life Cycle Costs					
For end of life at 40 years after startup	29 for EOL at 2012	54 for EOL at 2013	39 for EOL at 2016	23 for EOL at 2014	145
For end of life at 50 years after startup	19 for EOL at 2022	35 for EOL at 2023	26 for EOL at 2026	16 for EOL at 2024	96
For end of life at 60 years after startup	16 for EOL at 2032	31 for EOL at 2033	20 for EOL at 2036	13 for EOL at 2034	80

* costs incurred for each year of life are discounted by interest rate per year back to 1999 and summed; discounted losses of capacity and energy during construction are then added

TABLE VIII-9

ESTIMATED ENTRAINMENT CONDITIONAL MORTALITY RATES WITH WET/DRY COOLING TOWERS INSTALLED AT THE ROSETON, INDIAN POINT, AND BOWLINE POINT GENERATING STATIONS.

STATION	STRIPED BASS	WHITE PERCH	ATLANTIC TOMCOD	BAY ANCHOVY	RIVER HERRING	AMERICAN SHAD	SPOTTAIL SHINER
Roseton	0.0037	0.0039	0.0012	0.0003	0.0013	0.0002	0.0028
Indian Point	0.0121	0.0026	0.0116	0.0045	0.0004	0.0001	0.0039
Bowline Point	0.0010	0.0002	0.0053	0.0014	0.0000	0.0000	0.0012
Total	0.0167	0.0066	0.0180	0.0062	0.0017	0.0003	0.0079
% Reduction from Baseline CMR	90%	95%	93%	97%	96%	96%	86%

Storm King Application (1963), the Greene County Nuclear Power Plant Application (PSC case 80006, NRC Docket no.50-549, August, 1976); the Travis Coal RDF Application (PSC case 80004, December 1974); The Danskammer Coal Reconversion Application (UPA #30-83-0544, August, 1984); the crossing of the Hudson by both the Marcy-South 345KV Transmission Facility (PSC Case 70126, November 1982) and the Iroquois Gas Transmission System (PSC Case 70363, December, 1987); the Coal Reconversions of Lovett Units 4 and 5 (UPA # 30-82-0608, July 1981); and the New York State Energy Master Plan and Long Range Electric and Gas Report before the New York State Energy Planning Board (Plan I, 1979).

The plants would experience substantial deratings due to increased turbine back-pressure and auxiliary power loads. This would reduce the output of the plants without reducing fuel consumption, emissions or other related impacts at the Hudson River plants. The generation lost from the Hudson River plants, nearly 600,000 MWh per year, would have to be made up. At least part would be made up at other existing plants with the attendant impacts occurring there. To make up for the lost capacity of the Hudson River plants, 148 MW of additional capacity could be required.

Most of the cooling provided by the cooling towers is produced by evaporation of water. On an annual basis, the existing Bowline Point Units 1 & 2, Indian Point Units 2 & 3 and Roseton Units 1 & 2 plants operating at projected capacity factors would evaporate on the order of 15 billion gallons of river water annually, or about 40,000 acre/ft. This is more than twice the evaporation that occurs with the existing once-through systems. The maximum evaporation rates of up to 21 million pounds per hour (94 cfs) would occur during the warmest periods, which are often the times of the lowest freshwater flows. This maximum evaporation rate can equal approximately 5% of the minimum monthly average summer freshwater flow rate in the Hudson River.

Drift, consisting of small airborne droplets of cooling water, would be continuously emitted into the ambient air. These droplets contain salts and chemicals present in the cooling-tower water. During operation chemical constituents in the Hudson River intake water would be carried through and concentrated in the cooling tower and a portion of them would be dispersed into the ambient air with the drift. The drift would eventually reach the ground and contribute to increased ground level concentrations. The drift rate in modern, well designed and maintained, cooling towers is on the order of 0.001% to 0.002% of the total flow rate. These rates would lead to deposits of salts that may be harmful to hemlocks in the area of drift deposition.

Cooling towers generate noise from their fans, as well as from the water that splashes through the tower. To reduce the noise emitted by the tower, low-speed, quiet fans would be used and the towers would be equipped with inlet air baffles and splash shields. The claimed effect of these provisions would be that the noise level at 400 ft from the towers would be expected not to exceed 50 dBA. More typically, noise levels of 65 dBA could be achieved with the low speed fans and high quality fan drives. These noise levels would be comparable to those for a natural draft tower.

Blowdown discharge contains concentrated levels of salts and chemicals present in the makeup water as well as chemicals added to prevent fouling. The temperature of the blowdown would generally be 10 to 30 F higher than the river water to which it is returned. The discharge flow rates would be about 2 to 3% of the flow circulated through the towers.

Sludge would develop in the basin from silt and heavier suspended solids in the makeup water. The sludge would have to be properly managed and the cost of testing, removal and proper disposal could be substantial.

In order to install cooling towers at the existing Indian Point Units 2 & 3 and Bowline Point Units 1 & 2 stations, large tracts of land would have to be cleared of vegetation; at Indian Point Units 2 & 3 large quantities of rock would have to be excavated and most of it would have to be disposed of. The site clearing, excavation and transportation of surplus material and its disposal would impact the vicinity with significant increase in noise, vehicular traffic, dust and the potential spillage of earth and rock on the roads.

Increased air emissions are among the potentially significant environmental impacts that would accrue to the construction and operation of closed cycle cooling systems at the existing Hudson River stations. Power to replace that lost as a consequence of cooling system inefficiencies and outages taken during cooling tower construction would be generated at facilities burning fossil fuels.

In 1996 the utilities carried out PROMOD analyses of the effects of various cooling-tower designs on air emissions (Appendix VIII-1-B). These analyses preceded the deregulation of the utility industry that is now underway in New York, so the extent to which the results reflect conditions that will eventually emerge is uncertain. However, they represent the best approximation currently possible. No modeling of wet/dry systems was carried out, so the additional emissions associated with wet mechanical draft towers are presented as a proxy (Table VIII-10). Installation of wet cooling towers at all four stations would cause annual increases of 849 tons of NOx, 2792 tons of SO2, 74 tons of CO, 406,623 tons of CO2 and 194 tons of particulates. These additional emissions would be the result of increased fossil fuel use to make up for generating inefficiencies caused by the towers. Combination wet/dry towers impose a greater penalty on operating efficiency than wet towers alone, so emission increases would be expected to exceed these estimates.

TABLE VIII-10

ADDITIONAL AIR EMISSIONS ASSOCIATED WITH ELECTRIC POWER GENERATION TO REPLACE GENERATION LOST TO INEFFICIENCIES AT THE HUDSON RIVER STATIONS CAUSED BY COOLING TOWER OPERATION+

STATION	NO_x	SO_2	CO	CO_2	PARTICULATES
Roseton 1 & 2	87	230	16	59,493	18
Indian Point 2 & 3	829	2,992	59	375,295	201
Bowline 1 & 2	37	19	7	26,129	4
Total	870	2,942	76	423,388	203

+Does not include additional emission during construction/tie-in.

ii. Environmental Impacts at Bowline Point Units 1 & 2

The cooling towers for the existing Bowline Point Units 1 & 2 would occupy an area of approximately 6 acres adjacent to the Hudson River. This area is currently covered with a second growth mixed hardwood forest which is in the transition phase between late pioneer and mature species and shows some indications of being wetlands. The site would be entirely cleared for ease of construction and to allow maximum airflow to the towers.

The tower location is visible from the Hudson River and the pair of 432-ft-long and 50-ft-high (60 ft to the top of the fan stacks) towers at the river's edge presents an aesthetic issue. The second pair of towers some 400 ft further inland, would be largely obscured.

Assuming a tower drift rate of 0.002%, which is reportedly readily achievable from well designed and maintained towers, salt deposition rates could exceed 44,000 lb per month during the summer low freshwater flow months. Earlier studies of the potential effects of salt deposition from mechanical draft cooling towers on vegetation near Bowline Point Units 1 & 2 concluded that the annual deposition rates at all points off site would be below those that would cause any significant damage.

Assuming that the noise produced by the Bowline Point Units 1 & 2 boilers is similar to that at Roseton Units 1 & 2, the noise produced by cooling towers from splashing of the water and from the fans and gear boxes should not increase sound levels in nearby residential areas noticeably, with moderate noise abatement features included in the design. If the more elaborate noise abatement measures included in the cost estimate were as effective as the manufacturer claims, there would be essentially no noise impact from operation of the cooling towers.

The construction of the closed cooling system would require approximately two years. During this time there would be a substantial increase in traffic through the town center due to the flow of heavy equipment, materials, and workmen to the site. During the early construction phase, the pile-driving operation can be expected to be audible at the northwest plant boundary.

The PROMOD analyses (Appendix VIII-1B) predicted that operation of Bowline Point Units 1 & 2 with a mechanical-draft cooling tower would result in additional (beyond what would occur if Bowline Units 1 & 2 operated with once-through cooling) air emissions of 37 tons/year of NOx, 19 tons/year of SO2, 7 tons/year of CO, 26,129 tons/year of CO2, and 4 tons/year of particulates, as other New York State units were dispatched to make up the lost generating capacity (Table VIII-10). Additional emissions would be produced during the time that the units would be off-line to accommodate tie-in of the new cooling systems.

iii. Environmental Impacts at Indian Point Unit 2

The cooling towers for Indian Point Unit 2 would occupy an area of approximately 15 acres comprising a long narrow strip along the Hudson River. This area is currently covered with a mature hardwood forest. The site would be entirely cleared and undergo substantial excavation to allow maximum airflow to the towers.

The tower location is highly visible river frontage and the four 432-ft-long and 50-ft-high towers (60 ft to the top of the fan stacks) at the river's edge would add substantially to the aesthetic impact of the plant. Views from the Hudson River, from scenic overlooks on area highways and from Bear Mountain State Park on the western shore would be significantly impacted. Nearly all of the forested shoreline, from the plant security fence to Lent's Cove, would be replaced by the towers. Construction of the towers would preclude any potential access to the river for recreational or commercial purposes.

In considering salt deposition damage, the effects of towers at both Indian Point Units 2 & 3 should be considered together since the areas of deposition will overlap to a great degree. Assuming a tower drift rate of 0.002%, salt deposition rates could exceed 33,000 lb per month from each plant during the summer and fall low fresh water flow months. It appears that the flowering dogwoods and white ash trees in an area of about ten square kilometers would experience some damage during droughts. Any Canadian hemlocks in the vicinity may experience substantial, and perhaps fatal, deleterious effects during these drought periods. The area that may experience substantial damage includes most of Buchanan and Verplanck to near Montrose Point, and may include some of the park land on the west side of the river. Some additional areas in Peekskill and its immediate environs may be similarly affected.

As with salt deposition, noise from the towers at both Indian Point Units 2 & 3should be considered jointly. In the immediate vicinity of the units the nearer towers would provide the dominant portion of the sound energy. The fact that there would be a second set of towers in the general area should not have a significant effect. At large distances the presence of two sets of towers could add about 3 dBA to the noise level from a single unit's cooling towers. The combined noise levels from the two sets of towers would produce sound power levels (SPL) of no more than 48 dBA outside the site, except on the river itself within less than 3000 ft of the towers. The contribution from the towers, when combined with other noise sources, would lead to additional areas having SPLs greater than 48 or even 50 dBA. This would represent a violation of Buchanan noise ordinances. Perhaps more relevant than the absolute sound pressure levels is the L_{dn}. L_{dn} is a measurement of the impact of noise over both day and night. Night noises are weighed more heavily than daytime noises, reflecting their relative effect on people's quality of life. Thus a noise level which remains constant for both day and night, such as the noise level that the towers would produce, has an L_{dn} approximately 6 dB higher than its SPL, and the constant noise level of 48 dB is equivalent to an L_{dn} of 54 dB. This contribution to the ambient L_{dn} would result in the noise level in many residential areas increasing to the 55 to 60 L_{dn} level, a point at which residents can be expected to complain and seek redress in significant numbers. If the more elaborate noise abatement measures included in the cost estimate were as effective as the manufacturer claims, there would be essentially no noise impact from operation of the cooling towers.

The construction of the closed cooling system would require approximately three years. During this time there would be a substantial increase in traffic through the town, particularly along Route 9 and Bleakley Avenue, due to the flow of heavy equipment, materials, and workmen to the site. The increase in traffic is expected to raise the L_{dn} levels from the marginal to the probably objectionable level in these areas. Pollutants from truck exhausts are expected to be quite noticeable. During the early construction phase, the excavation can be expected to be audible beyond the plant boundary.

The PROMOD analysis (Appendix VIII-1B) predicted that operation of Indian Point Unit 2 with a mechanical-draft cooling tower would result in additional (beyond what would occur if Indian Point Unit 2 operated with once-through cooling) air emissions of 415 tons/year of NOx, 1,496 tons/year of SO2, 30 tons/year of CO, 187,648 tons/year of CO2, and 101 tons/year of particulates, as other New York State units were dispatched to make up the lost generating capacity (Table VIII-10). Additional emissions would be produced during the time the station would be off-line to accommodate construction of the new cooling system.

iv. Environmental Impacts at Indian Point Unit 3

The cooling towers at Indian Point Unit 3 would be located at two adjacent sites. One along the river's edge about 350 ft south of the unit and the second approximately 400 ft east and inland from the first. The installation of the cooling towers would displace warehouse and other support facilities and a large parking area. These facilities would have to be relocated on the site with probable destruction of the mature mixed hardwood forest occupying most of the site. In addition, a gas pipeline would have to be relocated with similar consequences, as well as disturbance of the shoreline and riverbed in the vicinity of the existing and relocated pipeline.

The towers can be expected to have a substantial aesthetic impact, particularly the 400-ft long by 60-ft-high tower immediately along the river. The intrusiveness of the riverside tower would be amplified because it would be placed on a combined filled and excavated site 45 ft above the river's edge.

The effects of salt deposition from the combined drift of towers at IP2 and IP 3 are discussed above. The noise levels from cooling towers at IP 3 are expected to be below 45 dBA at all residential and recreational areas. The IP 3 cooling towers would be a minor contributor to potentially unacceptable noise levels at the Bleakley Avenue area; the additional traffic from construction vehicles can be expected to be a major noise source during daytime hours for much of the three-year construction period (see Section iii, above).

The deratings that would be experienced at Unit 3 are about 80% of the deratings for Unit 2. Therefore, the increases in air emissions to replace the energy lost at Unit 3 would also be about 80 % of the Unit 2 values (Table VIII-10). The additional emissions during the time Indian Point Units 2 & 3 would be off-line for construction of the new cooling system would be approximately the same as those for Unit 2.

v. Environmental Impacts at Roseton Units 1 & 2

The cooling towers for Roseton Units 1 & 2 Power Plant would occupy an area of approximately 6 acres between the units and the Hudson River. This area is currently essentially vacant. The towers would be visible from the river and the opposite shore and their bulk would be imposing. However, for the most part, the towers would block the view of the power plants and related facilities rather than of natural features.

Assuming a tower drift rate of 0.002%, salt deposition rates could exceed 24,000 lb per month during summer drought months. Based on a review of results for the study of the Roseton Units 1 & 2 Plant performed in the late 1970s, it appears that several thousand flowering dogwoods and white ash trees would experience some damage during droughts that can be expected to occur at least twice in the next twenty years. Any Canadian hemlock trees in the tens of acres in the immediate vicinity of the plant may experience substantial, and perhaps fatal, deleterious effects.

The noise produced by cooling towers from splashing of the water and from the fans and gear boxes should not increase sound levels in nearby residential areas noticeably, with moderate noise abatement features included in the design. If the more elaborate noise abatement measures included in the cost estimate are as effective as the manufacturer claims, there would be essentially no noise impact from operation of the cooling towers.

The construction of the closed cooling system would require approximately two years. During this time there would be a substantial increase in traffic along Route 9W due to the flow of heavy equipment, materials, and workmen to the site. The increase in noise and the pollutants from truck exhausts would be quite noticeable, along Post Road and River Road.

The PROMOD analysis (Appendix VIII-1B) predicted that operation of Roseton Units 1 & 2 with a mechanical-draft cooling tower would result in additional (beyond what would occur if Bowline Units 1 & 2 operated with once-through cooling) air emissions of 87 tons/year of NOx, 230 tons/year of SO2, 16 tons/year of CO, 59,493 tons/year of CO2, and 18 tons/year of particulates as other New York State units are dispatched to make up the lost generating capacity (Table VIII-10). Additional emissions would be produced during the time the station would be off-line to accommodate tie-in of the new cooling system.