THERMAL DISCHARGE MIXING ZONE RECOMMENDATION
BRAYTON POINT STATION
SOMERSET, MASSACHUSETTS

NPDES Renewal: US GEN New England, Inc.
NPDES Permit No. MA0003654

Prepared By:
Massachusetts Department of Environmental Protection

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RE: Brayton Point Station Discharge
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Date: May 17, 2002

Recommendation for Potential Brayton Point Station Thermal Discharge Mixing Zone Requirements

I. INTRODUCTION:

As part of its review of the Brayton Point Station NPDES Discharge Permit renewal application (Permit #MA0003654), Massachusetts Department of Environmental Protection (MADEP) has applied its Massachusetts Surface Water Quality Standards in 314 CMR 4.00 to develop a potential Brayton Point Station Thermal Discharge Mixing Zone recommendation that meets the thermal requirements of those Standards along with the associated implementation policies. MADEP has sought input from EPA, Rhode Island Department of Environmental Management (RI DEM), the Massachusetts Division of Marine Fisheries (DMF), and Massachusetts Coastal Zone Management (CZM) to aid development of this mixing zone recommendation. The potential mixing zone recommended herein does not evaluate nor address the entrainment and impingement impacts that might result from the method of cooling or other means to be used to meet the mixing zone thermal limits and temperature compliance requirements.

*Because the different evaluations and back-up documents used to develop this recommendation document include temperature reflected in both Celsius (^{0}C) and/or Fahrenheit (^{0}F), for consistency with that information both ^{0}C and ^{0}F are used herein.

II. BACKGROUND:

Brayton Point Station is permitted to discharge up to 1.45 billion gallons per day (BGD) of heated wastewater to Mt. Hope Bay under the most recent, joint EPA/MADEP NPDES permit, issued in 1993. The permit sets a 95°F maximum discharge temperature and a maximum temperature increase (ΔT) of 22°F across the intake and discharge points. The permit includes a Section 316(a) Variance from Massachusetts Surface Water Quality Standards, issued in 1985 that among other things allowed Unit 4 to change from a closed-cycle cooling system to an open-cycle cooling system.

Currently, Brayton Point Station's thermal discharge, under Memorandum Of Agreement (MOA) II operating conditions, results in up to 42 trillion British Thermal Units (BTUs) of waste heat being released annually into the Mt. Hope Bay source/receiving waters. Review of applicable environmental data pertaining to the Mt. Hope Bay source/receiving waters along with evaluation of thermal discharge modeling runs prepared using a 3-D hydrodynamic thermal model reveals that Brayton Point Station thermal discharge plume impacts far exceed the impacts predicted when the facility owners successfully petitioned EPA for a thermal discharge variance under CWA Section 316(a) prior to Unit 4 going to open cycle cooling.

As part of Brayton Point Station's NPDES permit, the permittee has maintained a field sampling program for the Mt. Hope Bay source/receiving waters. Among other things, this program consists of trawl surveys to track finfish distribution and abundance. Evaluation of trawl survey data indicates a decline in certain populations of finfish has occurred in Mt. Hope Bay.

Mt. Hope Bay temperature modeling has shown the Brayton Point Station thermal discharge plume to exceed Massachusetts and Rhode Island Surface Water Quality Standards for temperature increase during warm summer conditions throughout more than 70% of the combined Massachusetts and Rhode Island Mt. Hope Bay waters. The proposed thermal mixing zone and associated proposed permit limits will meet Massachusetts Surface Water Quality Standards relative to thermal impacts of the discharge and will reduce the thermal exceedance percentage under the same warm summer conditions to an average of 10% or less of Mt. Hope Bay waters, thereby improving the opportunity for habitat and fishery recovery. The proposed mixing zone includes requirements that the mixing zone be abated during certain species migration periods and that the mixing zone be abated as necessary so that certain temperature maxima are not exceeded in the mixing zone during periods MADEP has determined to be of particular biological importance. MADEP has included these requirements to help ensure the proposed mixing zone adequately protects aquatic life and designated uses as defined in the Massachusetts Surface Water Quality Standards in 314 CMR 4.00. (See Attachment 3 for additional background information).

Changes in facility operation will be necessary to meet the discharge limits and mixing zone temperature compliance requirements. Changes in cooling practices, cooling system design, and/or changes in station configuration by themselves (or combined with reduced operation) could be used to meet the requirements and thermal limits of the proposed mixing zone.

III. MIXING ZONE DEVELOPMENT METHODOLOGY:

MADEP evaluated impact predictions of the Brayton Point Station thermal discharge under various potential station operating conditions to develop a proposed mixing zone that meets the thermal requirements of the Massachusetts Surface Water Quality Standards. As a result of evidence of a long-term warming trend in Narragansett Bay waters as a whole and because it is reasonable to assume the occurrence of unusually warm periods from time to time, the impacts of various potential Brayton Point Station operating conditions were evaluated for warm summer and warm winter environmental conditions, respectively. The 3-D hydrodynamic thermal model developed by Brayton Point Station's consultants, Applied Science Associates, and accepted by the Brayton Point Station NPDES permit Technical Advisory Committee, validated for mean winter and summer weather years respectively, was used to perform the evaluation. MADEP also assumed a maximum discharge temperature limit of 95°F.

In order to meet the requirements of the Massachusetts Surface Water Quality Standards and Implementation Policy for Mixing Zones, MADEP compared alternative BTU discharge quantities and discharge volumes with respect to predictions of the volumetric, cross-sectional and spatial extent of the resulting thermal impacts on Mt. Hope Bay and adjoining waters. The predictions of volumetric, cross-sectional and spatial extent thermal impacts of each alternative were reviewed to determine a potential discharge scenario that resulted in a suitable mixing zone that met the thermal requirements of the Massachusetts Surface Water Quality Standards, including narrative requirements for protection of aquatic life and designated uses of receiving waters. The establishment of mixing zone suitability was based on the evaluation of model predictions compared to mixing zone criteria pertaining to bank-to-bank coverage, maintenance of a 50% cross-sectional area free of mixing zones for Zones of Passage, protection of the biological community of the receiving water segment and the receiving water segment meeting its designated uses.

Massachusetts divides the Mt. Hope Bay waters within its jurisdiction into SA designated waters and SB designated waters. The Massachusetts Surface Water Quality Standards for SA and SB designated waters are, in part, as follows:

- 1.50^0F = Increase in temperature (ÄT) for both SA and SB waters
- 4.0^0F = ÄT increase in winter (October-June) for SB waters only
- 80.0^0F = Maximum Daily Mean for both SA and SB waters
- 85.0^0F = Maximum temperature for both SA and SB waters

- SA = Class SA waters are designated as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfish Areas). These waters shall have excellent aesthetic value.

- SB = Class SB waters are designated as a habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting with depuration (Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.

Water quality temperature standards have been developed to be protective of the habitat for fish and other aquatic life. These Massachusetts Surface Water Quality Standards for temperature were used to delineate the mixing zone's spatial and volumetric extent. Additional monitoring, temperature and abatement requirements are recommended as part of the mixing zone to assure it adequately protects aquatic life and designated uses.

Zone of Passage:

The requirement that mixing zones maintain Zones of Passage was the first development criterion used to evaluate the thermal impacts predicted to result from alternative BTU thermal discharge scenarios. The ÄT increase of 1.5^0F was the temperature standard that most limited mixing zone size relative to the maintenance of Zones of Passage. Seven day rolling averages for temperature were used for the ÄT 1.5^0F evaluation for consistency with EPA Redbook and Goldbook Guidelines. The predicted impacts from the following monthly BTU thermal discharge alternatives were compared to determine the maximum BTU thermal discharge that maintained Zones of Passage:

0.90 trillion BTUs per month	@	.440 BGD
1.10 trillion BTUs per month	@	.750 BGD
1.20 trillion BTUs per month	@	.750 BGD
1.81 trillion BTUs per month	@	.925 BGD
2.1079 trillion BTUs per month	@	.744 BGD
2.25 trillion BTUs per month	@	.925 BGD
2.50 trillion BTUs per month	@	.925 BGD
2.8093 trillion BTUs per month	@	.809 BGD
3.4933 trillion BTUs per month	@	1.0178 BGD
3.7354 trillion BTUs per month	@	1.04311 BGD

A thermal discharge of 1.20 trillion BTU was determined to be the maximum monthly thermal discharge quantity that maintained Zones of Passage. The mixing zone associated with such a waste heat discharge quantity left Zones of Passage free of mixing zone impacted waters along the Taunton River, and Cole's River during both summer and winter. It also did not disproportionately impact the Massachusetts SA designated waters during winter as did all higher waste heat discharge quantities. However, because a 1.20 trillion BTU monthly discharge leaves the Lee's River covered with water that exceeds the 1.5^0F temperature increase standard, site specific temperature limits for the Lee's River are necessary to protect Zones of Passage. These limits are more restrictive than a potential 1.20 trillion BTU discharge limit and will preside during periods of alewife migration.

The 1.20 trillion BTU monthly discharge was next evaluated to determine if such a discharge quantity met the requirement criterion that mixing zones must minimize the discharge impacts on the native, naturally diverse, community of aquatic flora and fauna and must not interfere with the attainment of designated uses of the receiving water segment.

Protection of Aquatic Life and Designated Uses:

The mixing zone criteria requirement that the aquatic life of the receiving water be protected, and that designated and existing uses of the receiving water be protected, was evaluated through development of critical temperatures. Critical temperatures were identified for different seasons in consideration of the most sensitive species and/or species life stage present in Mt. Hope Bay. The 1.20 trillion BTUs per month discharge and the resultant mixing zone were modeled and evaluated for areas that equaled or exceeded these selected absolute "critical" temperatures to ensure the proposed mixing zone and associated thermal discharge BTU limits would not excessively raise Mt. Hope Bay temperatures and would protect aquatic life and designated uses.

To evaluate protection of designated uses and protection of the Mt. Hope Bay biological community, Mt. Hope Bay was divided into three layers: a surface layer (the 2 surface data blocks of the 3-D hydrodynamic thermal model); middle layers (the 8 middle data blocks of the 3-D hydrodynamic thermal model); and the bottom layer (the one bottom data block of the 3-D hydrodynamic thermal model). Mt. Hope Bay was segmented in this manner so the pelagic (Species and/or life stages that inhabit the surface or middle layers of the water column) and the benthic (bottom dwellers) could be evaluated individually.

A literature search was performed by MADEP, EPA, CZM, and DMF to establish temperatures for the benthic layer (bottom layer) and pelagic layers (middle and surface layers) that could be considered as "no-effect", "target", "sub-optimal" or "acute" effect temperatures in relation to biological activity. The no- effect, target, sub-optimal, and acute effect temperatures were determined for the most sensitive species and/or species life stage among the RIS and identified as "Maximum Critical Temperatures". (See Attachment No. 1 for additional information and literature citations).

Target temperatures were derived using best professional judgement to apply best available scientific temperature information regarding aquatic species survivability and avoidances to the Mt. Hope Bay environment. In deriving target temperatures MADEP took into consideration Mt. Hope Bay ambient temperature conditions, the biological importance of maintaining a particular temperature for habitat suitability, and the attainability of particular temperatures within Mt. Hope Bay's benthic and pelagic layers.

The target temperatures for the pelagic layers are the same as, or only slightly higher than, the no-effect temperatures. MADEP has determined these temperatures are reasonably attainable in the Mt. Hope Bay pelagic layers and that the mixing zone should not cause the Mt. Hope Bay pelagic layers target temperature to be exceeded in order that it be protective of aquatic life and designated uses within Mt. Hope Bay.

During warm weather years hydrodynamic thermal modeling predicts Mt. Hope Bay's benthic layer to exceed no-effect temperatures. The no-effect temperatures are therefore less attainable in the benthic layer due to the elevated temperatures present at ambient in the benthic layer. Accordingly, the benthic layer target temperatures are higher than the no-effect temperatures. In this case, they are the temperatures beyond which MADEP has determined the level of decreased aquatic species survivability, feeding inhibition and/or avoidance response in the benthic layer becomes unacceptable. During normal weather years, the benthic layer target temperatures should be reasonably attainable. In that the Mt. Hope Bay benthic layer is temperature stressed during ambient conditions, during warm extreme weather years it often meets or exceeds the benthic layer target temperature prior to the addition of waste heat BTUs from the Brayton Point discharge. The addition of heat to the Mt. Hope Bay benthic layer therefore needs to be carefully monitored and restricted, especially during warm summer and warm winter biologically important periods. Such monitoring and additional heat restrictions are particularly important in view of Mt. Hope Bay's diminished fish abundance.

MADEP has determined that the mixing zone should not cause the target temperature in the Mt. Hope Bay benthic layer to be exceeded to ensure it adequately protects the aquatic life and designated uses in Mt. Hope Bay.

MADEP used 3-D hydrodynamic thermal model predictions of target temperatures to evaluate mixing zone impacts during warm summer and warm winter conditions in different Mt. Hope Bay depth strata to determine if the 1.20 trillion BTUs per month discharge limit determined to adequately maintain Zones of Passage would also adequately protect aquatic life during periods of particular biological importance. The target temperatures used for this evaluation are as follows:

	SUMMER	**WINTER**
BENTHIC (bottom layer)	24.0 degrees C (do not exceed)	5.0 degrees C (do not exceed)
PELAGIC (middle and top layers)	25.0 degrees C (do not exceed)	8.0 degrees C (do not exceed)

Hydrodynamic model run evaluation of 1.20 trillion BTUs per month lead MADEP to conclude that specific temperature maxima compliance requirements are needed to ensure the mixing zone protects aquatic life and designated uses. MADEP has determined from its evaluation that during warm summer and warm winter conditions station operation at a discharge limit of 1.20 trillion BTUs per month would excessively elevate temperatures in the benthic layer causing it to meet or exceed target temperatures and that more restrictive requirements for monitoring and temperature compliance are required to protect aquatic life. The temperature compliance requirements will reduce mixing zone size and the associated BTU discharge quantities during periods determined to be of particular biological importance.

Target Temperature Compliance During Summer Conditions:

The hydrodynamic model predicts that a 1.20 trillion BTUs per month thermal discharge would create a mixing zone during warm summer conditions that caused 35% of Mt. Hope Bay's benthic layer to meet or exceed the 24^0C target temperature. MADEP has determined this predicted impact needs to be reduced to ensure the mixing zone adequately protects aquatic life and designated uses during summer conditions. Accordingly, mixing zone and thermal discharge abatement requirements are included as mixing zone compliance conditions during certain biologically important periods. At such times the Brayton Point Station BTU thermal discharge will be less than 1.20 trillion BTUs per month. The actual BTU thermal discharge quantities will vary based on ambient conditions. These reduction measures will help ensure the mixing zone and associated thermal discharge does not negatively impact maintenance of the 24^0C target temperature in the Mt. Hope Bay benthic layer. Because the Brayton Point discharge canal terminates in Massachusetts SA designated waters, any area of less than suitable temperature would be concentrated in those Massachusetts SA waters. As discussed, SA designates waters as excellent habitat for fish and other aquatic life.

Target Temperature Compliance During Winter Conditions:

The hydrodynamic model predicts that a 1.20 trillion BTUs per month thermal discharge would create a mixing zone during warm winter conditions that caused 100% of Mt. Hope Bay's benthic layer to meet or exceed the 5^0C target temperature. MADEP has determined this predicted impact needs to be reduced to ensure the mixing zone adequately protects aquatic life and designated uses during winter conditions. Accordingly, mixing zone and thermal discharge abatement requirements are included as mixing zone compliance conditions during certain biologically important periods. At such times the Brayton Point Station BTU thermal discharge will be less than 1.20 trillion BTUs per month. The actual BTU thermal discharge quantities will vary based on ambient conditions. These reduction measures will help ensure the mixing zone and associated thermal discharge does not negatively impact maintenance of the 5^0C target temperature in the Mt. Hope Bay benthic layer. Because the Brayton Point discharge canal terminates in Massachusetts SA designated waters, any area of less than suitable temperature would be concentrated in those Massachusetts SA waters. As discussed, SA designates waters as excellent habitat for fish and other aquatic life.

(As discussed earlier, during warm summer and especially warm winter conditions the 3-D hydrodynamic thermal model has predicted that ambient temperatures in much of the Mt. Hope Bay benthic layer would be elevated above target temperatures prior to the addition of any Brayton Point Station generated waste heat BTUs. Recent observations by the National Oceanic and Atmospheric Administration (NOAA) have shown a 40-year warming trend in Narragansett and Mt. Hope Bay waters.

Additional introductions of heat to the Mt. Hope Bay ecosystem need to be carefully monitored and restricted, especially during warm ambient conditions.)

Target Temperature Compliance for the Pelagic Layer:

MADEP has determined that benthic layer monitoring and compliance with temperature maxima will be adequately protective of target temperatures maintenance in the pelagic layer.

Zone of Passage Waste Heat Discharge Temperature Limits for the Lee's River:

While the Massachusetts Implementation Policy for mixing zones provides that at least half a waterbody's area or volume should remain free from a mixing zone, the relevant regulatory language on mixing zones in 314 CMR 4.03(2)(b) states more generally that there shall be a safe and adequate passage for swimming and drifting organisms with no deleterious effects on their populations. Because under a potential thermal discharge limit of 1.20 trillion BTUs per month the Lee's River is predicted to be occupied by water that exceeds a ÄT increase of 1.5^0F bank-to-bank and/or across more than 50% of the cross sectional area, specific temperature maxima have been established for the Lee's River. During periods of fish migration in the Lee's River, in lieu of the 1.20 trillion BTUs per month thermal discharge limit, the mixing zone contains more restrictive requirements for specific temperature compliance. These requirements will help ensure that there will be no avoidance of the Lee's River by alewives and that the Zone of Passage is maintained in accordance with 314 CMR 4.03(2). There are a variety of species present in the Lee's River at different times, but in terms of anadromous and catadromous fish runs, only the alewife uses the Lee's River in any appreciable amount.

The lowest effect levels from 24-hr. tests were used to develop temperature limits for alewives so that at shorter exposures, no adverse effects should accrue to exposed individuals and a Zone of Passage is maintained. Data was gathered from fish runs in the northeast that serve the alewife to determine the temperatures necessary for different periods to ensure a Lee's River Zone of Passage is maintained for the alewife and avoidance does not occur.

IV. MIXING ZONE COMPLIANCE WITH MASSACHUSETTS SURFACE WATER QUALITY STANDARDS AND COMPARISON TO IMPACTS FROM CURRENT OPERATIONS:

The following section discusses how the proposed mixing zone meets the requirements of 314 CMR 4.03(2) and how it compares to the impacts on Mt. Hope Bay from current operations. Reference is made to the numbered 3-D hydrodynamic thermal modeling runs attached.

Temperature Standards and Zones of Passage:

The ÄT increase of 1.5^0F is the most constraining Massachusetts Surface Water Quality Standard for temperature as it applies to the Brayton Point Station discharge mixing zone with regard to maintaining Zones of Passage. It was used as the initial means of mixing zone delineation. Map Nos. 1 and 2 show the relative 1.5^0F increase exceedance areas of current operations compared to a potential 1.20 trillion BTUs mixing zone-based operations. Map No. 1 depicts the volume of Mt. Hope Bay that exceeds the Massachusetts Surface Water Quality standards for temperature of ÄT increase of 1.5^0F during current operations for warm summer conditions (approximately over 70% of Mt. Hope Bay). Map No. 2 depicts the volume of Mt. Hope Bay that exceeds the Massachusetts Surface Water Quality for temperature standard of ÄT increase of 1.5^0F that would result from potential operating conditions associated with 1.20 trillion BTUs discharge limit (approximately less than 10% of Mt. Hope Bay).

*More restrictive temperature monitoring and compliance requirements were deemed necessary for the mixing zone to protect the Zone of Passage for the Lee's River. These requirements will cause the mixing zone and associated thermal discharge quantities to be reduced at times when alewives migrate. (See Attachment No. 2: Temperature Considerations for Alewives in the Lee's River.)

The Zone of Passage monitoring and temperature compliance requirements for the Lee's River are based on alewife temperature sensitivities because they are the only anadromous or catadromous species who uses the Lee's River as a fish run in any appreciable amount. The Lee's River area of Mt. Hope Bay also will be monitored for the benthic layer summer target temperature of 24^0C, as well as the 5^0C winter benthic layer target temperature. A benthic layer temperature monitoring and compliance requirement that includes a monitoring transect incorporating Lee's River and Cole's River Mt. Hope Bay benthic areas is established as a mixing zone requirement.

The ÄT 1.5^0F increase exceedance area in winter conditions under current operations covers most of the Massachusetts SA waters and is bank-to-bank at both the mouth of the Lee's River and the mouth of the Cole's River providing no Zones of Passage in these water bodies. A potential 1.20 trillion BTUs per month thermal discharge limit would reduce the area of Massachusetts SA waters covered with water exceeding a ÄT increase of 1.5^0F and provides a Zone of Passage free of the mixing zone exceeding the ÄT increase of 1.5^0F across the mouth of the Cole's River. As previously noted, because the Lee's River remains covered with water that exceeds ÄT increase of 1.5^0F during winter conditions, specific temperature maxima limits and a monitoring requirement have been set for that water body to maintain a Zone of Passage and to ensure the alewife population does not avoid the Lee's River spawning area. During winter conditions, benthic layer monitoring for the 5^0C winter target temperature is also required. A benthic layer temperature monitoring and compliance requirement that includes a monitoring transect incorporating the Lee's

River and Cole's River Mt. Hope Bay benthic areas is established as a mixing zone requirement. (See Map Nos. 3 and 4).

Interruption of Migration:

As described above, under the proposed mixing zone, Zones of Passage will be maintained. The proposed mixing zone provides Zones of Passage for the anadromous and catadromous species of Mt. Hope Bay. Under current operating conditions the thermal discharge plume creates an attraction to striped bass as striped bass winter-over in the Brayton Point Station thermal discharge plume and discharge canal thereby failing to migrate as normal. The proposed mixing zone-based operating limits and requirements to follow stipulate that Brayton Point Station abate the mixing zone sufficiently in magnitude and for the duration needed to prevent striped bass from wintering-over in the mixing zone. Compliance with this requirement could result in complete mixing zone abatement and ultimate compliance with the Massachusetts Surface Water Quality Standards, 314 CMR 4.05(4)(a) 2., temperature limits at the end of the Brayton Point Station discharge canal. The thermal plume that could continue to exist under such discharge conditions may continue to cause some fish to winter-over. MADEP reserves the right to further evaluate this issue and impose appropriate conditions as part of its s. 401 Water Quality Certification. The Massachusetts Surface Water Quality Standards in 314 CMR 4.00 and the requirements for mixing zones prohibit mixing zones from interfering with migration or free movement of fish or other aquatic life.

Acute Toxicity to Swimming and Drifting Organisms:

Ninety $(90)^0$F is a generally accepted acute toxicity temperature threshold. The Massachusetts Implementation Policy for Mixing Zones requires that in-zone water quality must be such that swimming and drifting organism can pass through the mixing zone without acute exposure to toxicants. Neither Thermistor data nor the 3-D hydrodynamic thermal model have shown any area beyond the immediate discharge to exceed 90^0F under current operating conditions. Mixing is rapid enough at the discharge terminus and Zone of Initial Dilution (ZID) that the maximum 95^0F discharge does not cause the 90^0F temperature threshold to persist much beyond the discharge canal nor in the mixing zone. Therefore, MA DEP has assumed continuation of the 95^0F maximum discharge limit for the Brayton Point discharge as part of its mixing zone determination.

Protection of Designated Uses and the Mount Hope Bay Biological Community:

Evaluation of model runs for the summer pelagic target temperature indicates that current operating conditions result in unacceptable temperatures in much of Mt. Hope Bay. The summer pelagic target temperature of 25^0C is met or exceeded for five days per month or more in 76% of the Mt. Hope Bay surface water volume and 40% of the Mt. Hope Bay middle depth water volume. (See Map No. 5). (In doing its evaluation of hydrodynamic model predictions for temperature suitability, MADEP determined five days or more per month to be an unacceptable duration in terms of Mt. Hope Bay exceeding target temperatures.) By comparison, under a potential 1.20 trillion BTUs thermal discharge, the volume that would meet or exceed the 25^0C target temperature for five days or more per month is reduced to less than 5% of the surface waters and less than 1% of the middle layers of Mt. Hope Bay. (See Map No. 6). The temperature maximum monitoring and mixing zone compliance requirements for the benthic layer will likely reduce further the areas that meet or exceed target temperatures in the middle and upper layers. It is important that biologically acceptable temperatures are protected, especially in the SA portions of Mt. Hope Bay, to assure the mixing zone does not diminish the existing or designated uses of Mt. Hope Bay's SA and SB waters disproportionately. SA waters are designated as excellent habitat for fish, aquatic life and wildlife.

Current operating conditions also result in approximately 75% of Mt. Hope Bay's bottom (benthic layer) meeting or exceeding the summer benthic target temperature of 24^0C for 5 days or more per month. An area that crosses the mouth of the Lee's River bank-to-bank also meets or exceeds the suboptimal temperature and water quality standard of 26.7^0C. (See Map No. 7). The proposed mixing zone includes benthic layer temperature monitoring and compliance to ensure the mixing zone does not negatively impact the 24^0C benthic layer target temperature in Mt. Hope Bay. Compliance with this requirement will eliminate the 26.7^0C (See Map No. 8). Compliance with the mixing zone temperature requirements are intended so that juvenile winter flounder do not avoid substantial areas of Mt. Hope Bay benthic layer during summer.

During warm winter operating conditions, the hydrodynamic thermal model predicts the majority of Mt. Hope Bay's benthic layer will meet or exceed the 5^0C winter benthic target temperature prior to the addition of heat for the Brayton Point Station discharge. Five degrees C is important for winter flounder egg survivability. For this reason, the mixing zone includes monitoring and mixing zone abatement requirements so that it does not negatively impact the 5^0C target temperature in the Mt. Hope Bay benthic layer.

V. SUMMARY:

The Brayton Point Station current thermal discharge causes a substantial volume of Mt. Hope Bay to exceed the Massachusetts Surface Water Quality Standards for temperature. The thermal discharge also causes substantial portions of Mt. Hope Bay to meet or exceed certain temperature maxima determined by MADEP as important to support certain sensitive species in Mt. Hope Bay, including winter flounder. Data from Marine Research Institute, University of Rhode Island and RIDEM have documented a dramatic decline in fish abundance in Mt. Hope Bay, including winter flounder and several other RIS species. At present a native, naturally diverse community does not appear to exist in Mt. Hope Bay.

The mixing zone-based thermal discharge limits and requirements along with the associated operating conditions would substantially reduce the volume of Mt. Hope Bay that exceeds the Massachusetts Surface Water Quality Standards for temperature. It would protect Zones of Passage and not negatively impact maintenance of acceptable temperatures for the biological community throughout the vast majority of Mt. Hope Bay waters. For these reasons, MADEP has determined that its mixing zone recommendation will help create an improved Mt. Hope Bay environment. These predicted changes to the Mt. Hope Bay environment should improve the opportunity for a return of a native, naturally diverse biological community to Mt. Hope Bay and would protect the existing and designated uses of Mt. Hope Bay. This determination is based on current information available and reviewed by MADEP. As new or other information becomes available pertaining to environmental conditions in Mt. Hope Bay and/or the impacts of the Brayton Point Station discharge on the Mt. Hope Bay source/receiving waters, MADEP may need to amend the mixing zone and associated permit limits appropriately and reserves the right to do so.

VI. PROPOSED MIXING ZONE AND PERMIT CONDITIONS:

The operating conditions necessary to meet the proposed mixing zone are described below and are proposed as waste heat discharge (BTU) permit limits and other temperature monitoring and compliance requirements. As discussed in the previous sections, there are many environmental performance standards that need to be met to protect the ecosystem of Mt. Hope Bay and meet Massachusetts Surface Water Quality Standards. For some time periods only thermal limits as measured in BTUs per a specified time period will set operational requirements. However, throughout many other times of the year, performance standards to: protect "Zone's of Passage"; allow for species migration; and/or protect various species eggs and larvae, among other variables, will dictate operational conditions for the facility.

The Brayton Point Station proposed cooling water discharge thermal mixing zone and the proposed permit limits and other requirements needed to comply with the mixing zone are as follows:

PROPOSED MIXING ZONE CONDITIONS:

1) The mixing zone shall be limited to an area or volume as small as feasible. The location, design and operation of the discharge shall minimize adverse impacts on aquatic life and other beneficial uses.

2) The mixing zone shall not interfere with the migration or free movement of fish or other aquatic life. There shall be safe and adequate passage for swimming and drifting organisms with no deleterious effects on their populations.

3) The mixing zone shall not create nuisance conditions, accumulate pollutants in sediments or biota in toxic amounts or otherwise diminish the existing or designated uses of the segment disproportionately.

4) The Massachusetts Surface Water Quality Standards for temperature may be exceeded within the mixing zone and the ZID so long as compliance is attained at the mixing zone boundary and provided that the in-zone water quality protects public health, protects aquatic life, prevents nuisance conditions, and allows swimming and drifting organism to pass through without acute exposure to toxicants.

5) The mixing zone is limited to 50 percent of the cross-sectional area and should not cover the surface from bank-to-bank of any receiving, bordering, adjacent, contiguous, or impacted river, estuary, bay, or embayment. This includes Mt. Hope Bay, the Taunton River, Cole's River, and Rhode Island's Kickamuit River, and includes the Lee's River, which may experience cross-sectional and/or bank-to-bank excursions of the 1.5^{o}F ÄT increase standard at times but for which specific temperature maxima limits have been set to maintain a Zone of Passage (see Lee's River Zone of Passage limits to follow and see Attachment No. 2).

6) The mixing zone may exist in a three dimensional volume of Mt. Hope Bay and adjoining waters beginning at the end of the discharge canal and moving with discharge flow and tidal influences within the Class SA and SB waters of Mt. Hope Bay and adjoining waters within Massachusetts and Rhode Island, such that it meets all the above-described mixing zone criteria.

7) Compliance with the mixing zone criteria will be achieved through compliance with the proposed discharge limits and mixing zone requirements set forth below.

PROPOSED MIXING ZONE PERMIT LIMITS AND REQUIREMENTS:

<u>Waste Heat Discharge Limits</u>:

1) A maximum monthly BTU discharge limit of 1.20 trillion BTUs per month shall not be exceeded during the months of November, December and January. The specific temperature maxima compliance and associated mixing zone and thermal discharge reduction requirements to follow shall preside for all other periods. Because meeting the more restrictive requirement that specific temperatures not be exceeded in the mixing zone will result in variable mixing zone size and thermal discharge quantities, other monthly and annual BTU limits are not included for those periods.

2) Brayton Point Station (the permittee) shall maintain accurate records of daily, weekly and monthly BTU discharge amounts available for inspection by MADEP at Brayton Point Station.

Requirements for the Lee's River Zone of Passage:

All temperature limits for various periods, as stated in this section, pertain to the Lee's River only and cannot be exceeded bank-to-bank across the Lee's River nor over 50% of the cross sectional area of the Lee's River. The temperature limits are based on protection migrating alewife.

If the temperatures identified below for each respective period are exceeded bank-to-bank and/or across 50% of the Lee's River cross sectional area, the Brayton Point Station mixing zone shall be abated until the temperatures are no longer exceeded for the period in question, or until the Massachusetts Surface Water Quality Standards, 314 CMR 4.05(4)(a) 2., for temperature are met at the end of the discharge canal, whichever occurs first. Should a final NPDES permit be issued that includes a mixing zone, within ninety (90) days of such a permit becoming final, the permittee shall develop and implement Best Management Practices (BMPs) acceptable to MADEP to comply with this mixing zone requirement.

1) April 1-May 14 (Adult spawning): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 18.30^{0}C (65^{0}F)

2) May 15-May 31 (Adult spawning): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 20.0^{0}C (68^{0}F)

3) June 1-June 7 (Adult spawning): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 21.10^{0}C (70 ^{0}F)

4) June 8-June 23 (Eggs): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 26.70^{0}C (80^{0}F)

5) June 24-July 7 (Larvae): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 27.90^{0}C (82.2^{0}F)

6) July 8-October 31 (Juveniles): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 28.90^{0}C (84.1^{0}F).

Compliance with the mixing zone, Lee's River Zone of Passage maintenance temperatures, shall be demonstrated using field monitoring acceptable to MA DEP or through a demonstration (approved by MA DEP) using the accepted 3-D hydrodynamic thermal model.

Requirements for Striped Bass Migration:

Mixing zones cannot interfere with the migration or free movement of fish or other aquatic life. During the October/November striped bass migratory period, the mixing zone will need to be abated such that it is dissipated sufficiently in magnitude and for the duration necessary to prevent striped bass from wintering-over in the mixing zone. Should a final NPDES permit be issued that includes a mixing zone, within ninety (90) days of such a permit becoming final, the permittee shall develop and implement BMPs acceptable to MADEP to comply with this mixing zone requirement. The BMPs should, at a minimum, address methods of determining striped bass migration periods from year to year, duration of mixing zone abatement, magnitude of mixing zone abatement, and methods of determining effectiveness of winter-over reduction efforts. Additionally, as part of such a NPDES Permit, the permittee should be required to submit a plan for approval detailing the measures to be taken each respective year the permit remains in force to ensure the Brayton Point Station mixing zone does not interrupt the annual striped bass migration.

Requirements for Prevention of Nuisance Species Proliferation:

The mixing zone should not exacerbate conditions leading to a proliferation of nuisance species in Mount Hope Bay (e.g., blue-green algae in the summer and ctenophores in the winter). Increased presence of nuisance species can negatively impact the native, naturally diverse community and protection of designated uses in Mt. Hope Bay. Should a final NPDES permit be issued that includes a mixing zone, within 90 days of that permit becoming final, the permittee shall submit a nuisance species monitoring and prevention plan acceptable to MADEP. The prevention plan should include a proposed BMP implementation in the event that monitoring shows proliferation of nuisance species attributed to, or exacerbated by, the Brayton Point Station thermal discharge.

Requirements for Benthic Layer Monitoring and Temperature Compliance:

Mixing zones need to protect aquatic life and designated uses. In order to be protective of the winter flounder population during spawning and growth there shall be a maximum benthic layer compliance temperature within the mixing zone during late winter/early spring (to protect egg survival and development) and in summer (to protect juvenile survival, development and to protect from temperature avoidance).

From February 1, to April 23, the mixing zone shall not cause the benthic layer water temperature to exceed 5.0^0C, the target temperature MADEP has determined to be acceptable for protection of winter flounder eggs survivability. Brayton Point Station monitoring data gathered beginning in 1973 and continuing through 1999 shows 90% larvae egg abundance is occurring from February 12 to April 23. Monitoring and compliance beginning February 1, will protect early larvae egg development.

At no time shall the mixing zone cause the benthic water temperature to exceed 24.0^0C. This is the temperature threshold at which juvenile winter flounder show avoidance. Accordingly, MADEP has determined this as the acceptable target temperature.

Monitoring of the benthic layer shall be accomplished by thermistor strings placed every 200 meters along three separate two kilometer long transects. Thermistors shall monitor the benthic layer on a continuous basis during the critical spawning and growth periods mentioned above. Each transect shall provide independent data sets based on an hourly average of all monitors (averaged together) along the transect. The data for each string will be used respectively to inform the decision to reduce the thermal mixing zone by reducing the thermal discharge if the above cited temperatures are exceeded along a particular string transect. The first transect shall run westerly from the thermal discharge canal to the MA/RI border in Mt. Hope Bay. The second transect shall run southerly from the discharge canal parallel to the dividing line separating the MA-SA and MA-SB waters. The third transect shall run easterly from the thermal discharge canal to the opposite bank of the Taunton River. The first thermistor for each transect shall be located 200 meters beyond the end of the discharge canal.

If the temperatures identified above in this section for each respective period are exceeded for any one hourly average of all data points (averaged together) on a respective monitoring transect, the Brayton Point Station mixing zone and thermal discharge shall be abated until the temperatures are no longer exceeded for the period in question, or until the Massachusetts Surface Water Quality Standards, 314 CMR 4.05(4)(a) 2., for temperature are met at the end of the discharge canal, whichever occurs first. Should a final NPDES permit be issued that includes a mixing zone, within ninety (90) days of such a permit becoming final, the permittee shall develop and implement BMPs acceptable to MADEP to comply with this mixing zone requirement.

Previous studies of the thermal discharge have shown a correlation between intake temperatures of the cooling water and ambient bay temperatures both mid water column and bottom temperature. It is expected that the permittee may be able to further document and correlate the relationship between intake temperature and benthic layer temperature. If it shows that intake temperature correlates to benthic layer temperature sufficiently to be used as representative monitoring, MADEP will evaluate possible amendments to the monitoring requirement accordingly. The station should consider using this continuous temperature information to supplement the proposed thermistor data in making thermal reduction decisions during critical times of the year if appropriate and approved by MADEP. MADEP will consider evaluation of alternative benthic layer monitoring should EPA or the permittee propose other means to monitor biologically important areas of the Mt. Hope Bay benthic layer.

Attachment No. 1
Maximum Critical Temperature Methodology
May 17, 2002

Basic Methodology

In order to assess the impacts of Brayton Point's thermal discharge on the Mount Hope Bay (MHB) fishery, a list of the Representative Important Species (RIS) in MHB was established. The Technical Advisory Committee (TAC) and the Company looked at the list of species impacted by Brayton Point Station in the highest abundances. Species were also evaluated that are known to inhabit certain general habitats (e.g., benthic and pelagic) within MHB based upon trawl surveys. This latter list included winter flounder, windowpane flounder, blue mussel, quahog, and eelgrass as important benthic species. white perch, atlantic silverside, river herring, striped bass, bay anchovy, and threespine stickleback were identified as important pelagic species.

From the literature, the Company and the TAC identified critical temperatures for life stages of the species listed above. Critical temperatures are those temperatures that were identified as lethal to the individual, produced avoidance behavior in mobile life stages, or were the maximum or median tolerance temperatures for an individual ("tolerance" being the state before avoidance was elicited). Time periods were identified during which each benthic and pelagic life stage was expected to be present. Best professional judgment was used to determine which studies to include in this effort, as scientific literature does not replicate all of the conditions in Mt. Hope Bay.

The time periods identified by the TAC were used by Applied Sciences Associates (ASA), a consultant to PG&E National Energy Group, to help generate general "seasons" of importance for the purpose of modeling the thermal impact of Brayton Point Station on MHB. ASA characterized "Winter/Spring" as March 1-March 31 (roughly corresponding to the period of winter flounder egg and larval production and development in MHB as well as peak abundances of seaboard goby, white perch, threespine stickleback, and rainbow smelt). "Summer" was defined as July 15-August 12, corresponding to the time period when MHB temperatures were expected to be highest and when a number of species (winter flounder juveniles, tautog, hogchoker, bay anchovy, quahog, blue mussel, scup, seaboard goby, weakfish, bluefish, striped bass, atlantic silverside, and white perch, and eelgrass) are expected to be at or near peak abundance. "Fall" was identified as November 1-28 (corresponding to a period of return of winter flounder adults to MHB, as well as a period of out-migration for juvenile bluefish and menhaden). For the sake of consistency, these seasons were used, in part, as the time periods of interest for evaluating critical temperatures for RIS in MHB.

It is important to note that critical temperatures, as metrics of biological health, only represent physiological limits (tolerances) at the level of the individual life stage. There has been no investigation on how temperature affects trophic interactions (e.g., predator/prey dynamics), long-term reproductive success of individuals, or long-term fitness of individuals.

Critical Temperatures

For most species evaluated, there was no one critical temperature, rather, there was a range of critical temperatures. Part of the reason for this is that critical temperatures are dependent upon the acclimation temperature of the individual. When confronted with a range of critical temperatures, temperatures were chosen that were determined to be as close as possible to highest expected ambient temperature (without the facility) in MHB during the season of interest. For example, benthic temperatures in Winter/Spring in MHB are 2.1-5.7ºC near Spar Island, supposedly out of range of the thermal plume at bottom. Only studies using acclimation temperatures within this range were used to determine critical temperatures for benthic species in Winter/Spring.

Even after this attempt to identify a single critical temperature, there often was a range of temperatures from which to choose. In general, the TAC attempted to choose critical temperatures that were likely to be protective of the species.

After creating tables of overlapping critical temperatures for a number of species, the TAC selected the limiting temperature for each "season" for both benthic and pelagic habitats. As new information becomes available, it may be necessary to revise these values.

Critical Temperatures Used for Additional Hydrothermal Modeling Runs

After the Biological Modeling subcommittee of the TAC had presented a preliminary set of critical temperatures to the full committee, several agency members including DEP, EPA, CZM, and DMF met to identify the critical temperatures that were considered "no-effect", "sub-optimal", and having "acute" effects in relation to biological activities. These temperatures were used in a request to the Company for additional modeling runs (which the Company reported in a October 1, 2001 letter to Phil Colarusso of EPA).

"No-effect" temperatures were defined as those under which there were no observable negative effects from temperature. "Sub-optimal" temperatures were those under which fish or other life stages experienced some form of stress in the form of reduced survivorship, reduced growth, or elicited avoidance behavior. Temperatures that were considered having "acute" effects were those that induced 50% or greater mortality.

A fourth category of critical temperatures is included in this review, termed "target temperatures". These temperatures either are, or may be, slightly higher than "no-effect" temperatures. Reasons for using this term are different in each of the four cases where it is used and are explained below.

The table below summarizes the critical temperatures (in degrees C) that EPA included in its request to the Company for additional hydrothermal modeling runs. Subsequent review by agency TAC members provided further clarification regarding the categorization of each temperature value:

	SUMMER (degrees C)	WINTER (degrees C)
BENTHIC (bottom)	24(t), 26.7(so), 29.4(a)	5(t), 10(so), 15(a)
PELAGIC (water column)	25(ne/t), 29.4(a)	8(t), 10(so), 12(a)

t: target temperature
ne: no-effect temperature
so: sub-optimal temperature
a: acute temperature

SUMMER (July 15-August 15)

Benthic

Juvenile winter flounder was flagged as the species/life stage with the lowest critical temperature for species on the bottom during the summer. All three critical summer benthic temperatures were based on this species. Duffy and Luders (1978) found that winter flounder juveniles acclimated to 14°C and 20°C avoided areas that were 24.5 and 24.9°C, respectively. Recent data compiled by Gibson (pers. comm.) for two stations in Narragansett Bay show that YOY flounder vacated habitats when the temperature reached between 24 and 25°C. Based on this information, the **target temperature** was determined to be **24° C**. This temperature may be high because Grace Klein-MacPhee (pers. comm.) stated that sub-lethal effects begin at 20°C and that feeding inhibition and avoidance are evident at 24°C. Hoff and Westmann (1966) found that juvenile winter flounder acclimated at 14°C, suffer 50% mortality after experiencing 24°C for 48 hours; however, 14°C is probably lower than the ambient temperature for the time period used in the modeling.

The sub-optimal temperature, **26.7° C** (80°F) is also the Massachusetts Water Quality standard for Maximum Daily Mean temperature for SA and SB waters. It was chosen because feeding inhibition (Radle 1971) and avoidance (Casterlin and Reynolds 1982) of juvenile winter flounder are evident at temperatures between 24 and 27°C.

The acute temperature for juvenile winter flounder was determined to be **29.4° C** based upon Hoff and Westmann (1966) who found that juveniles acclimated at 28 C had 50% mortality after 48 hours at 29.3°C. In addition, Casterlin and Reynolds (1982) referred to 29°C as the point of heat-death. Modeling was done at 29.4°C, which was determined to sufficiently represent the area of Mt. Hope Bay experiencing 29°C and corresponded with 85°F, the Massachusetts Water Quality Standard for maximum allowable water temperature in Class SA and SB waters.

Pelagic

The sensitive species identified for summer conditions in the pelagic layer was striped bass. According to Coutant and Benson (1990), older sub-adults and adults tend to avoid temperatures above about 25°C when cooler water is available. In addition, striped bass in river systems have suffered or experienced direct mortality when fish cannot find refuge areas when the water temperature exceeds about 29°C (Coutant and Benson 1990). The **no-effect level,** above which avoidance was elicited, was chosen as **25°C**. Twenty-five degrees C (**25°C**) was also selected as the target temperature for the pelagic layer during this period. The **acute level** chosen was **29°C**. No sub-optimal temperature was chosen.

WINTER (March 1-March 31)

Benthic

Winter flounder eggs had the limiting critical temperatures. The **target temperature** for eggs was chosen as **5°C**. Dr. Grace Klein-MacPhee (pers. comm.) recommended that 3-5°C was appropriate for egg hatching, with 3°C being optimal. Rogers (1976) found that 3°C resulted in 100% viability of eggs, with 5°C producing 83.5 % viability. Keller and Klein-MacPhee (2000) found significantly-reduced hatching success in test mesocosms that had an average temperature of 5.1°C (range: 2.9-8.3°C) when compared to those that had a mean of 1.86°C (range: -0.1-3.7°C). The TAC chose 5°C as a target because ambient temperatures in the bay during the winter period average only slightly below this value. Temperatures at Spar Island range from 2.1 to 5.7°C with an arithmetic mean of 4.0°C.

A **sub-optimal** winter flounder egg temperature was determined to be **10°C** based upon Rogers (1976) who found that 10°C resulted in 50% viability of eggs. In addition, winter flounder eggs in the wild have been reported at water temperatures up to 10°C (Scarlett 1998; Lee et al. 1997).

At **15°C**, winter flounder eggs experienced 100% mortality (Rogers 1976); this was chosen as the **acute** temperature.

Pelagic

Winter flounder larvae had the limiting critical temperatures. Grace Klein-MacPhee (pers. comm.) stated that survival and condition of larvae (post-hatch, to about 3-4 weeks) is best at 8°C, but that larvae tolerate up to 12°C. She recommended temperatures less than or equal to 10°C as the temperature range not to be exceeded for the larvae from March to mid-April; beyond mid-April the metamorphosing larvae can tolerate higher temperatures. The agencies chose **8° C** as the **target** value, **10° C** as **sub-optimal** and **12° C** as not suitable (i.e., **acute**).

Attachment No. 2
Temperature Considerations for Alewives in the Lee's River

Background:

The Lee's River runs into Mt. Hope Bay between Somerset and Swansea in the Narragansett Bay drainage. Total river length of the Lee's River is a little over six miles. Currently, a small population of alewives is known to spawn in the Lee River. Two impoundments (total area about 16 acres) exist where alewives could potentially spawn although they cannot now access these ponds due to the presence of dams. Alewives are probably reproducing in the river section (less than ½ mile in length) below the first dam. Brayton Point electrogenerating station has an intake on the Lee's River. Its discharge on the east bank of the river drifts across to the west bank. The plume may, on incoming tides, partially move away from the Lee River entrance, providing a temporal window during which adults and juveniles may proceed upstream or downstream with limited interference from the plume.

About 25 years prior to Brayton Point operations in Mt. Hope Bay, a MA Division of Fisheries and Game, Department of Conservation report (MADF&G, no publishing date available) gave the following assessment of the Lee's River fishery:

> "Lee's River is little more than an arm of Mount Hope Bay, in which a few alewives are occasionally taken. Owing to lack of spawning ponds the fishery never has been and never will be of any importance."

The Final Completion Report Anadromous Fish Project prepared by the Massachusetts Division of Marine Fisheries, Project Title: "Anadromous Fish Investigations" July 1, 1969 to June 30, 1970, evaluated the potential of the Lee's River and Taunton River to support spawning anadromous fish runs. Regarding the Lee's River, the report concluded in part, "Because of limited spawning area available above the dams, an important fishery could not be developed and will be limited to alewives that are reported to spawn in tidal waters below the first dam."

According to Phillips Brady (pers. com., 10/23/2001), anadromous fish biologist for the Division of Marine Fisheries, because of the limited spawning area available, it would be difficult to develop a river herring fishery (alewives and blueback herring) of any import in the Lee's River. Even if fishways were installed around the dams, because of the total acreage of the ponds, there is still very limited potential for development of a spawning run.

Alewife Temperature Tolerance Data

The information provided below should be considered for the Lee's River and is consistant with the information and the evaluation approach being used for other Massachusetts permit reviews.

In many alewife runs in Massachusetts and New Hampshire, adult fish stop moving into freshwater by the time ambient temperatures reach 65 to 68°F (see "data from some river herring runs in MA and NH" to follow). Above these temperatures, certain stocks have been known to avoid entering the spawning run. Alewife runs typically occur in April and May. The majority of fish are known to run between 2:00 and 6:00 pm. A heated discharge at the mouth of the stream used for spawning may induce adults to stop their run. After spawning, adults returning to the sea may suffer from cold shock if they spend much time in the heated plume from the Brayton Point effluent prior to moving into the colder waters of the bay. Otto, et al. (1976) found that 30% of adult alewives acclimated to 21 °C (69.8 °F), died at a test temperature of 10.5 °C (50.9°F) when abruptly exposed. So, a 10.5 °C (about 19 °F) delta temperature from warm to cold could be acutely toxic or could render adults more susceptible to attack by predators.

Alewife larvae (<20-25 mm) drifting into the plume from upstream will experience rising temperatures as they enter the plume. The lowest observable acute effect level (LOAEL-about 5% mortality in this test) for yolk-sac larvae acclimated at 20 °C (68 °F) in a 24-hr exposure was 27.9 °C (82.3 °F) (see E.A., 1978).

Young of the year alewives (juveniles) swimming downstream through the plume can also suffer from excessive heat exposure. The 1-hr and 24-hr TL05s of young-of-the year alewives (mean length = 80 mm), acclimated to 23 °C (73.4 °F) were 31.1 and 29.3 °C (88 and 84.7 °F). Otto, et al. (1976), arrived at a similar figure (LOAEL of 30 °C [86 °F]) for young-of-the year acclimated to temperatures of 24-26 °C (75.2-78.8 °F).

Considerations for the Lee's River:

The MA Mixing Zone Policy states that there should be no acute toxicity in the mixing zone and that a zone of passage ½ the cross-sectional area of the waterbody should be maintained. Lowest effect levels from 24-hr tests were used in this document so that for shorter exposures, no adverse effects should accrue to exposed individuals. Following are the recommended maximum temperatures for Lee's River Zone of Passage maintenance for the time periods important for migration and spawning, egg and larval survivability, and juvenile development and non-avoidance:

Zone of Passage:

1) April 1-May 14 (Adult spawning): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 18.3^0C (65^0F)

2) May 15-May 31 (Adult spawning): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 20^0C (68^0F)

3) June 1-June 7 (Adult spawning): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 21.1^0C (70 ^{0}F)

4) June 8-June 23 (Eggs): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 26.7^0C (80^0F)

5) June 24-July 7 (Larvae): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 27.9^0C (82.2^0F)

6) July 8-October 31 (Juveniles): The Lee's River water temperature maximum shall not equal or exceed an hourly average of 28.9^0C (84.1^0F).

Literature Cited:

Ecological Analysts (E.A.), Inc. 1978. Hudson River Thermal effects, studies for representative species, Final Report. Prepared for Central Hudson Gas & Electric Corporation. 19 p.

MA Division of Fisheries and Game. 1937?. A report upon the alewife fisheries of Massachusetts. Department of Conservation 1M-6-64-938500.

Otto, R.G., M.A. Kitchel and J.O. Rice. 1976. Lethal and preferred temperatures of the alewife (*Alosa pseudoharengus*) in Lake Michigan. Trans. Am. Fish Soc., Vol. 1, 96-106.

Attachment 2 (continued)
Data from some River Herring Runs in MA and NH

Alewife Data

Monument River, Bourndale, Massachusetts

· **Alewife Data Only**

Year	Highest River Temperature Reached by end of Run		Day of Year at end of Run
	°C	°F	
1990	17.8	64	155
1991	18.9	66	147
1992	18.3	65	152
1993	18.5	65	144
1994	18	64	144
1995	20	68	155
1996	21	70	147
1997	14	57	148
1998	21	70	146

Parker River, Massachusetts 1997 – 2001

- **Alewife Run:** 99% of Fish Passed by 65°F; data from all years combined

Lamprey River, New Hampshire

· **Alewife Run**

Year Run	Max Temp, 95% Completed Run		Max. Temp. 99% Completed	
	°C	°F	°C	°F
2000	19	66	19	66
1999	---	--	19.5	67

Blueback Data

Taylor River, New Hampshire

Year Completed	Max Temp, 95% Run Completed		Max. Temp. 99% Run	
	°C	°F	°C	°F
1999	22.5	73	26	79

Oyster River, New Hampshire

Blueback Run

Year Completed	Max Temp, 95% Run Completed		Max. Temp. 99% Run	
	°C	°F	°C	°F
1999	20	68	22.5	73

Mixed Species (Blueback and Alewife) Data

Cocheco River, New Hampshire

Year Completed	Max Temp, 95% Run Completed		Max. Temp. 99% Run	
	°C	°F	°C	°F
2000	18	64	19	66
1999	23	73	24.5	76
1998	21.5	71	22	72
1997	22	72	23.5	74

Exeter River, New Hampshire

Year Run	Max Temp, 95% Run Completed		Max. Temp. 99% Completed	
	°C	°F	°C	°F
2000	19	66	19	66
1999	20.5	69	23.5	74
1998	22	72	23.5	74
1997	22.5	73	24	75

Merrimack River, Massachusetts

Year	Max. Temp @ Bulk of Run Complete and %	Max Temp. 95% Completed Run	Max. Temp 99% Completed Run
1983	64°F (85%)	78°F	79°F
1984		71°F	71°F
1985		73.5°F	73.5°F
1986	58°F	72°F	72°
1987		69°F	74°F

Merrimack River, Massachusetts (continued)

reached Year Completed	Max. Temp Reached when Bulk of of RunComplete	Max Temp. reached 95% Run Completed	Max. Temp. 99% Run
1988	64°F	62°F	66°F
1989	66°F	66°F	69°F
1990		66°F	68°F
1991		74°F	75°F
1992		66°F	68°F
1993	65°F	65°F	65°F
1994	64°F	64°F	64°F
1995	64°F	64°F	64°F
1996	64°F	64°F	64°F
1997	56°F	56°F	70°F
1998	59°F	64°F	70°F
1999	65°F	65°F	67°F
2000	64°F	64°F	64°F

Other information on Merrimack Data:

During the 1991 migration, alewives were reported to have come up the fish lift at the Essex dam at temperatures up to 75°F. As the dam is 26 miles upstream of the mouth of the Merrimack, the river temperature at which alewives enter the system is unknown.

Attachment No. 3
May 17, 2002

Brayton Point Station Discharge Impacts on Mount Hope Bay and Mixing Zone Requirement

This memorandum is prepared as a background briefing regarding the impacts of the Brayton Point Station discharge on Mount Hope Bay, and the Massachusetts Mixing Zone requirements under the Massachusetts Surface Water Quality Standards. MADEP prepared this material with the assistance of Rhode Island Department of Environmental Management, Massachusetts Division of Marine Fisheries, and Massachusetts Coastal Zone Management.

Background:

Brayton Point is a 1600 megawatt electric generating facility located in Somerset, Massachusetts and owned by PG&E National Energy Group USGen New England, Inc. The facility is primarily fired by coal, but also burns some natural gas and burns primarily oil in one unit. First constructed in 1963, the facility is currently comprised of four boiler units. Boiler Units 1, 2 and 3 use water taken from the Taunton River for open-cycle, once-through cooling. Boiler Unit 4 either uses the same Taunton River water or uses water taken from the Lee's River for open-cycle, once-through cooling.

The facility is permitted to discharge up to 1.45 billion gallons per day (BGD) of heated wastewater to Mt. Hope Bay under the most recent, joint EPA/MADEP NPDES permit, issued in 1993. The permit sets a 95°F maximum discharge temperature and a maximum temperature increase (ΔT) of 22°F across the intake and discharge points. The permit includes a Section 316(a) Variance from Massachusetts Water Quality Standards, issued in 1985 that among other things allowed Unit 4 to change from a closed-cycle cooling system to an open-cycle cooling system. To support the variance request, the permittee submitted documentation that predicted the impact of the proposed permit limits on the temperature distribution and aquatic community in Mt. Hope Bay. Included with this material were predictions of the thermal plume that would result from Brayton Point discharging 1.267 BGD, with a ΔT of 16°F, a discharge temperature of 93°F and under high intake temperature conditions experienced on July 29, 1975. The predicted maximum extent of the "1°F rise over background" thermal plume, under a variety of tidal conditions, anticipated a southerly extent reaching approximately 60% of the distance from Brayton Point to the Massachusetts/Rhode Island state line and occupying a maximum area of 451 acres. The discharge was expected to raise the temperature at the mouth of the Lee's River by less than 1°F. Recent monitoring and modeling data has demonstrated the variance request supporting data significantly under predicted the size, temperature, extent and impact of the Brayton Point thermal plume. Brayton Point's current thermal discharge plume, exceeding 1.5°F rise over background, occupies an average area of approximately 5,800 acres and extends into Rhode Island waters.

The 1993 permit expired in 1998 and is under review by EPA and MADEP for re-permitting. The expired permit remains in force during permit review. Since 1997, Brayton Point has operated under the conditions of a Memorandum of Agreement that limits waste heat discharge and discharge volume to levels below what the 1993 NPDES permit limits and operating conditions would allow.

At the time of initial application submittal on January 15, 1998, Brayton Point did not include a request for a new 316(a) Variance from the Massachusetts Surface Water Quality Standards as part of its NPDES permit application. PG&E National Energy Group USGen New England, Inc. did, at a later date, make a 316(a) variance request to EPA as part of their NPDES re-permit application. EPA is currently reviewing the 316(a) variance request as part of its Brayton Point Station NPDES re-permit review. MADEP with assistance from EPA, RI DEM, MADMF, and MACZM has as part of its permit review sought to determine potential NPDES permit limits that would meet the Massachusetts Surface Water Quality Standards and its mixing zone requirements.

Massachusetts Surface Water Quality Standards and Mt. Hope Bay Waters

Massachusetts established its Surface Water Quality Standards by regulations found at 314 CMR 4.00. The purpose of the Water Quality Standards is to assist Massachusetts in meeting the objective of the Federal Clean Waters Act for the restoration and maintenance of the chemical, physical, and biological integrity of the nation's waters. In addition to those regulations, MADEP uses the January 8, 1993, policy "Implementation Policy for Mixing Zones" and the June 9, 1992 Warren A. Kimball "Memorandum for the Record, Subject: Thermal Discharge/NPDES Review" to assist in making Water Quality Standards compliance determinations. The June 9, 1992 Warren A. Kimball Memorandum addresses thermal discharges to inland waters and therefore, for the most part, does not directly apply to the Mt. Hope Bay receiving waters for Brayton's discharge. Much of Mr. Kimball's memorandum focuses on establishment of specific temperature criteria for inland warm waters, cold waters and lakes. These criteria were based on evaluation of the temperature sensitivities of resident fish populations in the inland warm waters, cold waters and lakes subject to the memorandum. The memorandum does not address establishment of specific temperature criteria for marine environments like Mt. Hope Bay. Mr. Kimball's memorandum does, however, along with the January 8, 1993 Implementation Policy for Mixing Zones, provide guidance pertaining to maintaining Zones of Passage for anadromous and catadromous species as required by 314 CMR 4.00. Both recommend maintaining 50% of the cross sectional area of a water body with a mixing zone. These recommendations were developed to provide a safety factor for adequate passage and were not developed as a result of scientific testing regarding specific species requirements for Zone of Passage adequacy. The Implementation Policy for Mixing Zones, among other things, also stipulates that mixing zones not have acute exposure to toxicants for swimming and drifting organisms passing through the mixing zone.

Mt. Hope Bay is a saline coastal embayment that serves as the ultimate discharge basin for the Taunton River, Lee's River, Cole's River and Rhode Island's Kickamuit River systems. The Bay is tidally influenced from Rhode Island's Sakonnet River [Passage] and Narragansett Bay. Flushing, mixing and turnover are influenced by river flows, tidal action and Bay configuration. Two thirds of Mt. Hope Bay is in Rhode Island, one third is in Massachusetts. The Mt. Hope Bay waters within Massachusetts' jurisdiction are classified as either Coastal and Marine class SA waters or class SB waters. The Lee's River side of the Bay is class SA waters. The Taunton River side of the Bay is designated as class SB waters. The Massachusetts Surface Water Quality Standard regulations at 314 CMR 4.05(4) describe the criteria for the SA and SB waters classes.

> Class SA waters are designated as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfish Areas). These waters shall have excellent aesthetic value.
>
> Temperature shall not exceed 85°F (29.4°C) nor a maximum daily mean of 80°F (26.7°C), and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C): natural seasonal and daily variations shall be maintained, there shall be no change from background that would impair any uses assigned to this class including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.
>
> Class SB waters are designated as a habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting with depuration (Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.
>
> Temperature shall not exceed 85°F (29.4°C) nor a maximum daily mean of 80°F (26.7°C), and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C) during the summer months (July through September) nor 4°F (2.2°C) during the winter months (October through June); natural seasonal and daily variations shall be maintained; there shall be no changes from background that would impair any uses assigned to this class including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

Mixing Zones

In accordance with 314 CMR 4.03(2), when applying the Massachusetts Surface Water Quality Standards MADEP may recognize a limited area or volume of a water body as a mixing zone for the initial dilution of a discharge. The 1993 Implementation Policy for Mixing Zones distinguishes between the Zone of Initial Dilution (ZID) and the mixing zones as follows:

ZID – Initial dilution is the process that results in the rapid and irreversible turbulent mixing of the wastewater with the receiving water around the point of discharge. Initial dilution is considered complete when the momentum induced velocity of the discharge ceases to produce significant mixing of the wastewater.

Mixing Zone – Complete mixing occurs when the concentrations of pollutants within a waterbody reach a uniform concentration. This is accomplished by advection and dispersion. The use of this portion of the receiving water as a mixing zone needs to be justified by applying the following antidegradation considerations:

1. No less environmentally damaging alternative site for the activity, source for disposal, or method of elimination of the discharge is reasonably available or feasible;

2. To the maximum extent feasible the discharge or activity is designed and conducted to minimize the size and shape of the mixing zone; and

3. The mixing zone will not impair the integrity of the waterbody as a whole, including the existing and designated uses.

Waters within a mixing zone may fail to meet specific water quality criteria provided the following conditions are met:

(a) Mixing zones shall be limited to an area or volume as small as feasible. The location, design and operation of the discharge shall minimize impacts on aquatic life and other beneficial uses.
(b) Mixing zones shall not interfere with the migration or free movement of fish or other aquatic life. There shall be safe and adequate passage for swimming and drifting organisms with no deleterious effects on their populations.
(c) Mixing zones shall not create nuisance conditions, accumulate pollutants in sediments or biota in toxic amounts or otherwise diminish the existing or designated uses of the segment disproportionally.

The Implementation Policy for Mixing Zones provides guidance on the Location of Mixing Zones, Zones of Passage, and Protection of Aquatic Life as follows:

Location of Mixing Zones

Mixing Zones are permitted at the discretion of the division (MA DEP). Mixing zones are not appropriate in areas with critical water uses or where it is necessary to maintain a zone of passage.

Zone of Passage

Mixing zones should not impair the passage and free movement of migrating organisms. Water bodies that serve as anadromous or catadromous fish runs may need at least a portion of the water body free from mixing zones in order to assure safe passage. Even if the in-zone quality of the mixing zone is high enough to prevent toxic effects, mixing zones may cause attraction or avoidance responses in migrating fish. Either response may serve as an effective barrier to migration.

When zone of passage is an issue, at least half of a water body's area or volume should remain free from mixing zones. If mixing zones are allowed they should not occur on alternating banks of a river for this may form a barrier to migration even though half of a water body remains open. Generally, shore-hugging plumes should be avoided because food and cover for migrating fish are more likely to occur near the shoreline of a water body.

With respect to zones of passage as they pertain to periods of fish migration, since 1992, DEP has interpreted the phrase "at least half of a water body's area or volume" as outlined in Mr. Kimball's thermal mixing zone memorandum: "the mixing zone shall not exceed 50% of the cross-sectional area nor 50% of the surface distance from bank to bank of the receiving water". Mr. Kimball's memorandum, however, also provides that, "At dilutions less than these a site specific study must be used to ensure adequate zone of passage. Some professional judgement can be used here if there is some knowledge of the aquatic resources. It is recommended that at a minimum, a site specific study demonstrating adequate zone of passage requirement be conducted for all anadromous and catadromous fish runs. It is further recommended that 50 percent of the volume and 50 percent of the surface area from bank to bank be excluded from the mixing zone unless expert advise of a fisheries biologist is available for the specific case." This guidance was developed in part from the U.S. EPA publication entitled, "Technical Support Document for Water Quality-Based Toxics Control."

The Final Completion Report Anadromous Fish Project prepared by the Massachusetts Division of Marine Fisheries, Project Title: "Anadromous Fish Investigations" July 1, 1969 to June 30, 1970, evaluated the potential of the Lee's River and Taunton River to support spawning anadromous fish runs. Regarding the Lee's River, the report concluded in part, "Because of limited spawning area available above the dams, an important fishery could not be developed and will be limited to alewives that are reported to spawn in tidal waters below the first dam." Regarding the Taunton River, the report concluded in part, "The Taunton River drainage system is one of the largest watersheds in the Commonwealth. With its large, unimpounded main system, many tributaries and numerous headwater ponds, it offers potential for many species of anadromous fish."

The Lee's River provides limited habitat area and although there are a variety of species present in the Lee's River at different times, in terms of anadromous and catadromous fish runs, only the alewife uses the Lee's River in any applicable amount. The Taunton River serves as an anadromous fish spawning run for blueback herring, alewives, rainbow smelt, white perch, american shad, hickory shad and atlantic sturgeon (an endangered species in Massachusetts). Striped bass are also found in the Taunton River but it is not known the degree to which this species uses the river for spawning. American eel, a catadromous species, is also found in the Taunton River drainage basin.

Protection of Aquatic Life

314 CMR 4.02 defines Aquatic Life as, "A native, naturally diverse, community of aquatic flora and fauna." Aquatic life often becomes the governing concern with determining the in-zone water quality of mixing zones. In this regard the aquatic community can be divided into:

1. Non-mobile and sessile benthic organisms;
2. Swimming and drifting organisms.

To protect populations of non-mobile and sessile benthic organisms the habitat exposed to the mixing zone must be minimized and critical habitats must be avoided. The organisms within a mixing zone may experience severe damage to individuals, including lethality, because chronic criteria can be exceeded. A mixing zone may represent a living space denied these organisms. Therefore a mixing zone must be located and sized such that any loss is not significant to the biological community of the receiving water segment.

To protect swimming and drifting organisms the in-zone quality must be such that these organisms can pass through the mixing zone without acute exposure to toxicants.

Antidegradation Provisions

314 CMR 4.04 requires protection of existing uses and states in part, "in all cases existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected."

Aquatic Life in Mount Hope Bay

As part of Brayton Point's NPDES permit, the permittee has maintained a field sampling program for the Mt. Hope Bay source/receiving waters. Among other things, this program consists of ongoing trawl surveys to track finfish distribution and abundance. Evaluation of trawl survey data indicated that in the mid-1980s a dramatic decline in four of the Representative Important Species (RIS) populations of finfish (winter flounder, windowpane, tautog and hogchoker) occurred in Mt. Hope Bay. Although there were also declines in some of these species in greater Narragansett Bay, declines in Mt. Hope Bay were shown to be significantly greater (statistically). These declines represent a virtual collapse of these four groundfish populations in Mt. Hope Bay. No meaningful recovery has yet to occur. Reductions in abundance were also observed in other Representative Important Species (RIS) including both demersal and pelagic components of the finfish assemblages in Mt. Hope Bay. The data strongly suggest that the Mt. Hope

Bay production system has been compromised. This fishery collapse was documented in1996 by Dr. Mark Gibson in his report entitled, "Comparison of Trends in Finfish Assemblage of Mt. Hope Bay and Narragansett Bay in Relation to the Operations at the New England Power Brayton Point Station". Among other things, this report found, "…an unprecedented loss of species diversity cutting across life histories, strategies, exploitation rates, and migratory behaviors argues for a powerful local agent of stress that fits Brayton Point Station." The severe disruption in the relative abundance of major fish stocks continues to date and the community in Mt. Hope Bay has not yet recovered. Additional evaluation of the data set beginning in 1972 indicated that a decline in relative abundance was already occurring in the 1972 to mid-1980's period, before the mid-1980's collapse. Based on the information above, there does not currently exist a balanced, indigenous community of fish within Mt. Hope Bay. Dr. Gibson's report was reviewed by biologists from several state and federal agencies as well as members of the Brayton Point Station NPDES permit Technical Advisory Committee and unaffiliated outside peer reviewers, all of whom generally supported Dr. Gibson's final conclusions.

Brayton Point's Impact on Mt. Hope Bay and Measures Taken to Minimize Impact

Brayton Point's annual average daily cooling water withdrawal is approximately .98 BGD. Primarily, this water is taken from the lower Taunton River and at times from the Lee's River, and is pumped through the facility to cool its steam condensers. After the cooling water has been pumped once through the plant to cool the condensers, the approximately .98 BGD of resulting heated wastewater is discharged along with other facility-generated treated wastewater to Mt. Hope Bay. This average daily cooling water throughput equates to the Bay's entire low tide volume going through Brayton Point's cooling apparatus every 54 days. The plant represents that largest volume input to Mt. Hope Bay. The .98 BGD throughput is nearly three times the annual mean daily discharge of the Taunton River, which is the largest fresh water source to the Bay. The plant discharge is highest during the summer months, when the discharge of the Taunton River is at its lowest. During the month of August, the plant daily discharge is slightly more than ten times the daily discharge of the Taunton River. The most significant impacts from Brayton Point's utilization and discharge of cooling water include habitat degradation as a result of waste heat load (measured in British Thermal Units [BTUs]) discharges to the Bay and entrainment and impingement mortalities from water withdrawals using open-cycle, once-through cooling.

The location of the Brayton facility in Narragansett Bay minimizes the ability of the local environment to disperse plant thermal loadings in a number of respects. Mt. Hope Bay is a relatively enclosed sub-embayment located at the head of eastern Narragansett Bay. Exchange with other areas of Narragansett Bay is restricted to flow through two openings, and the passage connecting to the Sakonnet River is quite restricted. The constrained nature of the openings reduces the potential for exchange with the remainder of Narragansett Bay and the Atlantic Ocean and the moderation of thermal impacts. Surface temperature remote sensing data shows the Brayton Point thermal discharge plume and has revealed Mt. Hope Bay to be elevated in temperature compared to other similar embayments in Narragansett Bay.

Brayton Point's waste heat discharge increases the temperature of Mt. Hope Bay waters, primarily degrading the habitat in two ways. First, as water temperature increases, water's ability to maintain dissolved oxygen levels necessary to sustain suitable habitat decreases. Other sources of pollution (mainly nutrient loading from various point and non-point sources) to the Bay also negatively impact dissolved oxygen levels. Increased Bay water temperature within the Brayton Point thermal plume therefore exacerbates the problems associated with low dissolved oxygen levels in the Bay. Second, finfish and other species have limited tolerances to increased water temperature. Finfish can sense small changes in temperature and the juvenile and adult life stages will avoid areas that abruptly exceed surrounding temperature areas or that exceed certain temperature maximums. Sessile and drifting life stages and organisms are particularly vulnerable to temperature impacts and are more likely to suffer lethal impacts. Mt. Hope Bay is approximately 13.6 square miles in area and averages approximately 16.5 feet in depth. Brayton Point's hydrodynamic thermal modeling of the Brayton Point current (MOA II operating conditions) heat plume shows that during warm summer conditions it exceeds both Massachusetts and Rhode Island Surface Water Quality Standards for summer in over 70% of Mt. Hope Bay waters.

Four Tributaries, the Taunton, Kickamuit, Cole's and Lee's Rivers, discharge to the northern shore of Mt. Hope Bay. The Brayton Point Station discharges from a location where its heated effluent can adversely impact animal communities in each of these tributaries. Thermal data and model predictions conducted by PG&E show that current and historic plant heated effluent emissions cause exceedances of temperature and temperature difference standards at the entrances to these tributaries, thus impacting the movements of migrating and pelagic fish and the suitability of these rivers as spawning habitat.

Brayton Point's withdrawal of approximately one billion gallons of once-through, condenser cooling water per day entrains biota within the plant's cooling system and impinges larger biota on the plant's intake structures. Entrainment and impingement often results in mortality or induces chronic effects that reduce survival or the ability to reproduce. Entrainment of finfish eggs and larvae increases the mortality rate of these early life stages. Eggs and larvae entrained in the plant's cooling system can experience mortality rates of up to 100%. Decreased survival of eggs and larvae can lead to a reduction in spawning stocks in Mt. Hope Bay.

In April 1997, Brayton Point, EPA, MA DEP, RI DEM and others finalized a Memorandum of Agreement II (MOA II) to reduce the thermal discharge and "once through cooling flow" Brayton discharged to the Bay while revised permit limitation were under development. The company has adhered to the limits of the agreement as is reflected by monthly reports submitted to MADEP and EPA. A key component of the MOA II is the requirement that Unit 4 reuse the cooling water that has cooled Units 1, 2 and 3 during the cold months of the year, October through May, including winter flounder spawning season. The agreement has reduced Brayton's annual thermal discharge of 50.4 trillion BTUs (the BTU discharge level immediately prior to MOA I and MOA II) to 42 trillion BTUs per year and the flow from a maximum daily of 1.2985 billion gallons per day (BGD) to an average monthly limit of 0.925 (BGD) from October through May and 1.08 (BGD) from June through September. These voluntary interim operating conditions have not resulted in a change in the size of the ground fish populations that experienced a precipitous decline in Mt. Hope Bay. MADEP is of the opinion that based on the data it has thus far reviewed, a native, naturally diverse, community has not been re-established in Mt. Hope Bay. Additionally, total biomass, which could include other make-up replacement species, has not increased equivalently in comparison to greater Narragansett Bay.

Temperature Modeling of Mount Hope Bay

After MOA II agreement and in anticipation of submission of a NPDES permit renewal application, Brayton Point developed a 3-D hydrodynamic thermal model to depict the rise in water temperature being caused by the cooling water discharges from Brayton Point to Mt. Hope Bay. The hydrodynamic thermal model has been validated, reviewed and accepted by the Brayton Point Technical Advisory Committee which includes, among others, Brayton Point Representatives, EPA, MADEP, the Massachusetts Division of Marine Fisheries, the Massachusetts Office of Coastal Zone Management, and RIDEM. It has been used to compare current (MOA II operating conditions) and possible future alternative plant operating conditions to Massachusetts and Rhode Island Surface Water Quality Standards. The model has been validated for selected average and extreme weather years and can be used to develop possible discharge mixing zones. Brayton Point discharge thermal maps have been produced that indicate current facility operations discharge a volume/plume of heated wastewater that exceeds Massachusetts and Rhode Island Surface Water Quality Standards for temperature change in a majority of the Bay. The current heated effluent plume exceedance areas completely cover Mt. Hope Bay, the Taunton River, the Cole's River and Lee's Rivers shore to shore with more than a 1.5°F temperature increase for significant percentages of each day, during flood and ebb tides in winter and summer. The model also shows areas of the Bay where critical temperatures, which would effect the winter flounder development from eggs to adults, are exceeded.