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CHAPTER 4.0

TEMPERATURE TOLERANCE INFORMATION AND AREAS OF EXCLUSION

4.1 Discharge Considerations

Chapter 4.0 contains a quantitative theoretical assessment of thermal effects on representative important species (RIS) present within a defined discharge zone. Evaluation is focused on the discharge zone, rather than the mixing zone (Section 1.5). Such a limitation permits a much more realistic and reliable interpretation of potential impact because of the high frequency of plume occurrence in the discharge zone; whereas the expansive mixing zone, encompassing the discharge zone and all possible extreme plumes, contains large areas with only brief intermittent plume contact. Because of infrequent and unpredictive plume penetration much beyond the discharge zone, the applicant will not address mixing zone impacts except in a qualitative sense where needed. The discharge zone selected is defined in Section 1.5 as the segment of a circle encompassing the 3°F isotherm of an expected spring plume deflected east and west, containing 175.7 surface acres and having a radius of 3374 feet from the point of discharge. Size of the discharge zone at a depth of 6 feet is 64.9 acres and 2357 feet (linear extent); that portion of the discharge zone in contact with lake bottom encompasses 10.7 acres and extends 1029 feet lakeward from the point of discharge (note Section 1.4.2.2 and Figures 1.4-67 through 69).

Areas within each $1^{o}F$ ($0.55^{o}C$) increment of the discharge zone, at each of three depths (surface, 6 feet, and bottom) are presented in Table 1.5-1. These areas are incorporated with information on thermal sensitivities of various biological activities, for each RIS in Section 4.2, to develop and evaluate a theoretical impact of the Ginna discharge on biota within the discharge zone.

Evaluation of thermally impacted areas on the lake bottom must be viewed in perspective with a scour zone contained within the bottom portion of the discharge zone. The scour zone has been defined in subsection 1.4.3.1.2 as being that bottom region along the plume centerline near shore, which is bounded by a 1 fps velocity isopleth; it encompasses an average area of 2.8 acres, or a maximum of 5.2 acres (note Section 1.4.3.1.2 and Figure 1.4-82). Loose substrates such as silt, sand, and fine gravel in conjunction with their less productive associated fauna, are usually swept free from the scour zone. However, benthic organisms residing in crevices and on the down-current side of boulder sized rocks possibly remain unaffected by current velocity within this region. Organisms typically flourishing within mats of Cladophora may be somewhat reduced in proportion to the limitation on Cladophora biomass and filament length.

To assess the overall impact of scouring it should be recognized that many benthic forms are capable of inhabiting more than one type of substrate. Thus it is doubtful to expect that physical scouring will eliminate specific species. Instead, scouring will tend to reduce the population sizes relative to ambient conditions.

4.2 Thermal Effects Upon RIS

This section contains a detailed evaluation of theoretical thermal plume effects within a previously defined discharge zone (see Section 1.5).

Since the discharge zone is defined to be the 3°F isotherm as required by the New York State thermal criteria (6 NYCRR 704) and since, as this chapter will clearly demonstrate, the impact within the discharge zone is negligible, the applicant does not anticipate any effects within the adjacent water body segment.

In compliance with the EPA guidelines for this demonstration, the applicant will evaluate thermal effects of the discharge during each of four seasons. The thermal regime of each season is presented in Table 4.2-1, including individual monthly average temperatures. Winter, consisting of January, February, and March, is characterized by an average ambient lake temperature of 1.3°C (34.4°F). The spring season (average 8.1°C or 46.5°F) consists of April, May, and June; while the summer season consists of July, August, and September, and has an average ambient lake temperature of 18.8°C (65.8°F). Fall consists of October, November, and December, and has an average ambient temperature of 8.2°C (46.8°F).

If, during the course of analysis, the applicant finds that a particular life activity extends for more than one season, but less than two seasons, the impact will also be evaluated for mean temperatures in those months apart from the principal season in which the activity occurs. In addition to seasonal and/or monthly evaluations, the applicant has chosen to address specific times during the year when average ambient temperatures are exceeded for a brief period. All of these additional time segments occur during the summer season. For ten percent of the year, or 37 days during the summer, the maximum temperature of ambient lake water will be 21.1°C (70.0°F) or greater. During five percent of the year (18 days), ambient lake water will be 22.2°C (72°F), or greater. For one percent of the year (four days) ambient lake temperature will be 23.9°C (75°F); this is the single maximum ambient temperature expected.

Evaluation of thermal effects on Cladophora (Section 4.2.1), macroinvertebrates (Section 4.2.2), and fish eggs deposited on the bottom (Section 4.2.3), will focus on a small portion of the benthic habitat where the plume makes bottom contact. Analysis is restricted to this zone because it is the only place where these particular RIS organisms and eggs may be potentially impacted. Within this area of bottom contact, ranging in size from less than 5.1 acres to a maximum 10.7 acres and extending 1029 feet lakeward, is a physically impacted region termed the scour zone. The scour zone will occupy an average area of 2.8 acres (maximum 5.2 acres) along the main axis of the plume, and be bound by a 1.0 fps velocity isopleth (see Section 1.4.3.1.2 and 4.1).

The impact evaluation on fish is more complex since these organisms may occupy various levels within the water column, and the size of the discharge zone diminishes with depth. To facilitate evaluation, the discharge zone and associated isotherms are described for the lake surface and 6-foot depth (note Section 1.4). The expected spring plume, deflected both east and west, is used to derive the discharge zone (refer to Section 1.5); area at the surface is 175.7 acres, and 64.9 acres at a depth of six feet.

Since fish are rarely confined to the upper one foot of the water column, where the surface discharge zone applies, evaluation at the six-foot isotherms is a better indicator for potential effects. Fish listed as being taken in "top" nets at Ginna are actually caught in the upper five to six feet of the water column, thus supporting the need to consider both areas within the discharge zone.

Thermal effects are determined by comparing ambient and discharge temperatures with threshold sensitivity temperatures for various life activities of each RIS (sensitivity based on data in Tables 4.2-2(1) through (8)). The actual comparisons and resultant areas within the discharge zone, from which various activities may be excluded or limited on the basis of excessive temperatures, are provided in Tables 4.2-3(1) through (9).

Concerning the response of fish to these specific areas, the 316(a) Guidance Manual (EPA, 1974, p. 101) states, "...there are both vertical and horizontal thermal gradients that mobile organisms can follow to avoid unfavorable high (or low) temperatures". Therefore, exclusion could simply take the form of avoidance. All impact areas indicated are in the epilimnetic zone, thus sensitive species found in the hypolimnion will not be affected.

Impact areas and temperatures presented in the discussions below represent a conservative discharge zone, especially since this zone is normally twice the expected plume size (Table 1.5-3), and include the range of expected plume areas (bounded by 3°F isotherms) for all seasons. The state regulations imply that temperature increases less than 3°F are not expected to interfere with a balanced indigenous population of aquatic life (6NYCRR 704.1). Thus, there are no thermal effects of any significance anticipated for the adjacent water body segment.

Thermal effects discussed in Sections 4.2.1 to 4.2.3 are grouped according to the general categories listed in the 316(a) Guidance Manual (EPA, 1974). Where possible, upper lethal temperatures were interpolated using existing data in Tables 4.2-2(1) to (8) and prevalent ambient lake temperature as the acclimation temperature for the appropriate month or season. Sensitivity temperatures for growth, development, and reproduction, in addition to the appropriate time periods during which these activities occur, were derived for all RIS from the scientific literature. Specific life activities evaluated for each RIS are (1) maximum temperature for survival of the parent, (2) maximum temperature for summer survival, (3) optimum growth temperature, (4) maximum temperature for acceptable growth (where appropriate), (5) maximum temperature for development, and (6) normal temperatures for reproduction.

A brief description of the thermal evaluation data presented for each RIS in Tables 4.2-3(1) through (9) may simplify subsequent interpretation and discussion. The first column lists specific biological activities under consideration, while the second provides the time of occurrence for each activity (appropriate season, month, or part thereof). A third column contains ambient lake water temperature for respective time periods listed in the second column. The fourth column lists the sensitivity temperature which, when exceeded, could potentially impact the aforementioned biological activity. The column titled "isotherm exceeding sensitivity temperature" contains the lowest isotherm of the discharge zone that exceeds the sensitivity temperature during the appropriate time period (thus it equals Column 4 minus Column 3). The remaining columns provide (1) areas, in acres, from which the biological activity is excluded; (2) the area of exclusion represented as a percentage of the total surface area of the discharge zone; and (3) the number of days during which the activity is limited or excluded.

4.2.1 Macroflora: *Cladophora*

The discussion presented below is a theoretical evaluation of thermal impact upon *Cladophora*, and is based upon temperature sensitivity data cited in Table 4.2-3(1) for various life activities. As previously indicated in Section 4.2 any impact evaluation on *Cladophora* must center about that portion of the discharge zone which contacts the lake bottom out to a water depth of about three meters, and encompasses an area of 10.7 acres.

Maximum for Survival of Parent

The maximum temperature for survival of a reproducing *Cladophora* filament is about 22.2°C (72°F), as derived from the work of Storr and Sweeney (1971). This temperature would not be exceeded within the discharge zone during the early spring (April and May) and late fall (November and December) portions of the *Cladophora* reproductive period.

In the months of June and October this temperature may be exceeded within an area considerably less than 5.1 acres in size (note Table 4.2-3(1)). Concerning the summer period, parent survival may be limited within 6.5 to 10.7 acres of the bottom contact region for about 74 days. For the remainder of summer, ambient lake water temperatures will equal or exceed the sensitivity temperature of 22.2°C (72°F), thereby naturally repressing this life activity.

Maximum for Summer Survival

The applicant has observed a short stubble of viable *Cladophora* in the discharge waters at Ginna during the summer. This would indicate that the *Cladophora* filament, though greatly shortened, can withstand temperatures of 32.2°C (90°F) and possibly greater. Using 32.2°C (90°F) as a conservative estimate for sensitivity, the applicant predicts an elimination of *Cladophora* filament within an area less than 5.1 acres for about 18 days during the summer season.

Optimum Growth

Based on the results of Storr and Sweeney (1971), the temperature for optimum growth of *Cladophora* is 18.0°C (64.4°F). Within the spring season, growth would be suboptimal within less than 5.1 acres, or less than 2.9 percent of the discharge zone in May and June. During the entire summer, average ambient lake water temperature in Lake Ontario exceeds 18.0°C (64.4°F), thereby naturally resulting in suboptimal growth throughout the southern shoreline area. Conditions in the fall season are expected to be the same as for spring, growth is repressed within a bottom-contact area of less than 5.1 acres. No adverse impact is predicted for December or the winter months.

Maximum for Development

This activity is not applicable to *Cladophora* because its reproductive cells vegetate directly into a filament.

Normal Reproduction Dates and Temperatures

Cladophora may reproduce variously during spring, early summer, and fall. A very conservative upper limit of sensitivity for reproduction may be taken as 18.0°C (64.4°F). This temperature may be exceeded within less than 5.1 acres of the bottom discharge zone in May, June, October, and November. During the summer, average ambient water temperatures will naturally exceed this sensitivity. Cladophora is not necessarily eliminated by excessive temperature. The alga often produces resistant thick-walled cells termed akinetes, which are unaffected by subjection to excessive temperature. Upon the return of favorable conditions, these cells may germinate and recolonize the area.

Summary

To summarize the predicted thermal impact on Cladophora one must realistically consider the acreages cited above in relation to the scour zone. As discussed in Section 4.1, a maximum area of 5.2 acres may be physically scoured by the Ginna surface discharge. Life activities and biomass of Cladophora will be greatly limited within this zone by turbulence associated with discharge flow; any additional impact due to plume temperatures would be negligible. Therefore, reviewing each of the acreages listed in Table 4.2-3(1) and subtracting 5.2 acres for scour, the applicant would predict the following as a more refined theoretical thermal impact:

(a) maximum sensitivity for survival of parent _Cladophora_ will be exceeded at most within a small area of 1.3 acres (0.7 percent of the discharge zone) during 74 days of the summer period, and within about 5.5 acres for 19 days of the summer. No adverse thermal impact is predicted for spring, fall, and winter.

(b) summer survival, growth, and reproduction of _Cladophora_ will not be impacted outside of the scour zone during any season.

Considering that these potentially thermal impacted areas are extremely small, relative to the total region available for colonization of _Cladophora_ at the site, it is reasonable to conclude that the Ginna plume has a negligible adverse impact on this species.

4.2.2 Macroinvertebrates: Gammarus

An evaluation of thermal impact on various life activities of Gammarus is based on the data presented in Table 4.2-3(2) and discussed below. As with the evaluation for Cladophora, any impact on Gammarus will be limited to the region of bottom contact between the plume and lake bed.

Maximum for Survival of Parent

Based on the work of Sprague (1963), a conservative maximum temperature for survival of parent gammarids is 31.0°C (87.8°F) in summer. This temperature is exceeded within an area less than 5.1 acres (less than 2.9 percent of the discharge zone) for 37 days during the warmest part of the summer season (ambient temperatures equal to or in excess of 21.1°C (70°F). During the remainder of summer, spring and early fall, sensitivity temperatures are sufficiently high and ambient temperatures low enough so that no part of the plume will thermally impact Gammarus.

Maximum for Summer Survival

(a) Adults

Again based on Sprague's (1963) data, adult gammarids can withstand temperatures up to 31.0°C (87.8°F) during the warmest part of the summer. This sensitivity temperature may be exceeded within less than 5.1 acres of the discharge zone for 37 days, or less, during the warmest part of the summer season (ambient water temperatures equal or in excess of 21.1°C (70°F)). For the remainder of summer, the sensitivity temperature will not be exceeded in the plume.

(b) Eggs and Immature Forms

Deriving a most conservative upper limit of 26.0°C (78.8°F) for summer survival of these forms from Clemens (1950), one might expect a reduction in abundance at least within less than 5.1 acres throughout summer, and within a maximum 9.3 acres for about 4 days at the peak of summer temperatures.

Optimum Growth

(a) Adults

Utilizing 20.0°C (68°F) as a conservative upper limit for optimal growth of adult gammarids, the applicant might expect a theoretical suboptimal growth (smaller sized adults) within less than 5.1 acres of the discharge zone in June, 10.7 acres for about 55 days of the summer season, and less than 5.1 acres in October. For part of the summer (about 37 days) ambient water temperatures will exceed the optimum for adult growth and small sized adults will typically result throughout the lake, a condition well documented for Lake Erie (Clemens, 1950).

(b) Immatures

Immature gammarids have a sensitivity temperature of about 25.0°C (77°F) for optimum growth. Based on this the applicant might expect a suboptimal growth of these forms within an area ranging from less than 5.1 acres to a maximum 10.7 acres for various times during the summer season (note Table 4.2-3(2)).

Maximum for Development

An upper limit for the development of eggs and young gammarids was not cited in the literature. Since Clemens (1950) found eggs and young gammarids in his samples from Lake Erie at times when the ambient temperature was 26.0°C (78.8°F), it is reasonable to assume that the limit for this activity exceeds 26.0°C (78.8°F).

Again for purposes of prediction the applicant selected 26.0°C (78.8°F) as an extremely conservative estimate of sensitivity. Based on this value, development could be suppressed in an area ranging from less than 5.1 acres for most of the summer, to a maximum of 9.3 acres for 4 days during the warmest ambient temperature (23.9°C (75°F)).

5) Reproduction Dates and Temperature

An upper thermal limit for reproduction was not found in the literature. *Gammarus* typically reproduce from late March through late October over a complete range of seasonal lake temperatures (Clemens, 1950). Since Clemens (1950) reported the presence of breeding females at a lake temperature of 26.0°C (78.8°F), it is presumed that the upper limit must exceed 26.0°C (78.8°F). For predictive purposes the applicant selected 26.0°C (78.8°F) as an extremely conservative estimate of sensitivity. On this basis, the applicant could expect limited reproduction to occur within less than 5.1 acres for most of summer to a maximum of 9.3 acres for 4 days in mid-summer.

Summary

To summarize the thermal impact on *Gammarus*, one must again consider the scour zone (maximum area 5.2 acres). The velocity of discharge waters, in addition to a reduction of preferred habitat substrate (*Cladophora* biomass), could theoretically limit life activities of *Gammarus* within the scour zone. To evaluate areas within the discharge zone where *Gammarus* are solely impacted by temperature, one can subtract a scour zone of 5.2 acres from each acreage listed in Table 4.2-3(2). The following may be deemed a more refined theoretical thermal impact assessment:

(a) There should not be any area of bottom contact outside of the scour zone where parent gammarids are thermally stressed.

(b) Eggs and immature forms could be thermally stressed, resulting in reduced survival and suboptimal growth, within about 2.7 acres for 18 days in summer, and a maximum of 5.5 acres for 4 days during the height of ambient summer temperatures. No adverse impact is predicted for spring and fall.

(c) Adults may experience slight suboptimal growth within 5.5 acres for 55 days of summer.

(d) Activities such as development of eggs, and reproduction, may be thermally limited within an area of 4.1 acres for approximately 4 days during summer. No adverse impact is predicted outside of the scour zone for the remainder of summer, spring, or fall.

Considering the absence of potential thermal impact on survival of adult gammarids, the extremely small areas and brief periods of impact on eggs, immatures, and reproduction, and lastly the predicted suboptimal growth within a small area during summer, it appears unlikely that the Ginna discharge could have a significant, much less a measureable, adverse thermal impact on *Gammarus*.

4.2.3 Fish

As stated in the introduction to Section 4.2, evaluation of theoretical thermal impact on fish distribution is discussed in terms of both the surface and six foot isotherms. Since few fish occupy the top one foot of the plume where the surface isotherms apply, the six foot isotherms present a more reasonable area for assessing thermal effects. Since plume bottom contact extends about 1000 feet lakeward to the ten foot depth contour, there will not be adverse thermal effects on fish found below this depth. Development and reproduction temperatures, where applicable (as in the case of demersal eggs), are evaluated in terms of the areas where the plume contacts the bottom. Thermal impact in the scour zone, contained within the region of plume bottom contact, is expected to be negligible since many organisms and selected activities such as spawning will be excluded by the scour effect alone. The scour zone coincides with bottom areas subject to the greatest temperature elevations (delta T's of 7°F and greater).

In evaluating effects which may involve mortality, such as maximum temperature for survival of parents, and maximum temperature for summer survival, the upper lethal temperature (LD50) corresponding to acclimation temperatures (ambient water temperature) is usually reduced by 2°C (3.6°F) to provide a safe survival temperature for use in Tables 4.2-3(3) through (9). This assures survival and protects the fish from stress effects. When an upper lethal temperature is not reported in the scientific literature for a specific acclimation temperature, but other upper lethal temperatures are provided, the unknown is derived by interpolation within the limits of existing values.

Temperatures for optimum growth, reproduction, and development are taken directly as reported in the scientific literature, or from field observations. Acceptable growth temperature for each RIS is obtained, as set forth by Coutant in the 316(a) Guidance Manual (EPA, 1974) and in NAS (1973), by adding one-third of the difference between the optimum growth temperature and the ultimate incipient lethal temperature to the existing optimum growth temperature. Fish living at this temperature or below are capable of acceptable growth rates.

For each RIS-fish a discussion is provided concerning probable effects of reactor shutdowns on protection and propagation of a balanced indigenous aquatic community at Ginna. There are two distinct types of shutdowns, "scheduled" and "rapid" (unscheduled). The applicant anticipates a scheduled reactor shutdown once per year, normally in the spring, for refueling and maintenance purposes. During the process of shutdown there is a gradual decline in discharge temperature of about 10.6°C (19°F) over a 20 minute time period.

Rapid shutdowns are unscheduled and may occur anytime within the year for various reasons. The Ginna facility has had an average of about ten rapid shutdowns per year, with an average down-time of 16 hours. A temperature drop associated with rapid outage may vary from 10.6°C (19°F) to 13°C (23.4°F), depending upon season and the degree of recirculation. Assuming a condition of 10.6°C (19°F), the rate of discharge temperature change would approximate 9.8°C (17.6°F) within the first minute, and 1.0°C (1.8°F) in the second minute.

From an environmental standpoint, rapid and scheduled shutdowns do not differ sufficiently to require separate evaluations. A month by month analysis for each RIS fish encompasses both shutdowns. The potential environmental problem associated with shutdowns is a subjection of organisms, principally fish residing within the heated discharge, to "cold-shock" following removal of the heat component. Fish can withstand rapid decreases in water temperature, provided ambient lake temperatures are within lower lethal tolerance limits established for a series of acclimation or discharge temperatures. A reasonable first approximation for impact evaluation can be derived by determining lower lethal temperatures for individual average monthly discharge temperatures, and comparing these data with ambient lake temperatures. If lower lethal values based on maximum discharge temperature exceed ambient conditions, a potential for cold-shock could exist within some defined area of the plume. Conversely, if ambient values exceed lower lethal temperatures, then there is no potential for cold-shock.

To refine cold-shock evaluations and render them more applicable to the Ginna discharge, three additional factors will be considered:

(1) proximity of specific RIS fish populations to the shore region and discharge area for each month and/or season (note Chapter 3);

(2) swimming capability, specifically cruising speed, and thermal preference of each species (note Chapter 3) as they relate to potential distance of penetration into the plume (maximum discharge velocity is about 4.0 fps, at 246 ft USGS lake elevation; note Fig. 1.4-27);

(3) expected plume residence time and extent of acclimation to elevated discharge temperatures, given cruising speed capabilities at available temperatures; acclimation implies stabilizing physiologically to a particular thermal condition, and requires time on the order of days.

The reliability of lower tolerance levels is directly dependent upon acclimation to a particular thermal regime.

4.2.3.1 Alewife

Table 4.2-3(3) presents the evaluation of thermal effects upon the alewife.

Maximum for Survival of Parent

Maximum temperature for survival of mature alewives is not exceeded anywhere in the plume (surface or six foot depths) during the spring spawning season (including June). Should spawning extend on into early July (as noted in Carlander 1970), there is a possibility that mature alewives may be excluded from about 60 acres (34 percent of the surface discharge zone), or more realistically from about 19 acres at the six foot depths, for about 15 days. This would not, however, exclude mature alewives from entering the region under the plume and spawning near the bottom (to be discussed below). Considering that mature alewives spawn near shore in shallow waters, and considering the wedge shape of the discharge zone which results in the narrowest part of the exclusion zone being closest to shore (the region of great potential impact on spawning), the applicant is reasonably confident that the Ginna discharge would not adversely impact mature alewives.

Maximum for Summer Survival

Since adult alewives have a summer preference temperature of 16°C (60.8°F), they are not expected to inhabit near shore waters in summer, thus avoiding potential impact. The subsequent discussion will center on juveniles which do inhabit nearshore waters.

Analysis of the maximum temperature for summer survival shows that the sensitivity temperature increases with increased acclimation temperatures (note Table 4.2-3(3)). The maximum isotherm area that exceeds the temperature which assures survival for this period is 20.9 acres (11.9 percent of the discharge zone at the surface) and occurs for only four days during the summer. The maximum area at the six foot depth is 6.1 acres (3.5 percent of the discharge zone) and this also occurs for only a brief four days.

Considering the maximum duration for exclusion, juvenile alewives may avoid 5.6 acres and 1.5 acres at the surface and six foot depths, respectively for 92 days (the entire summer season). These are obviously small areas, respresenting 1 to 3 percent of the total discharge zone.

Optimum Growth

In examining growth temperature for the alewife, the optimum growth temperature is reviewed first. Using the value of 22.7°C obtained from the literature (Table 4.2-2(2)), the maximum area of theoretical impact occurs ten percent of the year (37 days) during the summer within 175.7 acres (100 percent of the discharge zone) at the surface, and 64.9 acres (36.9 percent of the discharge zone) at the six foot depths. This assumes a hypothetical worst case condition with alewives remaining in the area of impact continuously for the entire duration of 37 days. At least two factors enter in to minimize this degree of potential impact; (1) adult alewives will be offshore in summer and avoid the plume waters; (2) the remaining juveniles are pelagic and schooling, thus it is difficult to conceive having them reside continuously for the duration of impact within the discharge zone.

Aside from the summer season, alewives could potentially experience suboptimal growth in small confined areas of about 2.3 acres (surface), or 0.7 acres (six foot depth), during the months of June and October.

Acceptable Growth

It is apparent from Table 4.2-3(3) that all areas for potential impact on acceptable growth are reduced from optimal growth impact; in addition there are no potential impacts in June and October for either the surface or six foot isotherms. The largest area of potential impact (suboptimal growth) is about 102 acres (57.8 percent of the surface discharge zone) and 35.2 acres at the six foot depth; this occurs for a brief period of four days. The potential impact of greatest duration (92 days) encompasses 9.6 acres at the surface (5.5 percent of the discharge zone) and 2.7 acres (1.5 percent) at the six foot depths.

These areas of potential impact are considerably reduced from those for optimum growth temperature, and for the same reasons stated above, represent worst case conditions which are undoubtedly minimized through alewife behavior patterns.

Maximum for Development and Reproduction

Normal reproduction dates and temperatures, as shown on Table 4.2-3(3) occur in the spring with a peak from mid-June to early July. The normal temperature range for reproduction of the alewife is not exceeded or reached during spring within the plume. There is a small area nearshore at the surface of the discharge zone (5.6 acres), from which reproduction might be excluded in July. Since alewives spawn near the bottom in shallow water, these potential 5.6 acres coincide with the maximum scour zone (5.2 acres) where spawning is physically restricted by water flow. Therefore the applicant does not expect reproduction of alewives to be impacted thermally at the Ginna discharge.

Concerning development, a thermal evaluation finds no area of exclusion within the discharge zone.

Potential For Cold Shock

The evaluation for potential cold-shock of alewives centers on the spring, summer, and fall months when ambient nearshore lake temperatures exceed 3^{o}C (37.4^{o}F). As previously discussed in Section 3.3.3.2.1, and verified in winter studies by the applicant at Ginna, and in Lake Michigan by Otto et al. (1976), the alewife population moves offshore by late fall to overwinter in deep warmer (>3^{o}C) waters; thus avoiding any potential winter impact. Colby (1973) supports the need for alewives to escape from cold nearshore waters by experimentally demonstrating their susceptibility to severe stress at temperatures less than 3^{o}C (37.4^{o}F).

Lower lethal temperatures of alewives, determined for monthly discharge temperatures on the basis of data reported in Otto et al. (1976), are provided for each of nine months in Table 4.2-4. There is an apparent potential for cold-shock following shutdown in only two months, April and December, assuming an unlikely acclimation to a maximum discharge temperature of 15.6^{o}C (60^{o}F). To achieve physiological acclimation to 15.6^{o}C (60^{o}F), alewives must be capable of maintaining themselves by cruising for many hours, or more likely days, in a region characterized by a discharge velocity of about 3.5 to 4.4 fps. Given swimming speed data for alewives in Table 3.3.-5, and extrapolating to 15.6°C (60°F), it becomes readily apparent that Age II alewives (10.4 cm in length) can only cruise at about 1.2 fps (3.5 body lengths per second); thus clearly preventing their acclimation to maximum plume temperature in April and December. Even larger alewives, up to 15.2 cm (6 inches) could only cruise at about 1.8 fps at 15.6°C (60°F). They may penetrate the area of greatest velocity by darting, however they could not maintain themselves sufficiently long to achieve acclimation.

Assuming for conservative predictive purposes that alewives can maintain themselves at a discharge velocity of only 1.8 fps, it is reasonable to query the temperature corresponding to this velocity. Judging from the discussion on plume velocity in Section 1.4.3.1, and the data in Table 1.4-9, alewives might be capable of penetrating the plume to within about 518 m (1700 feet) from the discharge canal. Plume temperature is expected to be about 5°C (9°F) above ambient at this distance (note Table 1.5-1), thus alewives could become acclimated to a maximum 9.4°C (48.9°F) in April, and 9.3°C (48.7°F) in December. A lower lethal temperature range for these acclimation temperatures is about 4.1 to 4.15°C (39.4-39.5°F), and falls slightly below ambient lake conditions of 4.3 to 4.1°C (39.7-40°F).

Alewives normally tend to be cold stressed because of ambient conditions in spring, and easily succumb to any additional stress.

A plant shutdown in April has the potential for cold-shocking or stressing some of the alewives presumed to be present and acclimated to a Δt of $5^{o}C$ ($9^{o}F$) within the plume; the potential is warranted since their lower lethal temperature nearly coincides with ambient. Relative to the billions of individuals migrating shoreward in spring, and the millions which normally die-off, any loss of specimens accompanying a plant shutdown in April would be negligible and certainly not interfere with the protection and propagation of this species. Any potential for impact in December, the only other month of concern, would be minimal since most of the population has moved offshore away from the sphere of plume influence.

Summary

To summarize potential thermal effects of the Ginna discharge upon the alewife population, the applicant has shown there to be a small area of possible exclusion for mature alewives in July, very small areas or larger areas for brief time periods excluding juveniles in summer, suboptimal growth in various portions of the discharge zone mostly in summer (assuming alewives remain there for weeks or months), and finally negligible thermal impact on their development and reproduction activities. On this basis the applicant concludes no appreciable adverse thermal impact on the alewife population.

4.2.3.2 American Smelt

Table 4.2-3(4) presents the evaluation of thermal data for the American smelt.

Maximum for Parental Survival

To evaluate maximum for parental survival, the applicant selected the maximum temperature at which smelt spawn, 18.3°C (64.9°F). Spawning of smelt in Lake Ontario occurs primarily in early spring (April to May). No impact is expected for early spring since sensitivity temperature is not exceeded within the discharge zone.

Maximum for Summer Survival

As discussed in Section 3.3.4.2.1, adult smelt have a very low temperature preferendum and usually move offshore into deeper water either at or below the level of the thermocline. Therefore adults will not be subject to thermal impact by the Ginna discharge. Juvenile smelt, however, have a higher preference temperature than adults in summer and may be available for potential impact. Evaluation of the data indicates that juveniles could be excluded from about 133 surface acres of the discharge zone, and 47.6 acres at the six foot depth for 55 days. During the remainder of time in summer, ambient surface temperatures exceed sensitivity temperature.

Optimum Growth

In discussing thermal effects on growth for the smelt, it must again be pointed out that adult smelt are not found in the warm epilimnetic waters during the summer months. In fact, ambient surface water temperatures of Lake Ontario exceed optimum temperatures for both adult and juvenile smelt growth in summer.

Reproduction

As shown in Table 4.2-2(3), normal reproduction occurs in waters of temperature up to 14.5°C (58.1°F) in Lake Ontario from March to usually not later than May, but dates as late as July have been reported in the literature. The July lake water temperatures are too high for normal spawning, so any spawning which would occur would have to occur in colder streams.

The potential spawning area that might be thermally affected is less than 5.1 acres in size and located within the scour zone. Since this area will be physically impacted, the potential for adverse thermal effects on reproduction is negligible.

Maximum for Development

The maximum temperature for development of smelt eggs is found to be 15°C (59.0°F). During the spring season ambient waters are cooler than this sensitivity temperature. Eggs are found in less than 0.6 meters (2 feet) of water where they remain attached by means of a pedicel. In spring, the only bottom area (4.6 acres) within the discharge zone available for impact on egg development is scoured. There is, therefore, no area within the plume where egg development will be adversely affected by the thermal component of the discharge.

Potential for Cold Shock

In the absence of specific experimental data on lower thermal tolerances for smelt, the applicant considers it reasonable to utilize the EPA (1974) nomograph (note Figure 4.2-1) for assessing potential cold-shock impact. Smelt are basically cold-water fish which avoid warm nearshore epilimnetic waters in summer. They do, however, inhabit nearshore areas during spring, fall, and possibly winter.

Examination of the data in Table 4.2-4 indicates a potential for stress on smelt, acclimated to a maximum discharge temperature of 15.6°C (60°F), following a plant shutdown in April and December. Applying the same conservative logic utilized in Section 4.2.3.1 for alewives, it is realistic to presume that smelt (15.2 cm or 6 in. in length) can swim about 1.8 fps (3.5 body lengths per second), and thus penetrate only to the 5°C (9°F) Δt isotherm during these two months. Assuming acclimation to a maximum temperature of 9.4°C (48.9°F) in April and December, smelt can safely return to an ambient temperature of 2.2°C (36°F). Since ambient conditions in April and December exceed 2.2°C (36°F), the applicant is reasonably confident there will not be a cold-shock impact.

During winter months, it is again presumed that smelt are restricted from acclimating to temperatures in excess of 9.4°C (48.9°F); however a lower lethal value of 2.2°C (36°F) exceeds ambient temperatures and renders the fish susceptible to cold-shock in the event of a shutdown at this time. The extent of potential impact is not presumed to be adverse. A gill net study conducted by the applicant in February 1975, (RG&E, 1976a) resulted in the capture of only one smelt among all the nets set, which included the plume, E-0 shore, and also W-1 shore areas. This suggests that despite a preference for warmer water in winter (10°C, see Section 3.3.4.2.1) there does not appear to be a large concentration or attraction of smelt to the immediate discharge area, thus minimizing the potential for winter cold-shock.

Summary

Due to American smelt's preference for cold water, and its normal distribution in deep, offshore waters in the summer, the potential for thermal impact on this species is expected to be minimal. Reproduction and development activities would not be thermally impacted outside from the maximum scour zone.

4.2.3.3 Spottail Shiner

Table 4.2-3(5) presents the evaluation of thermal data for the spottail shiner.

Maximum for Parental Survival

Mature spottail shiners typically spawn in June and July. Each of these two months is evaluated separately since they represent spring and summer seasons. Evaluation of ambient and sensitivity temperatures for June indicates no potential impact in the discharge zone.

In July, spottails may be excluded from a small portion of the discharge zone (4.3 acres) close to the discharge canal (within the 9.4°C or 17°F Δt isotherm). At the six foot depth, which is close to the bottom near shore, mature spottails would be thermally excluded from about 1.2 acres; this area is contained within the scour zone. Given the small magnitude of these exclusion areas, relative to the available non-impacted areas nearshore at Ginna, the applicant considers the potential for thermal impact to be negligible.

Maximum for Summer Survival

Depending upon their vertical location within the discharge zone, and ambient temperatures in summer, spottails may be excluded from a maximum area of 14.5 to 45.8 acres for a brief period of four days in summer, to a minimum of 1.2 to 4.3 for acres for the entire summer (see Table 4.2.3(5)).

Judging from the preference temperature data presented in Table 3.3.3.2-1, and discussed in Section 3.3.5.2, it appears that spottails normally avoid the warmest nearshore waters in summer. This would tend to minimize the potential for impact in summer.

Optimum Growth

In evaluating optimum growth, attention is focused on the summer period since Carlander (1970) states that growth of spottail shiners ceases below 18°C (64.4°F). Results of thermal assessment suggest a potential for suboptimal growth of spottails inhabiting about 11 to 176 acres of the discharge zone in summer. It is doubtful that the potential for impact exists since spottails avoid the plume area in summer (note Section 3.3.5.3).

Acceptable Growth

Evaluation of potential impact on acceptable growth results in a reduction of areas for suboptimal growth to about 3.5 to 133 acres. Avoidance of the plume by spottails in summer renders this an unlikely life activity for impact.

Maximum for Development and Reproduction

A review of the available literature failed to uncover specific incubation and hatch temperatures for spottail shiners. However, since hatching occurs shortly after spawning, the temperatures for both processes are assumed to be the same, 20°C (68°F). It is reported that spottail shiners spawn near shore in 0.9 to 1.25 meters (3-4 feet) of water.

Evaluation of the thermal data reveals a potential bottom zone of thermal impact (less than 5.1 acres in size) which is coincident with the scour zone. Spawning is expected to be greatly reduced in the area of scour, and the potential effect on reproduction and development would be negligible since the eggs would be swept away.

Potential for Cold Shock

Spottail shiners tend to be somewhat smaller (average length of 11 to 12 cm) than the two previously discussed forage species, and are therefore expected to exhibit a slower cruising speed (1.3 fps, assuming a length of 11.5 cm, and potential for 3.5 body lengths per second). A limited penetration into the plume (verified by their absence from the discharge canal in TV monitoring studies

(RG&E, 1976b)), coupled with the spottail shiner's final preference for temperatures below those in the area of maximum discharge velocity, suggests a low potential for cold-shock effects.

Lower lethal tolerances provided for spottail shiners in Table 4.2-4 , are interpolated from cold-shock results reported in Reutter and Herdendorf (1974), and assume (1) a most conservative winter final preference and acclimation to 12.0°C (53.6°F), (2) a spring and fall final preference (with the exception of June and October) for 14.3°C (57.7°F), and (3) a summer preference (including June and October) for 19.5°C (67.1°F), see discussion in Section 3.3.5.2.1. With the possible exception of February, an unexpected plant shutdown at Ginna should not produce measureable cold-shock effects upon spottail shiners. In the case of February, when ambient temperatures are near 0.9°C (33.7°F), there is some uncertainty about realizing 100% survival in the event of a shutdown. Judging from the applicant's gill net study in February 1975 (RG&E, 1976a), relatively few spottails inhabit the nearshore area off Ginna at this time; this lends support to a prediction for minimal potential impact.

An important noteworthy comparison between experimentally derived lower lethal temperatures, and those based on the EPA (1974) nomograph, for spottail shiner (a moderate cold-water species), will clearly demonstrate a conservative quality in the nomograph below plume temperatures of 13.3°C (56°F). This assures the applicant that cold-shock evaluations based on the nomograph (for species having little or no test data) will be reasonably conservative for the most critical period, namely winter.

Summary

In summary, the applicant anticipates no consequential thermal effects on either reproduction, development, or parent survival within the Ginna discharge zone. The potential for direct impact on spottails and suboptimal growth within various sized areas in summer, is minimized by their natural avoidance of the area at this time.

4.2.3.4 White Perch

Table 4.2-3(6) presents the thermal evaluation data for the white perch.

Maximum for Parental Survival

Reproduction occurs in the spring and the maximum temperature for parental survival is interpolated from the data available. A sensitivity temperature of 28°C (82.4°F) is not expected to occur anywhere within the discharge zone in spring, thus there should be no effect on parental survival.

Maximum for Summer Survival

Evaluation of temperatures for summer survival shows that the maximum potential area for exclusion is about 21 acres in size at the lake surface, and 6.1 acres at the six foot depth; exclusion would be extremely brief (4 days). The size of area impacted for the longest duration (37 days) ranges from 5.6 surface acres to 1.5 acres at six foot depths.

In general these small areas and short duration of exclusion, confined to the warmest part of summer, constitute a minimal potential for impact.

Optimum Growth

Evaluation of optimum growth temperatures shows no potential for impact in the discharge zone during late spring (June). During summer months, white perch could experience suboptimal growth in an area ranging from about 35 to 176 acres at the surface of the discharge zone, and 11 to 65 acres at the six foot depths. The latter range may be more applicable since white perch are not expected to reside in the surface waters all summer.

Acceptable Growth

Examination of acceptable growth temperatures reveals a reduction in the areal extent of potential impacts. Again there is no impact expected for late spring (June). During the summer months, a theoretical suboptimal growth may occur in fish continuously residing within 7 to 78 acres at the surface region, and 2 to 26 acres at the six foot depths. The potential for impact may be reduced by the greater availability of food near the plume; growth is regulated not only by temperature but by food supply.

Maximum for Development and Reproduction

Examination of the thermal data for development and reproduction activities shows a very small area (less than 5.1 acres) of potential thermal impact which is contained within the scour zone. Since spawning is not expected to occur, and eggs are not expected to be retained within the scour zone, the potential for thermal impact is considered negligible.

Potential for Cold Shock

White perch appear most abundant in the nearshore areas at Ginna during the summer (July and August), and generally migrate to deeper offshore waters in the fall, remaining there through the winter (note Section 3.3.6). Since the applicant did encounter some white perch at both plume and control locations during the February 1975 gill net survey (range of 4.5-6 fish/net/day), it was decided to include winter months in the cold-shock evaluation.

Using a most conservative cruising type swimming speed of 3.6 body lengths per second, based on temperatures in excess of 21°C (69.8°F) (note Table 3.3-5), and assuming an average white perch (15.2 cm (6 in.) in length) can maintain this unlikely speed at reduced temperatures in winter, it becomes readily apparent this species could only achieve acclimation to plume temperatures corresponding to the 1.8 fps isopleth. According to the plume velocity data in Table 1.4-9, white perch could cruise at a distance about 1700 feet from the point of discharge, a location characterized by a surface Δt of about 5°C (9°F) (See Table 1.5-1). At worse, this species could acclimate to a maximum temperature of 9.4°C (48.9°F) during winter, early spring (April), and late fall (December). During all remaining months, acclimation temperature is expected to exceed ambient by about 5°C.

Since specific cold-shock data were not available for white perch, the applicant chose to utilize the EPA (1974) nomograph for impact evaluation, at least in the warmer months. White perch, and their close relative, white bass, are warm-water fish. Reutter and Herdendorf (1974) demonstrated that white bass withstand a rapid temperature decline from 13.5°C (56.3°F) to 0.9°C (33.6°F) with no apparent stress. From this it is presumed white perch exhibit a similar capability for an even lower acclimation temperature during the colder months; this is in keeping with the nomograph evaluation for 9.4°C (48.9°F), which is at least 5°C (9°F) above ambient in winter.

A comparison of lower lethal and ambient temperatures in Table 4.2-4, indicates a slight potential for cold-shock effects only in mid-winter (February). White perch should not experience cold-shock effects following plant shutdown in any other month.

Summary

In summary, the applicant finds no potential for thermal impact on reproduction, development, and parent survival within the Ginna discharge zone. There is a potential for some exclusion of white perch from small areas during the warmest part of summer, and a potential for suboptimal growth in areas of various dimensions during the summer months. Enhancement of food reserves in and about the discharge may compensate for thermally induced suboptimal growth, and serve to minimize the extent of potential impact.

4.2.3.5 Smallmouth Bass

Table 4.2-3(7) presents the thermal evaluation data for smallmouth bass.

Maximum for Survival of Parents

Smallmouth bass reproduce primarily in the spring, but have been known to spawn as late as early July. Given a sensitivity temperature of 20.7°C (69.3°F) for survival of parent in spring, the applicant finds no potential for thermal impact within the Ginna discharge zone. Should spawning extend into early July there is a potential for exclusion of mature fish from about 4.3 acres (2.4 percent) of the surface discharge zone. The impact is expected to be negligible since most spawning activity will have occurred previous to this time.

Maximum for Summer Survival

Evaluating the potential temperature effects on summer survival of smallmouth bass, the applicant finds extremely small areas of possible exclusion, ranging from 1.5 to 5.6 acres at the six foot depths and surface region, respectively. Areas in this size range comprise less than 3.5 percent of the discharge zone. The potential for impact is limited because smallmouth bass have a distinct preference and tolerance for warm-water habitats (note Section 3.3.7.2.1).

Optimum Growth

Examination of the thermal data on optimum growth indicates a potential for limited or suboptimal growth of bass within about 1.2 acres (92 days) to 14.5 acres (4 days) at the six foot depth region. Areas at the surface are somewhat larger (about 4 to 46 acres), however less applicable because fish would be expected to spend much less time in that region. Enhanced production and availability of food resource for bass near the plume may compensate for thermally induced suboptimal growth.

Acceptable Growth

Acceptable growth would be even less impacted in terms of time and acreage at the surface and six foot depth. Areas of potential impact range from about 1 to 5 acres, to 4 to 16 acres at the six foot depths and surface region respectively. Impact would be limited to 37 days or less during the warmest part of summer.

Maximum for Development

The maximum temperature for development is estimated from the literature using the optimum growth temperature for larvae. This temperature is not exceeded within the discharge zone during spring. In the summer, the only area for potential impact is contained within the scour zone, where spawning is expected to be negligible. Thus the potential for impact on development is negligible.

Reproduction

Reproduction normally occurs in the spring, but may continue as late as July. Evaluating the potential for impact in the bottom waters, since smallmouth bass are nest builders, one can conclude that there would be no effects in May, no effects in June (area of impact is within the scour zone), and a limited potential impact within about 4 acres outside from the scour zone in July. Since most spawning occurs prior to July the overall impact may be regarded as negligible.

Potential for Cold Shock

Evaluation of lower thermal tolerance data for smallmouth bass in Table 4.2-4, indicates no potential cold-shock for those individuals acclimated to maximum discharge temperatures during spring, summer, or fall. Since smallmouth bass migrate offshore and overwinter on the lake bottom, there is no potential for winter cold-shock. Support is derived by the absence of smallmouth from the discharge area during a winter gill-net study (RG&E, 1976a), and during TV monitoring in the winter (RG&E, 1976b).

Summary

To summarize the findings of a theoretical thermal impact assessment on various life activities of smallmouth bass, one could safely conclude that the Ginna discharge has a negligible impact on development, reproduction, and parent survival, and would exclude individuals from inhabiting very small areas (less than 3.5 percent of the discharge zone) during the summer. Growth could be sub-optimal within reasonably small subsurface areas, however enhanced availability of food resources may compensate for such potential effects.

4.2.3.6 Coho Salmon

Table 4.2-3(8) presents the thermal evaluation data for coho salmon. Evaluation of thermal effects data differs somewhat for this species from that of the other RIS discussed thus far. Coho salmon are stocked in Lake Ontario as fingerlings and natural reproduction is presumed to be insignificant because of limited available streams with adequate water quality. Reproduction would be expected to occur in streams during the fall. Adults spawn only once and then die after spawning is completed.

Maximum for Survival During Reproductive Season

Using the months of September and October to determine thermal effects, if any, on survival of adults near the Ginna discharge zone, the applicant finds a potential for exclusion from about 78 acres (extending lakeward about 2500 feet) of the surface discharge zone in September (assumes an ambient of 17.7^{o}C (63.8^{o}F). In October, coho could be theoretically excluded from an area 5.6 acres in size (extending lakeward about 900 feet).

Because of its vertical configuration, the discharge zone should not pose a barrier to coho migrating through the Ginna area. Coho could pass under all but about 7 acres of the plume near the bottom. The area of thermal exclusion contains the previously discussed scour zone (maximum 5.2 acres).

Maximum for Summer Survival

Coho salmon are reported to inhabit colder offshore waters near the thermocline in summer, and are not expected to encounter the discharge zone, or warm nearshore waters in general, at this time.

Optimum Growth

The optimum growth temperature for juvenile coho salmon may be exceeded within about 58 percent (101.6 acres) of the surface discharge zone in June and October. At the six foot depth region of the discharge zone, there is a potential for suboptimal growth within about 35 acres (20 percent of the discharge zone), also restricted to June and October.

Acceptable Growth

An acceptable growth temperature was calculated using criteria discussed in the 316(a) Guidance Manual (EPA, 1974). The applicant's analysis demonstrates potential suboptimal growth of juveniles within a small area of 9.6 acres (surface) or 2.7 acres (six foot depths) during both June and October. This assumes a continuous uninterrupted residence of coho within the discharge zone for about 30 days in June and October, an unlikely condition. In all probability, residence time and the potential for impact will be of lesser magnitude.

Reproduction and Maximum for Development

As previously mentioned, the season and temperatures for development and reproduction are not applicable to this stocked species.

Potential for Cold Shock

Coho salmon are excellent swimmers and may encounter the plume area during winter, spring, and fall; they normally avoid warm nearshore waters in summer. For conservative predictive purposes, the applicant assumes coho can achieve acclimation to maximum plume temperatures in the cold months (note preference data in Table 3.3-4). Spigarelli et. al. (1974) report that coho, as well as other salmonids encountering thermal plumes, tend to acquire body temperatures somewhat less than discharge maximum, thus supporting the conservative nature of the applicant's approach and findings. During warmer months coho are expected to inhabit waters near their thermal preferendum, which the applicant presumes to be a maximum 15.6^{o}C (60^{o}F).

Lower lethal temperatures for coho (Table 4.2-4) were interpolated from data provided in Table 4.2-2(7). The data suggest a potential for cold shock during winter months, assuming coho are present. However, a paucity of coho in the applicant's winter fish studies suggests that the extent of impact, associated with a winter shutdown, is expected to be extremely small. No salmonids were observed in the discharge canal (region of maximum plume temperature) during two of the winter months monitored by a TV camera (January and

February) (RG&E, 1976b), and no coho salmon were netted in the February 1975 gill net study (RG&E, 1976a). These observations suggest the Ginna plume is not a strong attractant for coho during at least two, and presumably all three, of the critical winter months.

Summary

In summary, the applicant's evaluation of theoretical thermal impact on coho salmon of Lake Ontario, has demonstrated a low potential for impact on mature forms migrating through the region beneath the discharge zone in late summer and October, and a minimum potential impact on acceptable growth of individuals occupying the discharge zone in spring and fall.

4.2.3.7 Brown Trout

Table 4.2-3(9) presents the thermal evaluation data for brown trout. The brown trout of Lake Ontario is another stocked species whose capability for natural reproduction along the south shore of Lake Ontario is questionable.

Maximum for Parental Survival

Spawning has been recorded to occur primarily in October and November, though mature specimens may enter nearshore waters in September. The sensitivity temperature for parental survival exceeds all temperatures within the Ginna discharge zone during October and November, thus eliminating potential impact during the critical period. There may be possible exclusion of brown trout from about 21 acres of the surface region, or 6 acres of the six foot depths, in September.

Maximum for Summer Survival

Evaluation of potential impacts on brown trout in regard to summer survival, shows a potential exclusion from areas ranging from 60 acres (92 days) to 176 acres (18 days) within the surface waters of the discharge zone, and exclusion within about 20 acres (92 days) to 65 acres (18 days) at the six foot depths. These represent conservative areas based on safe sensitivity temperatures (2^{o}C or 3.6^{o}F below lethal temperatures). Judging from the normal distribution of brown trout in summer (see Section 3.3.9.2.1), and their preference for offshore waters in the temperature range of 10-18^{o}C (50-64.4^{o}F), it appears unlikely that many individuals would encounter the nearshore portions of the discharge zone in summer and be subject to a potential impact; note that ambient nearshore waters in summer (average 18.8^{o}C and maximum 23.9^{o}C) exceed preferred temperatures of brown trout.

In evaluating the data on optimum growth the same rationale as mentioned above applies. Most brown trout are not expected to occupy nearshore waters in summer, thus minimizing the potential for impact on this activity. For what few individuals might reside nearshore, there is a potential for suboptimal growth within 133 acres of the surface region and about 48 acres of the six foot region. During late spring (June) there is a potential for suboptimal growth within a small area of 1.5 and 5.6 acres at the six foot depth and surface, respectively.

Acceptable Growth

In reviewing the acceptable growth temperatures (Table 4.2-3(9)) a decrease in potential impact occurs for those few individuals residing near shore in summer. There is no potential for thermal impact on acceptable growth in late spring (June), when ambient temperature (12.1°C or 53.7°F) is within the preferred range for brown trout.

Reproduction and Development

As previously mentioned, the capability for stocked brown trout to reproduce along the southern shoreline of Lake Ontario is questionable. Therefore the applicant assumes no potential for impact on reproduction and development.

Potential for Cold Shock

Brown trout are also strong swimmers and have been observed in the Ginna discharge canal in fall. Results of gill-net studies at Ginna indicate relatively low densities of brown trout near shore in spring, followed by an absence in July and August, and a maximum seasonal influx during the fall (note Table 3.3-6(7)). A winter survey indicated considerably reduced concentrations relative to the fall period.

For conservative cold-shock evaluation purposes, the applicant will assume brown trout can acclimate to a maximum plume temperature of 15.6°C (60°F) during cold months, and can thermoregulate to a preference temperature of 17.6°C (63.7°F, note Table 3.3-4) in warmer months, excluding July and August when they avoid near-shore waters. In the absence of definitive lower lethal temperatures for brown trout, it appears reasonable to approximate the data utilizing coho salmon data (Table 4.2-2(7))since both species are cold-water members of the Salmonidae, and display similar upper thermal tolerances.

A comparison of lower lethal values and ambient temperatures (Table 4.2-4), indicates a potential for cold-shock effects only during the winter months. This assumes a worst case acclimation to maximum plume temperatures; Spigarelli et al. (1974) found that salmonids do not necessarily acclimate to maximum discharge temperatures, but may thermoregulate to some intermediate elevated temperature. If browns acclimate to 10°C (50°F), their lower lethal temperature would decline to about 1.9°C (35.4°F), and the potential for impact would likewise diminish.

The results of a February 1975 gill-net study at Ginna (RG&E, 1976a), which yielded a total of only five brown trout among 152 m (500 feet) of experimental gill distributed between plume, near plume (E-O), and control locations for 24 hours, would indicate that a large brown trout population is not continually inhabiting the discharge area and thus suggests that the loss of brown trout following an unscheduled winter shutdown would not be measurable.

Summary

In summary, the results of a theoretical impact assessment on brown trout at Ginna suggest no impact on mature specimens occupying nearshore waters in the fall, though there is a possible exclusion from a small area of the discharge zone should some individuals migrate shoreward earlier (September). The potential for impact on growth (optimal and acceptable) is greatly minimized in summer since brown trout occupy waters somewhat offshore within their preferred temperature range. No significant impact is predicted on growth in late spring (June); maximum exclusion area is 5.6 acres. Reproduction and development of this stocked species is not expected to occur to any extent in Lake Ontario; therefore the applicant anticipates no potential for thermal impact on these activities.

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TABLE 4.2-1
AVERAGE MONTHLY AND SEASONAL
INTAKE TEMPERATURES
GINNA NUCLEAR POWER STATION

Month	Average Intake Temperature		Season	Average Seasonal Temperature	
	°C	°F		°C	°F
Jan	1.6	34.9			
Feb	0.9	33.7	Winter	1.3	34.4
Mar	1.5	34.7			
Apr	4.4	40.0			
May	7.6	45.7	Spring	8.1	46.5
June	12.1	53.7			
July	18.7	65.7	Summer	18.8	65.8
Aug	20.0	68.0	10% maximum*	21.1	70.0
Sept	17.7	63.8	5% maximum*	22.2	72.0
			1% maximum*	23.9	75.0
Oct	12.1	53.8			
Nov	8.2	46.8	Fall	8.2	46.8
Dec	4.3	39.7			

NOTE: * Temperature equal to or exceeded 10%, 5%, or 1% of the year, whichever is appropriate.

TABLE 4.2-2(1)
RIS TEMPERATURE DATA SHEET
CLADOPHORA AND GAMMARUS

	Acclimation Temperature		Juvenile	Adult	Data Source
I. Lethal threshold:					
Upper					
Cladophora				26.1-32.2°C	Storr & Sweeney, 1971, Observations in Ginna Discharge
Gammarus				31.0°C	Sprague, 1963
			>26.0°C		Clemens, 1950
II. Growth:					
Optimum and range					
Cladophora				18.0°C*	Storr & Sweeney, 1971
Gammarus			~25.0°C	20.0°C	Clemens, 1950
		Optimum	Range	Month(s)	
III. Reproduction:					
Cladophora		18.0°C	4.0-18.3°C	Spring, early summer, and fall	Storr & Sweeney, 1971
Gammarus		~26.0°C	<5.0->26.0°C	Late March-late October	Clemens, 1950
Incubation and hatch		~26.0°C	<5.0->26.0°C		Clemens, 1950

NOTE: * Very conservative upper limit for optimal growth.

TABLE 4.2-2(2)
TEMPERATURE DATA SHEET
RIS FISH

SPECIES: Alewife (Alosa pseudoharengus)

	Acclimation Temperature	Larvae	Juvenile	Adult	Data Source
I. Lethal threshold:					
Upper	16.5°C			27.5°C***	Reutter & Herdendorf, 1974, P. 14
	16.5°C		(CTM)	28.5°C	"
	16.3°C			27.3°C**	"
	10.0-12.0°C		26.5		Otto et. al. 1976, Table 2
	18.0-20.0°C		30.0		"
	24.0-26.0°C		32.0		"
	10.0			23.0°C	"
	15.0			23-24.0°C	"
	20.0			24-25.0°C]	"
	27-28°C			33.3°C	Carlander, 1970, p.75
Lower	17.0°C			7.0°C*	USDI, 1970
II. Growth:					
Optimum and range				22.7°C	USDI, 1970
				>18.4°C	Carlander, 1970, P. 73

		Optimum	Range	Month(s)	Data Source
II. Reproduction:					
Migration					
Spawning		22.8°C	15.6-27.7°C		Christianson & Tichenor, 1968
			13.0-27.0°C	April to early August	Carlander, 1970, P. 74
Incubation and hatch		17.8°C	6.9-29.4°C		Edsall, 1970, P. 378 (optimum)
			13.0-23.0°C		Carlander, 1970, P. 74 (range)

* LD-50.
** Alive but stressed.
*** Lethality <50%.

TABLE 4.2-2(3)
TEMPERATURE DATA SHEET
RIS FISH

SPECIES: American Smelt (*Osmerus mordax*)

	Acclimation Temperature	Larvae	Juvenile	Adult	Data Source
I. Lethal threshold:					
Upper	6.0°C		(CTM)	24.9°C	Reutter & Herdendorf, 1974, P. 19, L. Erie
	Not given			21.5-28.5°C	Carlander, 1970, P. 314 (Marine specimens)
Lower					
II. Growth:					
Optimum and range			>18.4°C		Carlander, 1970, P. 314
				3.9-10.6°C	Bell, 1973, Chapter II, Table B
III. Reproduction:		Optimum	Range	Month(s)	
Migration			8.9-18.3°C		Scott & Crossman, 1973, P. 314
Spawning			2.2-14.5°C	April to June, as late as July	Hale, 1960, L. Superior
			8.9-18.3°C		Scott & Crossman, 1973
Incubation and hatch		8.3°C	19-20 days at 5-8°C, 10 days at 15.0°C		Bell, 1973, Chapter II (optimum) Table D; Carlander, 1970, P. 315 (range)

TABLE 4.2-2(4)
TEMPERATURE DATA SHEET
RIS FISH

SPECIES: Spottail Shiner (*Notropis hudsonius*)

	Acclimation Temperature	Larvae	Juvenile	Adult	Data Source
I. Lethal threshold:					
Upper	7.2°C			30.6°C	Trembley, 1961, P. 55
	6.0°C			(CTM) 27.6°C	Reutter & Herdendorf, 1974, P. 18, L. Erie
	5.6°C			(CTM) 27.0°C	" "
	5.8°C			(CTM) 27.0°C	" "
	10.0°C			(CTM) 27.9°C	" "
	2.9°C			>13.9°C	" "
Lower	12.0°C			< 1.6°C*	Reutter & Herdendorf, 1974, P. 25, L. Erie
	21.5°C			<11.5°C*	" "
	14.0°C			< 3.0°C*	" "
II. Growth:					
Optimum and range				>18.0°C	Carlander, 1970, P. 426
				23.9°C	Brett, 1944
III. Reproduction:		Optimum	Range	Month(s)	
Migration					
Spawning			20.0°C	June-July	Carlander, 1970, P. 426
Incubation and hatch					

* Specimens alive at temperatures cited, therefore LD-50 is at some lower temperature.

TABLE 4.2-2(5)
TEMPERATURE DATA SHEET
RIS FISH

SPECIES: White Perch (*Morone americana*)

	Acclimation Temperature	Larvae	Juvenile	Adult	Data Source
I. Lethal threshold: Upper	27.8°C			32.8°C	McErlean & Brinkley, 1971, P. 102, estuarine
	28.2°C			33.0°C	" "
	28.5°C			34.4°C*	" "
	4.4°C			27.8°C	Christianson & Tichenor, 1968, P. 42
	17.5°C		27.7°C*		McErlean & Brinkley, 1971, P. 109, estuarine
	10.4°C		27.2°C*		" "
	10.0°C		26.2°C*		" "
	20.3°C		29.2°C*		" "
	28.5°C		33.2°C*		" "
	10.0°C		25.2°C		" "
II. Growth: Optimum and range				24.0°C	Scott & Crossman, 1973, P. 680
III. Reproduction:		Optimum	Range	Month(s)	
Migration				Spring	Sheri, 1968
Spawning		19.1°C	14.4-23.0°C	Mid May-June	
	Max	20.7°C	11.0-15.0°C		Sheri & Power, 1968
Incubation and hatch		15.0°C	15.0-20.0°C		Scott & Crossman, 1973, P. 686

* LD-50

TABLE 4.2-2(6)
TEMPERATURE DATA SHEET
RIS FISH

SPECIES: Smallmouth Bass (*Micropterus dolomieui*)

	Acclimation Temperature	Larvae	Juvenile	Adult	Data Source
I. Lethal threshold: Upper		32.8-35.0°C	32.8°C		Kerr in Coble, 1975, P. 22
	12.8°C			32.2°C	Trembley, 1960
	4.8°C			16.0°C**	Reutter & Herdendorf, 1974, P. 18
	4.8°C			(CTM) 28.0°C	" "
	22.2°C			32.2°C***	" "
	24.1°C			35.2°C***	" "
Lower	12.0°C			1.0°C*	Reutter & Herdendorf, 1974, P. 18
	15.0°C		2.0°C		Horning & Pearson in EPA, 1974, P. 146
	18.0°C		4.0°C		" "
	22.0°C		7.0°C		" "
	26.1°C		10.0°C		" "
		4°C (lower incipient)			Larimore & Duever, 1958, P. 183
II. Growth: Optimum and range		28.0-29.0°C			Peak in EPA, 1974, P. 146
			26-29°C		See summary by Coutant 1975, P. 276
				28.3°C	NAS, 1973

* No mortality after 56 hours.
** Fish normal, no stress
*** Fish died after brief period.

TABLE 4.2-2(6) (Cont'd)

	Optimum	Range	Month(s)	Data Source
II. Reproduction:				
Migration				
Spawning	17.0-18.0°C	13.0-21.0°C	May - July	Breder & Rosen, in EPA 1974 (optimum)
		15.0-18.0°C		Coutant (1975), P. 273
Incubation and hatch		12.8-26.1°C		"

TABLE 4.2-2(7)
TEMPERATURE DATA SHEET
RIS FISH

SPECIES: Coho Salmon (<u>Oncorhynchus kisutch</u>)

	Acclimation Temperature	Larvae	Juvenile	Adult	Data Source
I. Lethal threshold: Upper	5.0°C		23.0°C*		Brett, 1952, P. 301
	10.0°C		24.0°C		"
	15.0°C		24.0°C		"
	20.0°C		25.0°C		"
	23.0°C		25.0°C		"
	10.0°C			21.0°C	Anonymous, in EPA 1974, P. 132
Lower	5.0°C		0.2°C		Brett, 1952, P. 301
	10.0°C		1.9°C		"
	15.0°C		3.5°C		"
	20.0°C		5.0°C		"
	23.0°C		6.0°C		"
II. Growth: Optimum and range					
			15.0°C		GLRL in EPA, 1974, P. 132
			5.0-17.0°C		Averett in EPA, 1974, P. 132
II. Reproduction:		Optimum	Range	Month(s)	
Migration			7.0-16.0°C		Burrows, and anonymous in EPA, 1974, P. 132
Spawning			7.0-13.0°C	Early Sept.-early Oct.	Scott & Crossman, 1973, 161
Incubation and hatch			8.9-10.7°C		"

TABLE 4.2-2(8)
TEMPERATURE DATA SHEET
RIS FISH

SPECIES: Brown Trout (*Salmo trutta*)

	Acclimation Temperature	Larvae	Juvenile	Adult	Data Source
I. Lethal threshold:					
Upper	14.0-18.0°C			25.0°C	Klein, 1962
	26.0°C			26.0°C	"
	5.0-6.0°C		22.5°C		"
	Not given	23.5°C			Bishai in NAS, 1973, P. 160
	20.0°C		23.0°C		Klein, 1962
	Not given			34.0°F	Carter, 1887
II. Growth:					
Optimum and range				18.3-23.9°C	Scott & Crossman, 1973, P. 199
				8.0-17.0°C	Brett in NAS, 1973, P. 160
				12.0-15.0°C	Swift, 1961, P. 598
III. Reproduction:		Optimum	Range	Month(s)	
Migration					
Spawning			6.7-8.9°C	October-November	Scott & Crossman, 1973, P. 199
Incubation and hatch			2.8-12.2°C		Gray, J., 1928
			1.9-11.2°C		Embody, 1934

TABLE 4.2-3(1)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Cladophora glomerata[1]

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Acres[1]	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	May	7.6 (45.7)	22.2 (72.0)	*	0	0	0	Storr & Sweeney, 1971
	June	12.1 (53.7)	22.2 (72.0)	10.1 (18.2)	<5.1	<2.9	30	
	Summer	18.8 (65.8)	22.2 (72.0)	3.4 (6.1)	6.5	3.7	74	
	10% Maximum	21.1 (70.0)	22.2 (72.0)	1.1 (2.0)	10.7	6.1	19	
	5% Maximum	22.2 (72.0)	22.2 (72.0)	**	-	-	18	
	October	12.1 (53.8)	22.2 (72.0)	10.1 (18.2)	<5.1	<2.9	31	
	November	8.2 (46.8)	22.2 (72.0)	*	0	0	0	
Maximum for Summer Survival	Summer	18.8 (65.8)	32.2 (90.0)	*	0	0	0	Observations in Ginna Discharge
	10% Maximum	21.1 (70.0)	32.2 (90.0)	*	0	0	0	
	5% Maximum	22.2 (72.0)	32.2 (90.0)	10.0 (18.2)	<5.1	<2.9	18	
	1% Maximum	23.9 (75.0)	32.2 (90.0)	8.3 (14.9)	<5.1	<2.9	4	
Optimum Growth	May	7.6 (45.7)	18.0 (64.4)	10.4 (18.7)	<5.1	<2.9	31	Storr & Sweeney, 1971
	June	12.1 (53.7)	18.0 (64.4)	5.9 (10.6)	<5.1	<2.9	30	
	Summer	18.8 (65.8)	18.0 (64.4)	**	-	-	92	
	October	12.1 (53.8)	18.0 (64.4)	5.9 (10.6)	<5.1	<2.9	31	
	November	8.2 (46.8)	18.0 (64.4)	9.8 (17.6)	<5.1	<2.9	30	
Maximum for Development	Not applicable							
Normal Reproduction Dates and Temperature	May	7.6 (45.7)	18.0 (64.4)	10.4 (18.7)	<5.1	<2.9	31	Storr & Sweeney, 1971
	June	12.1 (53.7)	18.0 (64.4)	5.9 (10.6)	<5.1	<2.9	30	
	Summer	18.8 (65.8)	18.0 (64.4)	**	-	-	92	
	October	12.1 (53.8)	18.0 (64.4)	5.9 (10.6)	<5.1	<2.9	31	
	November	8.2 (46.8)	18.0 (64.4)	9.8 (17.6)	<5.1	<2.9	30	

NOTE: * No Δt exceeds sensitivity temperature at this time.
** Ambient lake temperature is equal to or greater than sensitivity temperature at this time.
1. Evaluation for Cladophora based on bottom contact region.

TABLE 4.2-3(2)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Gammarus fasciatus

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	Spring	8.1 (46.5)	28.2 (82.8)	*	0	0	0	Sprague 1963, p. 401 & 408.
	Summer	18.8 (65.8)	31.0 (87.8)	*	0	0	55	
	10% Maximum	21.1 (70.0)	31.0 (87.8)	9.9 (17.8)	<5.1	<2.9	37	
	5% Maximum	22.2 (72.0)	31.0 (87.8)	8.8 (15.8)	<5.1	<2.9	18	
	1% Maximum	23.9 (75.0)	31.0 (87.8)	7.1 (12.8)	<5.1	<2.9	4	
	October	12.1 (53.8)	29.0 (84.2)	*	0	0	0	
Maximum for Summer Survival A[1]	Summer	18.8 (65.8)	29.7 (85.5)	*	0	0	0	Sprague 1963, p. 401.
	10% Maximum	21.1 (/0.0)	31.0 (87.8)	9.9 (17.8)	<5.1	<2.9	37	
	5% Maximum	22.2 (72.0)	31.0 (87.8)	8.8 (15.8)	<5.1	<2.9	18	
	1% Maximum	23.9 (75.0)	31.0 (87.8)	7.1 (12.8)	<5.1	<2.9	4	
					<			
E & I[2]	Summer	18.8 (65.8)	26.0 (78.8)	7.2 (13.0)	<5.1	<2.9	92	
	10% Maximum	21.1 (70.0)	26.0 (78.8)	4.9 (8.8)	<5.1	<2.9	37	
	5% Maximum	22.2 (72.0)	26.0 (78.8)	3.8 (6.8)	5.1	2.9	18	
	1% Maximum	23.9 (75.0)	26.0 (78.8)	2.1 (3.8)	9.3	5.3	4	
Optimum Growth A[1]	June	12.1 (53.8)	20.0 (68.0)	7.9 (14.2)	<5.1	<2.9	30	Clemens 1950, p. 35
	Summer	18.8 (65.8)	20.0 (68.0)	1.2 (2.2)	10.7	6.1	55	
	10% Maximum	21.1 (70.0)	20.0 (68.0)	**	-	-	-	
	October	12.1 (53.8)	20.0 (68.0)	7.9 (14.2)	<5.1	<2.9	30	

TABLE 4.2-3(2) (Cont'd)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Gammarus fasciatus

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Optimum Growth I[3]	Summer	18.8 (65.8)	25.0 (77.0)	6.2 (11.2)	<5.1	<2.9	92	Clemens 1950, p. 35
	10% Maximum	21.1 (70.0)	25.0 (77.0)	3.9 (7.0)	5.1	2.9	37	
	5% Maximum	22.2 (72.0)	25.0 (77.0)	2.8 (5.0)	7.9	4.5	18	
	1% Maximum	23.9 (75.0)	25.0 (77.0)	1.1 (2.0)	10.7	6.1	4	
Maximum for Development, Reproduction Dates and Temperatures	Summer	18.8 (65.8)	26.0	7.2 (13.0)	<5.1	<2.9	92	Clemens 1950, p. 52
	10% Maximum	21.1 (70.0)	26.0	4.9 (8.8)	<5.1	<2.9	37	
	5% Maximum	22.2 (72.0)	26.0	3.8 (6.8)	5.1	2.9	18	
	1% Maximum	23.9 (75.0)	26.0	2.1 (3.8)	9.3	5.3	4	

NOTE: * No Δt exceeds sensitivity temperature at this time.
** Ambient lake temperature is equal to or greater than sensitivity temperature at this time.
1. Adults, 2. Eggs and Immatures, 3. Immatures.

TABLE 4.2-3(3)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Alewife (*Alosa pseudoharengus*)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Temperature °C (°F) Sensitivity	Temperature °C (°F) Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	Spring	8.1 (46.5)	22.0 (71.6)	*	0	0	0	Table 4.2-2(2)
	June	12.1 (53.7)	23.0 (73.4)	*	0	0	0	
	July	18.7 (65.7)	"	4.3 (7.7)	59.7	34.0	15	
	6' June	12.1 (53.7)	"	*	0	0	0	
	6' July	18.7 (65.7)	"	4.3 (7.7)	19.4	11.0	15	
	Summer	18.8 (65.8)	28.0 (82.4)	9.2 (16.6)	5.6	3.2	92	Table 4.2-2(2)
	10% Maximum	21.1 (70.0)	28.0 (82.4)	6.9 (12.4)	16.1	9.2	37	
	5% Maximum	22.2 (72.0)	29.0 (84.2)	6.8 (12.2)	16.1	9.2	18	
	1% Maximum	23.9 (75.0)	30.0 (86.0)	6.1 (11.0)	20.9	11.9	4	
Maximum for Summer Survival[1]	6' Summer	18.8 (65.8)	28.0 (82.4)	9.2 (16.6)	1.5	0.9	92	
	6' 10% Maximum	21.1 (70.0)	28.0 (82.4)	6.9 (12.4)	4.6	2.6	37	
	6' 5% Maximum	22.2 (72.0)	29.0 (84.2)	6.8 (12.2)	4.6	2.6	18	
	6' 1% Maximum	23.9 (75.0)	30.0 (86.0)	6.1 (11.0)	6.1	3.5	4	
Optimum Growth	June	12.1 (53.7)	22.7 (72.9)	10.6 (19.1)	2.3	1.3	30	Table 4.2-2(2)
	Summer	18.8 (65.8)	"	3.9 (7.0)	59.7	34.0	92	
	10% Maximum	21.1 (70.0)	"	1.6 (2.9)	175.7	100.0	37	
	October	12.1 (53.8)	"	10.6 (19.1)	2.3	1.3	31	
	6' June	12.1 (53.7)	"	10.6 (19.1)	0.7	0.4	30	
	6' Summer	18.8 (65.8)	"	3.9 (7.0)	19.4	11.0	92	
	6' 10% Maximum	21.1 (70.0)	"	1.6 (2.9)	64.9	36.9	37	
	6' October	12.1 (53.8)	"	10.6 (19.1)	0.7	0.4	31	

TABLE 4.2-3(3) (Cont'd)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Alewife (Alosa pseudoharengus)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Acceptable Growth	Summer	18.8 (65.8)	26.8 (80.2)	8.0 (14.4)	9.6	5.5	92	Table 4.2-2(2)
	10% Maximum	21.1 (70.0)	"	5.7 (10.3)	27.1	15.4	37	
	5% Maximum	22.2 (72.0)	"	4.6 (8.3)	45.8	26.1	18	
	1% Maximum	23.9 (75.0)	"	2.9 (5.2)	101.6	57.8	4	
	6' Summer	18.8 (65.8)	"	8.0 (14.4)	2.7	1.5	92	
	6' 10% Maximum	21.1 (70.0)	"	5.7 (10.3)	8.2	4.7	37	
	6' 5% Maximum	22.2 (72.0)	"	4.6 (8.3)	14.5	8.3	18	
	6' 1% Maximum	23.9 (75.0)	"	2.9 (5.2)	35.2	20.0	4	
Maximum for Development	Spring	8.1 (46.5)	29.4 (84.9)	*	0	0	0	Table 4.2-2(2)
	July	18.7 (65.7)	"	*	0	0	0	
Normal Reproduction Dates and Temperatures	Spring	8.1 (46.5)	27.7 (81.9)	*	0	0	0	Table 4.2-2(2)
	July	18.7 (65.7)		9.0 (16.2)	5.6	3.2	31	

NOTE: * No Δt exceeds sensitivity temperature at this time.
1. For juveniles.

TABLE 4.2-3(4)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: American Smelt (*Osmerus mordax*)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	April-May	6.0 (42.8)	18.3 (64.9)	*	0	0	0	Table 4.2-2(3)
	Summer	18.8 (65.8)	21.0 (69.8)	2.2 (4.0)	133.2	75.8	55	Carlander 1970, p. 314
	10% Maximum	21.1 (70.0)	"	**	-	-	-	
	5% Maximum	22.2 (72.0)	"	"	-	-	-	
	1% Maximum	23.9 (75.0)	"	"	-	-	-	
Maximum for Summer Survival[1]	6' Summer	18.8 (65.8)	"	2.2 (4.0)	47.6	27.1	55	
	6' 10% Maximum	21.1 (70.0)	"	**	-	-	-	
	6' 5% Maximum	22.2 (72.0)	"	"	-	-	-	
	6' 1% Maximum	23.9 (75.0)	"	"	-	-	-	
Optimum Growth Juveniles	Summer	18.8 (65.8)	>18.4 (65.1)	**	-	-	-	
Optimum Growth Adults	Summer	18.8 (65.8)	<10.6 (51.1)	**	-	-	-	Table 4.2-2(3)
Maximum for Development	Spring (Bottom)	8.1 (46.5)	15.0 (59.0)	6.9 (12.4)	<5.1	<2.9	91	Table 4.2-2(3)
Normal Reproduction Dates and Temperature	Winter (Bottom)	1.3 (34.4)	14.5 (58.1)	*	0	0	0	Table 4.2-2(3)
	Spring (Bottom)	8.1 (46.5)	"	6.4 (11.5)	<5.1	<2.9	91	
	Summer (Bottom)	18.8 (65.8)	"	**	-	-	-	

NOTE: 1. Only juveniles subject to impact at this time.
* No Δt exceeds sensitivity temperature at this time.
** Ambient lake temperature is equal to or greater than sensitivity temperature.

TABLE 4.2-3(5)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Spottail Shiner (Notropis hudsonius)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	June	12.1 (53.7)	28.6 (83.5)	*	0	0	0	Table 4.2-2(4)
	July	18.7 (65.7)	28.6 (83.5)	9.9 (17.8)	4.3	2.4	31	
Maximum for Summer Survival	Summer	18.8 (65.8)	28.6 (83.5)	9.8 (17.6)	4.3	2.4	92	Table 4.2-2(4)
	10% Maximum	21.1 (70.0)	"	7.5 (13.5)	12.4	7.1	37	
	5% Maximum	22.2 (72.0)	"	6.4 (11.5)	20.9	11.9	18	
	1% Maximum	23.9 (75.0)	"	4.7 (8.5)	45.8	26.1	4	
	6' Summer	18.8 (65.8)	"	9.8 (17.6)	1.2	0.7	92	
	6' 10% Maximum	21.1 (70.0)	"	7.5 (13.5)	3.5	2.0	37	
	6' 5% Maximum	22.2 (72.0)	"	6.4 (11.5)	6.1	3.5	18	
	6' 1% Maximum	23.9 (75.0)	"	4.7 (8.5)	14.5	8.3	4	
Optimum Growth	Summer	18.8 (65.8)	23.9 (75.0)	5.1 (9.2)	35.2	20.0	92	Table 4.2-2(4)
	10% Maximum	21.1 (70.0)	"	2.8 (5.0)	101.6	57.8	37	
	5% Maximum	22.2 (72.0)	"	1.7 (3.0)	175.7	100.0	18	
	1% Maximum	23.9 (75.0)	"	**	-	-	4	
	6' Summer	18.8 (65.8)	"	5.1 (9.2)	10.9	6.2	92	
	6' 10% Maximum	21.1 (70.0)	"	2.8 (5.0)	35.2	20.0	37	
	6' 5% Maximum	22.2 (72.0)	"	1.7 (3.0)	64.9	36.9	18	
	6' 1% Maximum	23.9 (75.0)	"	**	-	-	4	

TABLE 4.2-3(5)(Cont'd)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Spottail Shiner (Notropis hudsonius)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Acceptable Growth	Summer	18.8 (65.8)	26.1 (79.0)	7.3 (13.1)	12.4	7.1	92	Table 4.2-2(4)
	10% Maximum	21.1 (70.0)	"	5.0 (9.0)	35.2	20.0	37	
	5% Maximum	22.2 (72.0)	"	3.9 (7.0)	59.7	34.0	18	
	1% Maximum	23.9 (75.0)	"	2.2 (4.0)	133.2	75.8	4	
	6' Summer	18.8 (65.8)	"	7.3 (13.1)	3.5	2.0	92	
	6' 10% Maximum	21.1 (70.0)	"	5.0 (9.0)	10.9	6.2	37	
	6' 5% Maximum	22.2 (72.0)	"	3.9 (7.0)	19.4	11.0	18	
	6' 1% Maximum	23.9 (75.0)	"	2.2 (4.0)	47.6	27.1	4	
Maximum for Development	June - July (Avg.) (Bottom)	15.4 (59.7)	20.0 (68.0)	4.6 (8.3)	<5.1	<2.9	61	Table 4.2-2(4)
Normal Reproduction Dates And Temperature	June - July (Avg.) (Bottom)	15.4 (59.7)	20.0 (68.0)	4.6 (8.3)	<5.1	<2.9	61	Table 4.2-2(4)

NOTE: * No Δt exceeds sensitivity temperature at this time.
** Ambient lake temperature is equal to or greater than sensitivity temperature.

TABLE 4.2-3(6)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: White Perch (*Morone americana*)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	Spring	8.1 (46.5)	28.0 (82.4)	*	0	0	0	Table 4.2-2(5)
Maximum for Summer Survival	Summer	18.8 (65.8)	29.6 (85.3)	*	0	0	0	Table 4.2-2(5)
	10% Maximum	21.1 (70.0)	29.9 (85.8)	8.8 (15.8)	5.6	3.2	37	
	5% Maximum	22.2 (72.0)	30.0 (86.0)	7.8 (14.0)	9.6	5.5	18	
	1% Maximum	23.9 (75.0)	30.3 (86.5)	6.4 (11.5)	20.9	11.9	4	
	6' Summer	18.8 (65.8)	29.6 (85.3)	*	0	0	0	
	6' 10% Maximum	21.1 (70.0)	29.9 (85.8)	8.8 (15.8)	1.5	0.9	37	
	6' 5% Maximum	22.2 (72.0)	30.0 (86.0)	7.8 (14.0)	2.7	1.5	18	
	6' 1% Maximum	23.9 (75.0)	30.3 (86.5)	6.4 (11.5)	6.1	3.5	4	
Optimum Growth	June	12.1 (53.7)	24.0 (75.2)	*	0	0	0	Table 4.2-2(5)
	Summer	18.8 (65.8)	"	5.2 (9.4)	35.2	20.0	92	
	10% Maximum	21.1 (70.0)	"	2.9 (5.2)	101.6	57.8	37	
	5% Maximum	22.2 (72.0)	"	1.8 (3.2)	175.7	100.0	18	
	1% Maximum	23.9 (75.0)	"	**	-	-	-	
	6' June	12.1 (53.7)	"	*	0	0	0	
	6' Summer	18.8 (65.8)	"	5.2 (9.4)	10.9	6.2	92	
	6' 10% Maximum	21.1 (70.0)	"	2.9 (5.2)	35.2	20.0	37	
	6' 5% Maximum	22.2 (72.0)	"	1.8 (3.2)	64.9	36.9	18	
	6' 1% Maximum	23.9 (75.0)	"	**	-	-	-	

TABLE 4.2-3(6) (Cont'd)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: White Perch (*Morone americana*)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Temperature °C (°F) Sensitivity	Temperature °C (°F) Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Acceptable Growth	June	12.1 (53.7)	27.5 (81.5)	*	0	0	0	Table 4.2-2(5)
	Summer	18.8 (65.8)	"					
	10% Maximum	21.1 (70.0)	"	8.7 (15.7)	7.4	4.2	92	
	5% Maximum	22.2 (72.0)	"	6.4 (11.5)	20.9	11.9	37	
	1% Maximum	23.9 (75.0)	"	5.3 (9.5)	35.2	20.0	18	
				3.6 (6.5)	77.8	44.3	4	
	6' June	12.1 (53.7)	"	*	0	0	0	
	6' Summer	18.8 (65.8)	"					
	6' 10% Maximum	21.1 (70.0)	"	8.7 (15.7)	2.0	1.1	92	
	6' 5% Maximum	22.2 (72.0)	"	6.4 (11.5)	6.1	3.5	37	
	6' 1% Maximum	23.9 (75.0)	"	5.3 (9.5)	10.9	6.2	18	
				3.6 (6.5)	26.1	14.9	4	
Maximum for Development	Bottom June	12.1 (53.7)	20.0 (68.0)	7.9 (14.2)	<5.1	<2.9	30	Table 4.2-2(5)
Normal Reproduction Dates and Temperature	Bottom Mid-May-June	9.9 (49.8)	15.0 (59.0)	5.1 (9.2)	<5.1	<2.9	30	Table 4.2-2(5)

NOTE: * No Δt exceeds sensitivity temperature at this time.
** Ambient lake temperature is equal to or greater than sensitivity temperature.

TABLE 4.2-3(7)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Smallmouth Bass (*Micropterus dolomieui*)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Temperature °C (°F) Sensitivity	Temperature °C (°F) Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	Spring	8.1 (46.5)	20.7 (69.3)	*	0	0	0	Table 4.2-2(6)
	July	18.7 (65.7)	28.4 (83.1)	9.7 (17.5)	4.3	2.4	15	
Maximum for Summer Survival	Summer	18.8 (65.8)	28.5 (83.3)	9.7 (17.5)	4.3	2.4	92	Table 4.2-2(6)
	10% Maximum	21.1 (70.0)	30.5 (86.9)	9.4 (16.9)	4.3	2.4	37	
	5% Maximum	22.2 (72.0)	31.5 (88.7)	9.3 (16.7)	5.6	3.2	18	
	1% Maximum	23.9 (75.0)	33.2 (91.8)	9.3 (16.7)	5.6	3.2	4	
	6' Summer	18.8 (65.8)	28.5 (83.3)	9.7 (17.5)	1.2	0.7	92	
	6' 10% Maximum	21.1 (70.0)	30.5 (86.9)	9.4 (16.9)	1.2	0.7	37	
	6' 5% Maximum	22.2 (72.0)	31.5 (88.7)	9.3 (16.7)	1.5	0.9	18	
	6' 1% Maximum	23.9 (75.0)	33.2 (91.8)	9.3 (16.7)	1.5	0.9	4	
Optimum Growth	Summer	18.8 (65.8)	28.3 (82.9)	9.5 (17.1)	4.3	2.4	92	Table 4.2-2(6)
	10% Maximum	21.1 (70.0)	"	7.2 (13.0)	12.4	7.1	37	
	5% Maximum	22.2 (72.0)	"	6.1 (11.0)	20.9	11.9	18	
	1% Maximum	23.9 (75.0)	"	4.4 (7.9)	45.8	26.1	4	
	6' Summer	18.8 (65.8)	"	9.5 (17.1)	1.2	0.7	92	
	6' 10% Maximum	21.1 (70.0)	"	7.2 (13.0)	3.5	2.0	37	
	6' 5% Maximum	22.2 (72.0)	"	6.1 (11.0)	6.1	3.5	18	
	6' 1% Maximum	23.9 (75.0)	"	4.4 (7.9)	14.5	8.3	4	

TABLE 4.2-3(7) (Cont'd)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Smallmouth Bass (*Micropterus dolomieui*)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Acceptable Growth	Summer	18.8 (65.8)	30.6 (87.1)	*	0	0	0	Table 4.2-2(6)
	10% Maximum	21.1 (70.0)	"	9.5 (17.1)	4.3	2.4	37	
	5% Maximum	22.2 (72.0)	"	8.4 (15.1)	7.4	4.2	18	
	1% Maximum	23.9 (75.0)	"	6.7 (12.1)	16.1	9.2	4	
	6' Summer	18.8 (65.8)	"	*	0	0	0	
	6' 10% Maximum	21.1 (70.0)	"	9.5 (17.1)	1.2	0.7	37	
	6' 5% Maximum	22.2 (72.0)	"	8.4 (15.1)	2.0	1.1	18	
	6' 1% Maximum	23.9 (75.0)	"	6.7 (12.1)	4.6	2.6	4	
Maximum for Development	(Btm) Spring	8.1 (46.5)	29.0 (84.2)	*				Table 4.2-2(6)
	(Btm) Summer	18.8 (65.8)	"	10.2 (18.4)	<5.1	<2.9	92	
	(Btm) 10% Maximum	21.1 (70.0)	"	7.9 (14.2)	"	"	37	
	(Btm) 5% Maximum	22.2 (72.0)	"	6.8 (12.2)	"	"	18	
	(Btm) 1% Maximum	23.9 (75.0)	"	5.1 (9.2)	"	"	4	
Normal Reproduction Dates and Temperatures	(Btm) May	7.6 (45.7)	21.0 (69.8)	*	0	0	0	Table 4.2-2(6)
	(Btm) June	12.1 (53.7)	"	8.9 (16.0)	<5.1	<2.9	30	
	(Btm) July	18.7 (65.7)	"	2.3 (4.1)	9.3	5.3	31	

NOTE: * No Δt exceeds the sensitivity temperature.

TABLE 4.2-3(8)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Coho Salmon (Oncorhynchus kisutch)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F)				Activity Excluded		
		Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Acres	Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	September	17.7 (63.8)	21.0 (69.8)	3.3 (5.9)	77.8	44.3	30	Table 4.2-2(7)
	October	12.1 (53.8)	21.0 (69.8)	8.9 (16.0)	5.6	3.2	31	
Maximum for Summer Survival	Coho salmon reside offshore near the thermocline in summer.							NYSDEC, 1975
Optimum Growth	June	12.1 (53.7)	15.0 (59.0)	2.9 (5.2)	101.6	57.8	30	Table 4.2-2(7)
	Summer	18.8 (65.8)	"	**	-	-	-	
	October	12.1 (53.7)	"	2.9 (5.2)	101.6	57.8	31	
	6' June	12.1 (53.7)	"	2.9 (5.2)	35.2	20.0	30	
	6' Summer	18.8 (65.8)	"	**	-	-	-	
	6' October	12.1 (53.7)	"	2.9 (5.2)	35.2	20.0	31	
Acceptable Growth	June	12.1 (53.7)	20.0 (68.0)	7.9 (14.2)	9.6	5.5	30	Table 4.2-2(7)
	Summer	18.8 (65.8)	"	**	-	-	-	
	October	12.1 (53.7)	"	7.9 (14.2)	9.6	5.5	31	
	6' June	12.1 (53.7)	"	7.9 (14.2)	2.7	1.5	30	
	6' Summer	18.8 (65.8)	"	**	-	-	-	
	6' October	12.1 (53.7)	"	7.9 (14.2)	2.7	1.5	31	
Maximum for Development and Reproduction Dates and Temperatures	Not applicable - stocked species. Spawning occurs in streams, not in the lake.							NYSDEC, 1975

NOTE: ** Ambient lake temperature exceeds sensitivity temperature.

TABLE 4.2-3(9)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Brown Trout (Salmo trutta)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Sensitivity	Isotherm Exceeding Sens. Temp.	Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Maximum for Survival of Parent	September	17.7 (63.8)	24.0 (75.2)	6.3 (11.3)	20.9	11.9	30	Table 4.2-2(8)
	October	12.1 (53.8)	24.0 (75.2)	*	0	0	0	
	November	8.2 (46.8)	24.0 (75.2)	*	0	0	0	
Maximum for Summer Survival	Summer	18.8 (65.8)	23.0 (73.4)	4.2 (7.6)	59.7	34.0	92	Table 4.2-2(8)
	10% Maximum	21.1 (70.0)	23.6 (74.5)	2.5 (4.5)	133.2	75.8	37	
	5% Maximum	22.2 (72.0)	23.7 (74.7)	1.5 (2.7)	175.7	100.0	14	
	1% Maximum	23.9 (75.0)	23.7 (74.7)	**	-	-	-	
	6' Summer	18.8 (65.8)	23.0 (73.4)	4.2 (7.6)	19.4	11.0	92	
	6' 10% Maximum	21.1 (70.0)	23.6 (74.5)	2.5 (4.5)	47.6	27.1	37	
	6' 5% Maximum	22.2 (72.0)	23.7 (74.7)	1.5 (2.7)	64.9	36.9	14	
	6' 1% Maximum	23.9 (75.0	23.7 (74.7)	**	-	-	-	
Optimum Growth	June	12.1 (53.7)	21.1 (70.0)	9.0 (16.2)	5.6	3.2	30	Table 4.2-2(8)
	Summer	18.8 (65.8)	"	2.3 (4.1)	133.2	75.8	55	
	10% Maximum	21.1 (70.0)	"	**	-	-	-	
	6' June	12.1 (53.7)	"	9.0 (16.2)	1.5	0.9	30	
	6' Summer	18.8 (65.8)	"	2.3 (4.1)	47.6	27.1	55	
	6' 10% Maximum	21.1 (70.0)	"	**	-	-	-	

TABLE 4.2-3(9) (Cont'd)
EVALUATION OF THERMAL DATA
FOR RIS

SPECIES: Brown Trout (Salmo trutta)

Biological Activity Considered	Time of Occurrence (Month or Season)	Temperature °C (°F) Ambient	Temperature °C (°F) Sensitivity	Temperature °C (°F) Isotherm Exceeding Sens. Temp.	Activity Excluded Acres	Activity Excluded Percent of Surface Discharge Zone	No. of Days/Yr.	Data Source
Acceptable Growth	June	12.1 (53.7)	22.7 (72.9)	*	0	0	0	Table 4.2-2(8)
	Summer	18.8 (65.8)	"	3.9 (7.0)	59.7	34.0	92	
	10% Maximum	21.1 (70.0)	"	1.6 (2.9)	175.7	100.0	37	
	6' June	12.1 (53.7)	"	*	0	0	0	
	6' Summer	18.8 (65.8)	"	3.9 (7.0)	19.4	11.0	92	
	6' 10% Maximum	21.1 (70.0)	"	1.6 (2.9)	64.9	36.9	37	
Maximum for Development and Reproduction Dates and Temperatures	Not applicable - stocked species. Spawning expected in streams, not in the lake.							

NOTE: * No Δt exceeds the sensitivity temperature.
** Ambient lake temperature is equal to, or exceeds, sensitivity temperature.

TABLE 4.2-4

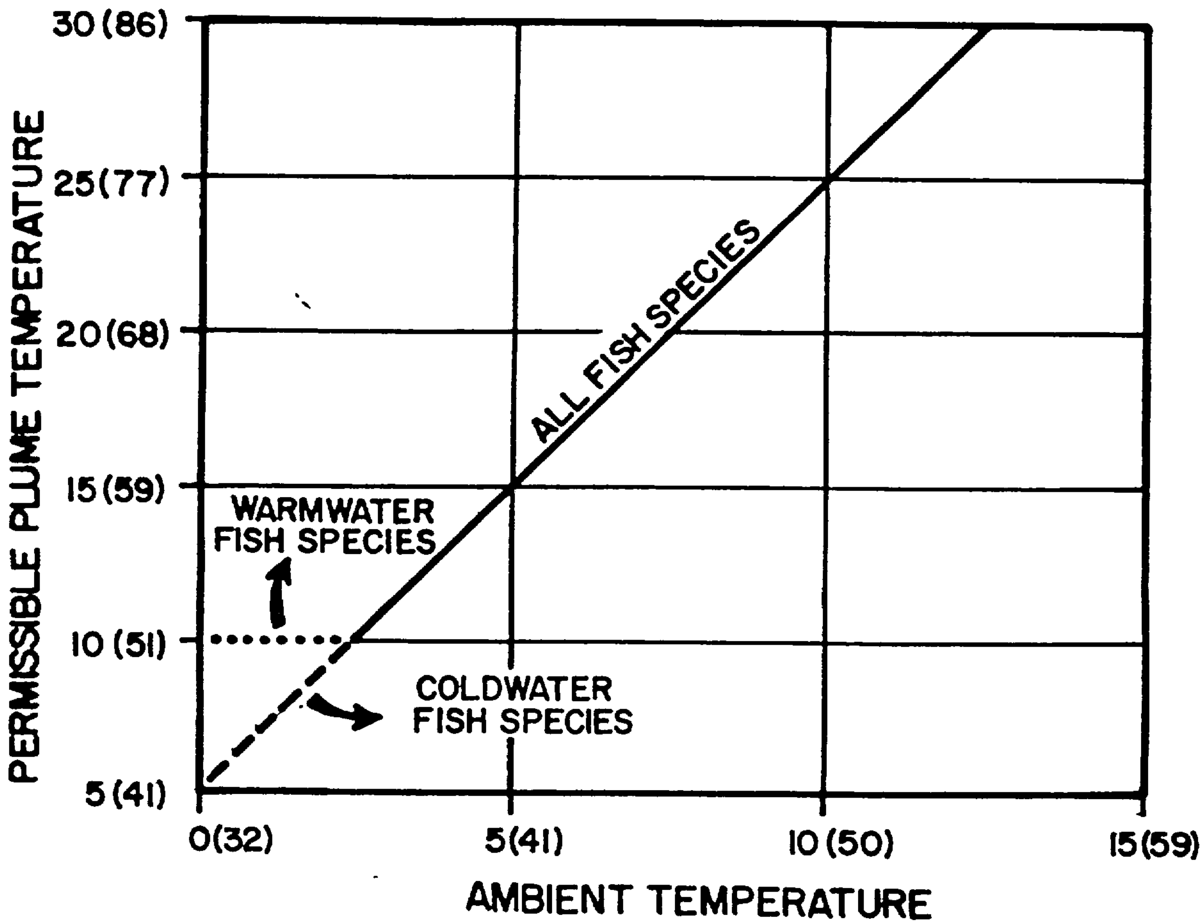
LOWER THERMAL TOLERANCE[1] OF RIS FISH AS RELATED TO DISCHARGE AND AMBIENT WATER TEMPERATURES °C (°F)

	Winter			Spring			Summer			Fall			Data Basis and Comments
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
Average Monthly Discharge Temp.	15.6 (60.0)	15.6 (60.0)	15.6 (60.0)	15.6 (60.0)	18.7 (65.7)	23.2 (73.7)	29.8 (85.7)	31.1 (88.0)	28.8 (83.8)	23.2 (73.8)	19.3 (66.8)	15.6 (60.0)	
Average Monthly Ambient Temp.	1.6 (34.9)	0.9 (33.7)	1.5 (34.7)	4.4 (40.0)	7.6 (45.7)	12.1 (53.7)	18.7 (65.7)	20.0 (68.0)	17.7 (63.8)	12.1 (53.8)	8.2 (46.8)	4.3 (39.7)	
Lower Lethal Temperature for RIS													
Alewife	NA	NA	NA	6.2* (43.2)	7.2 (45.0)	8.7 (47.7)	9.3[2] (48.7)	9.3[2] (48.7)	9.3[2] (48.7)	8.7 (47.7)	7.4 (45.3)	6.2* (43.2)	interpolated from LD_{50}'s in Table 4.2-2(2)
Smelt	5.3* (41.5)	5.3* (41.5)	5.3* (41.5)	5.3* (41.5)	6.9 (44.4)	9.1 (48.4)	NA	NA	NA	9.1 (48.4)	7.2 (45.0)	5.3* (41.5)	EPA(1974)nomograph, acclimation to maximum discharge
Spottail Shiner	<1.6 (34.9)	<1.6* (34.9)	<1.6 (34.9)	3.3 (37.9)	3.3 (37.9)	8.7 (47.7)	8.7 (47.7)	8.7 (47.7)	8.7 (47.7)	8.7 (47.7)	3.3 (37.9)	3.3 (37.9)	these values exceed LD_{50}'s see Table 4.2-2(4)
White Perch	∿0.9 (33.6)	∿0.9* (33.6)	∿0.9 (33.6)	∿0.9 (33.6)	3.8 (38.8)	6.1 (43.0)	9.4 (48.9)	10.0 (50.0)	8.9 (48.0)	6.1 (43.0)	4.1 (39.4)	∿0.9 (33.6)	EPA(1974)nomograph and other (see Section 5.4.4) acclimation to ambient+5°C
Smallmouth Bass	NA	NA	NA	2.5 (36.5)	5.3 (41.5)	8.1 (46.6)	13.9 (57.0)	14.4 (57.9)	12.4 (54.3)	8.1 (46.6)	5.8 (42.4)	2.5 (36.5)	interpolated from Table 4.2-2(6)
Coho Salmon	3.7* (38.7)	3.7* (38.7)	3.7* (38.7)	3.7 (38.7)	3.7 (38.7)	3.7 (38.7)	NA	NA	NA	3.7 (38.7)	3.7 (38.7)	3.7 (38.7)	acclimation does not exceed 15.6°C, lower lethal based on Table 4.2-2(7)
Brown Trout	3.7* (38.7)	3.7* (38.7)	3.7* (38.7)	3.7 (38.7)	4.1 (39.4)	4.1 (39.4)	NA	NA	4.1 (39.4)	4.1 (39.4)	3.7 (38.7)	3.7 (38.7)	based on coho data Table 4.2-2(7)

Note: NA = Not Applicable at this time because most of the population is located offshore and not subject to plume influence.

* = Lower lethal temperature exceeds average monthly ambient temperature, thus signifying a potential for cold shock.

1. Variously based assuming acclimation to either maximum discharge temperature, preference temperature, or some other value associated with plume penetration; see text, Section 4.2, for a complete account and evaluation.
2. Based on summer preference temperature of 25°C for juveniles; adults will be offshore by mid-August.



NOMOGRAPH TO DETERMINE
THE MAXIMUM WEEKLY
AVERAGE TEMPERATURE OF
PLUMES FOR VARIOUS
AMBIENT TEMPERATURES °C (°F)

RG&E ROCHESTER GAS AND ELECTRIC
THE STERLING POWER PROJECT

FIGURE 4.2-1

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CHAPTER 5: ASSESSMENT OF ADDITIONAL PLUME EFFECTS

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5.1 PLUME ENTRAINMENT

5.1.1 HYDROLOGICAL DISCUSSION

The flow rate within any vertical plume cross section can be calculated from a knowledge of the discharge characteristics and the temperature and velocity distributions. Since virtually all of the temperature decay in the near field plume is a result of mixing with the ambient, the local temperature excess also tells one the ratio of total flow to discharge flow. That is,

$$D = \frac{\Delta T_o}{\overline{\Delta T}} = \frac{Q_t}{Q_d} \quad (1)$$

where

D = average dilution in cross section

ΔT_o = discharge excess temperature

$\overline{\Delta T}$ = average cross sectional excess temperature

Q_t = total plume flow rate through cross section

Q_d = discharge flow rate

The portion of the flow that is water entrained by the plume can be calculated from,

$$Q_e = Q_t - Q_d \quad (2)$$

where

Q_e = portion of plume flow rate through cross section which is entrained water.

The average temperature in a plume cross section can be found by assuming that the plume excess velocity has the same lateral distribution as the excess temperature, where the lateral excess temperature distribution is given by:

$$\Delta T = \Delta T_c \exp\left(-\frac{r^2}{2\sigma^2}\right) \qquad (3)$$

where

r = lateral distance from the centerline

ΔT_c = centerline excess temperature

ΔT = excess temperature at lateral distance r from centerline

σ = Gaussian standard deviation $\left(= \frac{r_h}{\sqrt{2 \ln 2}}\right)$

r_h = plume half width (see Section 1.4.1.1.4.4).

The average temperature in any horizontal plane is then:

$$\overline{\Delta T} = \frac{\int_{-\infty}^{\infty} U_c \exp\left(-\frac{r^2}{2\sigma^2}\right) \Delta T_c \exp\left(-\frac{r^2}{2\sigma^2}\right) dr}{\int_{-\infty}^{\infty} U_c \exp\left(-\frac{r^2}{2\sigma^2}\right) dr} = \frac{\Delta T_c}{\sqrt{2}} \qquad (4)$$

where U_c = excess centerline velocity.

Note that U_c is not present in the result and, therefore, no assumption need be made of its value. Substituting equation 4 into equation 1 yields:

$$Q_t = Q_d \left(\frac{\sqrt{2}\,\Delta T_o}{\Delta T_c} \right) \tag{5}$$

ΔT_o and Q_d are known from the discharge conditions and ΔT_c , as a function of distance along the plume centerline, can be found by the methods given in Section 1.4. Therefore, Q_t is determined.

The fraction of the total flow within a lateral distance of $\pm$ R from the plume centerline can be found from:

$$F_R = \frac{\int_{-R}^{R} U_c \exp\left(-\frac{r^2}{2\sigma^2}\right) dr}{\int_{-\infty}^{\infty} U_c \exp\left(-\frac{r^2}{2\sigma^2}\right) dr} = \text{erf}\left(\frac{R}{\sigma\sqrt{2}}\right) \tag{6}$$

where:

F_R = fraction of plume flow within $\pm$ R of the centerline
R = distance from centerline

Substituting R for r in equation 3, solving for R, and substituting the result in equation 6 yields:

$$F_{\Delta T} = \text{erf}\left(\sqrt{\ln \frac{\Delta T_c}{\Delta T}}\right) \tag{7}$$

where $F_{\Delta T}$ = fraction of plume flow with excess temperature greater than ΔT

Equations 5 and 7 were used to estimate the flow as a function of temperature and distance along the plume centerline. Plume depth was assumed to vary from 10 feet at the end of the zone of flow establishment to six feet at the point where T = 0 in equation 41 of Section 1.4 to zero feet at the point where T = 0 in equation 38 of Section 1.4.

Figure 5.1-1 shows the plume flow versus temperature and centerline distance for the expected spring conditions of Section 1.4.2.5. The plume flow exposed to excess temperatures of $3^{o}F$ or higher is seen to reach a maximum of 3300 cfs at approximately 2000 feet along the plume's trajectory. This represents 69% of the total plume flow of 4800 cfs at this point. The discharge flow is 891.2 cfs. This means the entrainment flow at this point is approximately 3910 cfs, 81% of the total flow. Applying this same percentage to the $3^{o}F$ flow yields approximately 2690 cfs of entrained water exposed to $3^{o}F$ temperatures or higher at a distance of 2000 feet along the plume centerline.

Figure 5.1-2 shows the plume flow versus temperature and centerline distance for the extreme spring conditions of Section 1.4.2.5. The maximum $3^{o}F$ flow is 3700 cfs at 5500 feet along the plume centerline. The total plume flow at this point is 7300 cfs, 88% of which is entrained water. The $3^{o}F$ flow at this point can therefore be estimated as consisting of 88% entrained water, or approximately 3250 cfs.

Of special note is the behavior of the total plume flow curves in Figures 5.1-1 and 2. According to equation 1, the total plume flow approaches infinity as the plume excess temperature approaches zero. This is the behavior indicated in the figures. Realistically, however, when the excess temperature of the plume is small, the plume water is indistinguishable from the ambient. Under such conditions it would be more correct, from the standpoint of impact assessment, to consider the plume flow as decreasing with smaller excess temperatures. It therefore follows that the use of the total plume flow of Figures 5.1-1 and 2 for impact assessment purposes is misleading for small excess temperatures. A more realistic approach would be to consider the flow within a given isotherm, say 3°F, as the plume flow. All water outside of this isotherm can, for practical purposes, be identified as ambient water.

Table 5.1-1 gives 3°F entraining water flow rates for expected and extreme spring conditions. Also included are natural lake flows based on a cross-current of 0.2 fps, a normal value for the site. It can be seen that the expected and extreme spring 3°F entrainment flows are greater than the lake flows out to approximately 1500 and 750 feet from shore, respectively. This indicates the presence of a return flow along the sides of the plume in the near shore region, supplying water of offshore origin for entrainment. Indeed, such a return flow must occur based on conservation of mass principles. The plume is entraining local lake water and transporting it out into the lake. This offshore transport of lake water must be replaced by an equal onshore movement of lake water. The offshore water will, therefore, be the supply of most of the near shore entraining water.

In the offshore regions where the normal lake flow is sufficient to supply the plume with entraining water, the principle of conservation of mass still dictates a current opposite in direction to the plume. Such a countercurrent is usually found under the plume when the plume is not contacting the bottom. Indeed, proof of such an onshore current has been found at the Ginna site, as will be shown in the biological discussion which follows. How much of the entraining water in the offshore region is the normal lake flow and how much is the onshore countercurrent is a matter of conjecture. It should be noted, however, that at offshore locations where the plume is not in contact with the lake bottom, the plume is quite wide and not very deep. Therefore, it is reasonable to presume that most of the water being entrained into the plume is coming from the lower edge of the plume. Since the countercurrent is located beneath the plume, where most of the entrainment is occurring, one can conclude that much of the entraining flow has its origins offshore of the plume area.

5.1.2 BIOLOGICAL ASSESSMENT

For the purposes of determining the numbers of macroinvertebrates and ichthyoplankton entrained into the plume the following assumptions were made:

(1) Only that water which is entrained within the 3°F or greater isotherm could produce a thermal impact on organisms carried along,

(2) Water entrained from the lake flow is the only water assumed to contain organisms, and

(3) that component flowing shoreward as part of a limnetic countercurrent is assumed to be organism free.

With these assumptions in mind, the following methodology was used. Sampling stations along the E-0 transect, running lakeward from the discharge, at 2.5m, 5m, and 8m of water depth correspond to plume centerline distances of 650', 1250' and 2500' respectively. To determine the numbers of organisms entrained, water volumes and organism concentrations were estimated for each of the plume segments 0 to 650', 650' to 1250' and 1250' to 2500'. Concentrations of Gammarus at each station and in the area of the intake were determined from the 1975 Ginna Benthic Report (RG&E, 1977). Concentrations of Larvae and Eggs were determined from the 1974 Study presented in RG&E, (1975), Appendix A74.1-3. From the 1975 Entrainment Report (RG&E, 1977) the average monthly entrainment of Gammarus, Fish Eggs and Fish Larvae as the number per $1000m^3$ of flow, were calculated for the growing season.

This was compared to the concentration of each organism or group found in the vicinity of the intake to determine the ratio of entrainable organisms in the water column to the concentration found around the intake or on the bottom. By extrapolating back to shallower depths (2.5m, 5m and 8m) the probable numbers of each organism, or group, which were available for entrainment within each plume segment were determined and expressed as the number per $1000m^3$ of water. These numbers are listed on Table 5.1-3.

Information contained in Table 5.1-1 was used to calculate the average amount of lake flow water which would be entrained into the 3°F isotherm during a 30 day month for each segment of the plume. Table 5.1-2 lists these flow values. By multiplying the probable concentrations of organisms by the flow values, expected monthly entrainment values for each plume segment, and the total plume were determined. These numbers are presented in Table 5.1-3, and show that the maximum expected entrainment would be 18,970,659 Gammarus, 12,240,910 Fish Eggs, and 1,715,850 Fish Larvae per month from May through September when the organisms are present in the area. During the other months, especially the winter months, plume entrainment of these organisms would approach zero.

Studies of the distribution of *Asellus*, the aquatic sow bug, have shown the presence of a persistent, cold countercurrent flowing shoreward beneath the thermal discharge plume (RG&E, 1977). Concentration of *Asellus* are usually found lakeward of the 12m depth out into 35 to 40m of water. In the 1975 Benthic Report (RG&E, 1977), it is clearly shown that *Asellus* were present beneath the plume in concentrations significantly greater than at the comparable stations along the control transects. This strongly supports the presence of a persistent countercurrent but says nothing of its magnitude. For the purpose of this discussion, it is assumed that this countercurrent is free of any of the representative important species (RIS).

Calculations were made to determine the levels of entrainment expected assuming that 10 percent, 50 percent and 90 percent of the entrained water came from this countercurrent (Table 5.1-4). Although the exact volume of the countercurrent is not known, it is most likely contained within the range of 10 percent to 90 percent of the total entrainment flow. This countercurrent, depending upon its magnitude, could reduce the numbers of entrained organisms significantly as is shown in Table 5.1-4.

Certain factors regarding these entrained organisms are important. First, Gammarus entrained into the plume will never experience sufficient thermal stress to produce a lasting biological effect, sc that the actual numbers entrained have no bearing on their survival. The only effect could be a slight lakeward displacement of their concentrations. However, when viewing this it must be kept in mind that a natural shift in wind direction can displace tons of water several miles offshore, causing a complete replacement of the shore water. Temperature recorders placed on nets around the discharge area and along the control transect have shown temperature changes of 10 to 15°F in a few hours. Second, most of the fish eggs found in the area are assumed to be alewife eggs. These eggs are dimersal, and adhesive when alive. This would indicate that the eggs found within the water column are non-viable. Support is also lent by our finding that eggs from benthic cages at Ginna were successfully hatched in an aquarium, while eggs collected from the water column in the same area were not. This would indicated that very few of the eggs entrained into the plume are viable, greatly reducing the possible impact. Lastly, although the thermal stress information is scant it would appear that only a very small portion of the plume is sufficiently warm enough to thermally stress the fish larvae in the area. This would result in the actual numbers of larvae impacted by plume entrainment being much lower than the numbers entrained into the plume.

The above discussion serves to demonstrate that the actual impact of the plume entrainment is not necessarily reflected in the numbers of entrained organisms, and that the consideration of other factors is important. Taking the aforementioned factors into consideration it is concluded that the actual effects of plume entrainment on the area populations of the RIS are negligible.

TABLE 5.1-1

AMBIENT AND ENTRAINING WATER FLOW RATES

Distance Offshore (feet)	Lake Flow Rate (cfs)	Expected Spring 3°F Entrainment Flow (cfs)	Extreme Spring 3°F Entrainment Flow (cfs)
0	0	0	0
250	80	340	160
500	280	760	330
750	610	1150	620
1000	1030	1530	810
1250	1540	1880	1000
1500	2250	2230	1180
1750	3130	2530	1350
2000	4190	2690	1520
2250	5440	2720	1690
2500	6780	2650	1840

Table 5.1-2

Projected Plume Entrainment of Ichthyoplankton and Macroinvertebrates

Segment of Plume Feet Offshore		Water Entrained m^3/month (≥3°F)	% Local Water Entrained	Local Water Entrained m^3/month
0	650'	72,964,800	48	35,023,104
650'	1250'	65,033,280	82	53,327,289
1250'	2500'	56,505,600	100	56,505,600

Table 5.1-3

Projected Plume Entrainment of Ichthyoplankton and Macroinvertebrates

Organism or Group	Segment of Plume		# Entrainable Per 1000m^3	Expected Entrainment #/month (May - Sept.)
Gammarus	0	600'	288.179	10,092,923
	600'	1250'	138.059	7,362,312
	1250'	2500'	26.819	1,515,424
	Total			18,970,659
Fish Eggs	0	600'	138.6	4,854,202
	600'	1250'	108.0	5,759,347
	1250'	2500'	28.8	1,627,361
	Total			12,240,910
Fish Larvae	0	600'	10.49	367,392
	600'	1250'	11.66	621,796
	1250'	2500'	12.86	726,662
	Total			1,715,850

Table 5.1-4

Projected Plume Entrainment Assuming Various Levels of Countercurrent Mixing

Organism or Group	Maximum Total Monthly Entrainment	10% Countercurrent	50% Countercurrent	90% Countercurrent
Gammarus	18,970,659	17,073,593	9,485,329	1,897,066
Fish Eggs	12,240,910	11,016,819	6,120,455	1,224,091
Fish Larvae	1,715,850	1,544,265	857,925	171,585

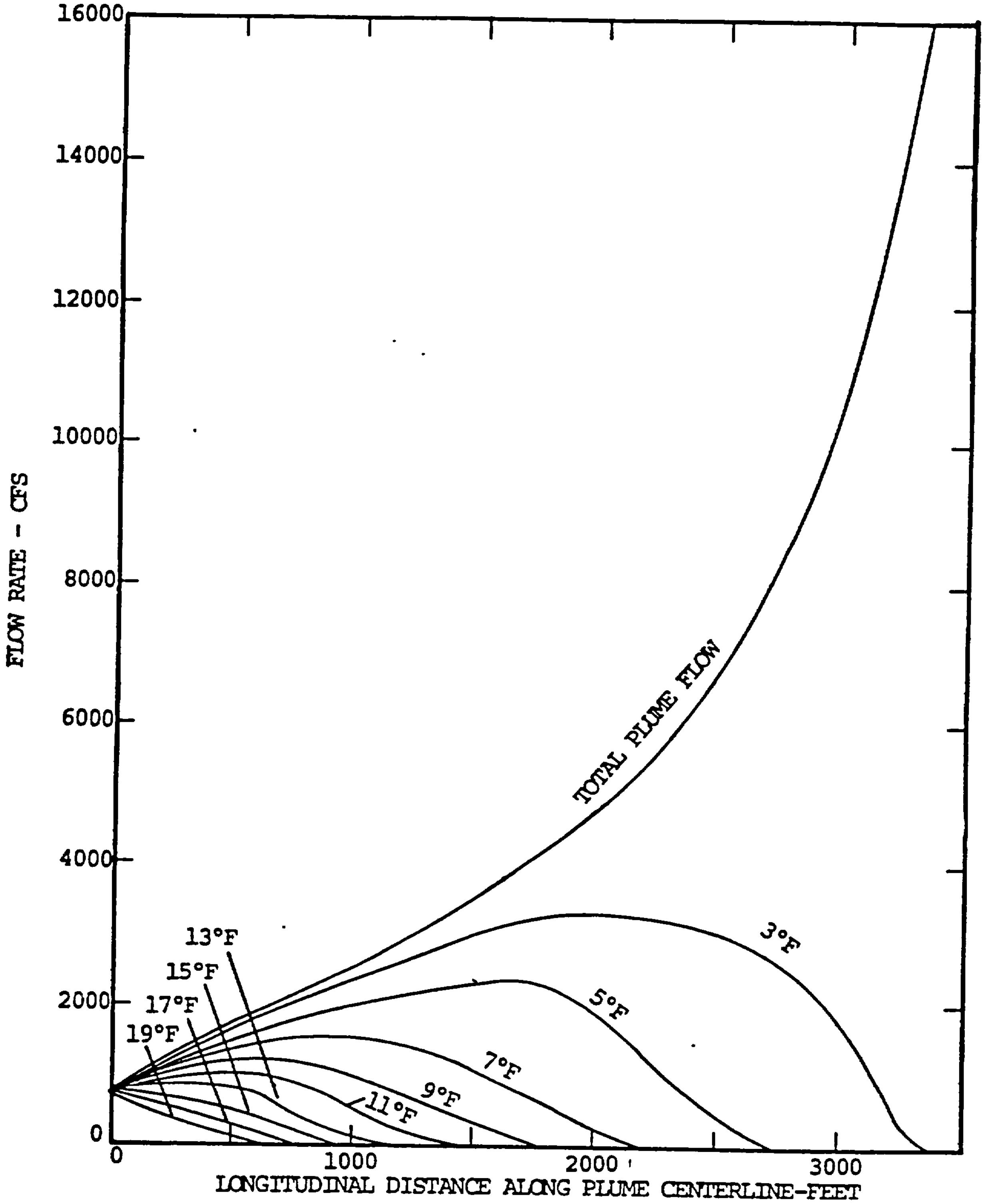

FIGURE 5.1-1
ISOTHERMAL FLOW RATES-EXPECTED SPRING CONDITIONS

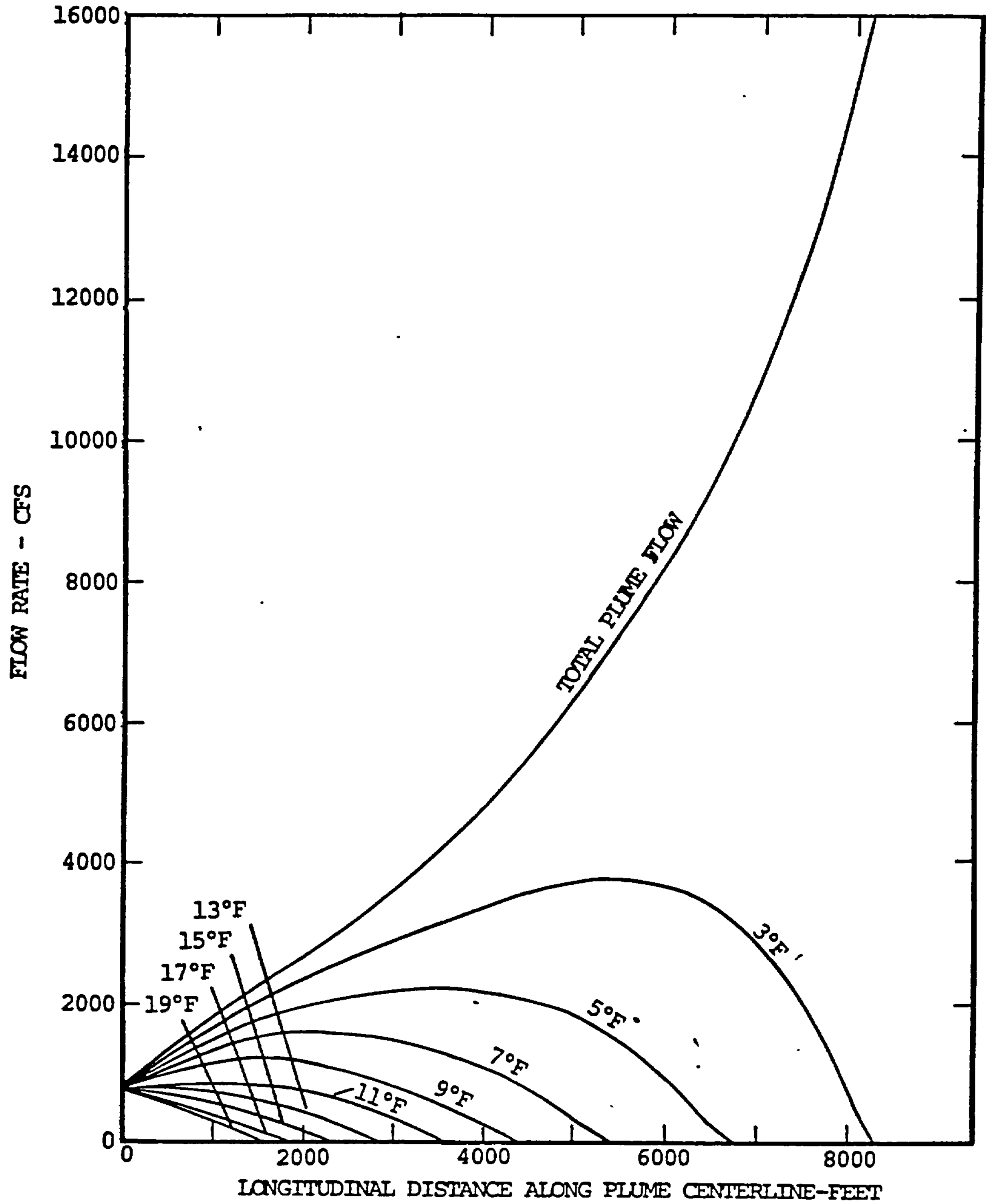

FIGURE 5.1-2
ISOTHERMAL FLOW RATES-EXTREME SPRING CONDITIONS

5.2 EFFECTS ON FISH MIGRATION

A continual tagging effort from 1973 - 1976 has been carried out at Ginna. Additional tagging studies have been conducted in the Nine Mile Point area (NMPC, 1977). From the tag returns for these tagging programs there is enough evidence to determine for some species that the thermal discharge is not a strong attractant. For other species there is insufficient evidence to make a good determination but nevertheless it appears that the thermal discharge does not exert a strong holding power on any species for which there is data. The species concerned here are those which are large enough for tagging purposes and comprise the major portion of the larger fish excluding the salmonids.

The patterns of fish movement and distance of movement often passed one or more thermal discharges and indicates that there is little, if any, interference with shorewise movement of fish. Further, it can be demonstrated that whenever there is heavier wave activity, a common occurrence is that fish move offshore and it is unreasonable to suppose that they are capable of returning shoreward to the same location. Rather the tag return data supports the observation that fish are generally carried eastward by the predominant counterclockwise current in the lake. In the Ginna area only 20% of all species have been recaptured west of the point of tagging. Other research results by Kelso (1974 and 1976) using the sonic tagging technique indicate almost constant movement back and forth along shore. To be sure these studies do indicate that a thermal discharge may attract and hold a fish for a short period of time, but no holding period of greater than 24 hours was recorded.

The following summary of the fish tag returns tagged at the Ginna Nuclear Power Station provides the main supportive evidence indicating unrestricted movement. In these studies more than 3,000 fish were tagged from 1973 through 1976 and from these over 100 fish tag returns were received. Briefly, the results may be summarized as follows:

1) Less than 25% of the fish tag returns were from less than one mile from the point of tagging. If we assume these tag returns are representative of the residents in the area, then it can be said that 75% of the larger fish in the area are moving away and are not held in the area.

2) Looking at the tag return data more closely, only ten tag returns in the area less than one mile were from fish recaptured more than ten days after tagging. If we assume (conservatively) that these represent the resident population in the area, then only 10% of the fish tagged would represent the resident population in the area (of the larger fish). This is based on the assumption that those

fish recaptured in the area less than ten days after tagging will move away.

3) The fish tag returns strongly support the hypothesis that between 75 and 90% of the larger fish are not held by the thermal discharge. One can look at these returns in another way. It can be assumed that 75 to 90% of the larger fish were, in fact, being tagged as they moved past the Ginna discharge.

Experience has indicated that, in fact, a percentage of almost every species of larger fish may remain in one area for long periods of time and since there is movement back and forth along the shore, some fish being recaptured at the Ginna site may, in fact, have returned to the area after a lengthy period of time in some other part of the lake. Certainly this has been demonstrated for yellow perch in other fish tag studies (NMPC, 1977).

Looking at the Ginna fish tag data alone, however, it can be seen that at least 8 of the tag returns were from the area east of Nine Mile Point. Fish tagged at Ginna had moved along the shore eastward past the thermal discharges at Oswego, Nine Mile #1, and possibly Fitzpatrick. There is little reason to assume, therefore, that any type of thermal discharge is preventing fish from moving freely along the shore.

5.3 Potential for Gas Bubble Disease

5.3.1 General Description

Gas bubble disease (GBD) is a collective condition exhibited by fish when exposed for some critical duration to water supersaturated with some critical threshold of dissolved gas. Obvious external symptoms of GBD, reflecting the lodging of gas bubbles in tissue, include emphysema of the fins, cutaneous blisters on the head and in the mouth, emboli in the lateral line, and exophthalmia (bulging eye condition). In addition there are often other less obvious but more fatal internal symptoms of GBD such as accumulations of gas emboli in the heart, ventral aorta, and gills, any of which could lead to anoxia and death (Stroud and Nebeker, 1976).

Susceptibility and sensitivity to GBD appears to vary among species and among different sizes within a single species (Dawley et. al., 1976; Bouck et. al., 1976, Nebeker and Brett, 1976, and Rucker, 1976); salmonids in general exhibit a greater sensitivity, and larger fish (coho 8 to 10 cm) appear less resistant than smaller specimens (3.8-6 cm). Although GBD may not be fatal, it may render fish more susceptible to secondary infections, predation, and less responsive to other environmental stimuli. Depending upon the extent of sublethal symptoms, GBD may be reversed if fish are provided waters with sufficient depth and/or total gas levels at or below saturation; since gas solubility in body tissues increases with water depth, bubbles may be resorbed. Likewise in waters with gas at, or below, saturation levels, the fish can exhaust excess gases dissolved in their tissues, resulting in bubble resorption. Exophthalmia may be reversed, however the eye lens is often permanently displaced rendering the fish blind.

5.3.2 Cause

Nitrogen is suspected of being the prime cause of GBD because it is the least soluble of the three principal gases in water (oxygen, nitrogen, and carbon dioxide), and is not removed from the dissolved state by chemical combination with blood components (Adair and Hains,1974). When fish acclimated to ambient gas saturation levels enter super-saturated waters,there is a net flow of gas across the gill membrane and into the fishes blood. If the fish is unable to metabolize the newly acquired gas (which is especially true for nitrogen) it tends to come out of solution, giving rise to the various bubble-associated, internal and eventually external symptoms. The warming of fish may aggravate internal problems since the solubility of gas is inversely related to temperature.

5.3.3 Threshold Studies

While nitrogen is usually implicated in GBD, recent studies have shown two variables to be particularly crucial in the development of GBD; they are oxygen-nitrogen saturation ratios, and <u>total</u> gas (TG) pressure or saturation (Nebeker et. al., 1976; Rucker, 1976, and Nebeker and Brett, 1976). Experiments with three species of salmonid smolts, at a temperature of 12°C (53.6°F), revealed a lethal threshold of 114.5 percent saturation of total gas (TG) for coho, 113.5 percent for sockeye, and 114 percent for steelhead trout. Ninety-six hour LC50 values were 120.5, 116.7, and 116.0 percent (TG) for coho, sockeye, and steelhead respectively. Non-lethal external symptoms were apparent at a TG level of 110 percent.

For any given TG saturation level, Nebeker et. al. (1976) found a significant decrease in mortality of juvenile sockeye when the ratio of oxygen to nitrogen was increased; however they found much more extensive and severe external signs of GBD at high O_2/N_2 ratios than at low O_2/N_2 ratios, suggesting that oxygen plays a significant part in forming external emphysema and lesions. As an example of ratio effects, 50 percent of the test specimens died after 71 hours at 120 percent TG when O_2/N_2 ratio was 117.2/121.3 percent; however only 7 percent died after 167 hours when the O_2/N_2 ratio was changed to 170.5/107.0 percent. Coho salmon fingerlings respond similarly at a temperature of 13.6°C (56.5°F) and constant TG of 119%; when maintained at an O_2/N_2 ratio of 173/105 percent, 25 percent of the fish died after 34 days, whereas at a ratio of 75/131, 25 percent died in only 2.3 days (Rucker).

The important point of these studies is that supersaturation of waters solely with oxygen, will not be sufficient to produce fatal

GBD; a critical level of nitrogen saturation (109 percent in the case of coho), and a critical level of total gas (TG) saturation, must be achieved.

5.3.4 Case Histories of GBD at Thermal Discharges

Dissolved gas supersaturation in the thermal effluent of a power plant occurs because of the inverse relationship between gas solubility and temperature in water. When intake waters are at or near saturation with oxygen and nitrogen, and subjected to substantial temperature increases as a result of condenser passage,particularly in winter, the discharged waters will become supersaturated with gases. The decrease in ambient pressure between intake and discharge also contributes to supersaturation.

From a purely theoretical standpoint, fish subjected to supersaturated thermal discharge waters for a critical period should contact GBD and succumb. However for various reasons, such as plume avoidance in winter by most fish, short residence time of those that do encounter a plume, sub-critical threshold levels of supersaturation, or some unknown physiological condition, there have been very few reported incidents of fish kills attributed to GBD at power plant discharges (Marcello and Fairbanks, 1976).

There are two often cited, but insufficiently described, cases of fish kills associated with GBD which warrant discussion. The first and most cited case occurred in the heated effluent from Marshall Steam Station, located on Lake Norman, N.C., during the winter months (especially February and March) of 1971 (Miller, 1974; Adair and Hains, 1974). The incidence of GBD was particularly high in 1971 relative to the previous or following winter at that station. A careful examination of the data results in the following important points:

1) Δt values and discharge flows were extremely high in 1971; Δt's were in the range of 13.6 to 15.9^{O}C (24.6-28.6^{O}F) with intake temperatures of 10.6-5.4^{O}C (51.1-41.8^{O}F) from January to March in 1971. This contrasts with Δt's of 10.8-11.5^{O}C (19.5-20.7^{O}F) during the same period in 1972, and 11.6-15.7^{O}C (20.9-28.3^{O}F) in 1970.

2) Average O_2/N_2 saturation ratios of discharge water were 118.7/132.4 percent (maximum critical 111.2/144.2) in the winter of 1971, versus a lower average 119.2/121.3 (maximum critical 124.9/130.6) in 1972.

3) The most sensitive species were white bass (Morone chrysops) and crappies (Pomoxis spp,), with crappies comprising the bulk of the fish kill.

4) Concurrent sampling at other thermal discharges in the general vicinity in 1972, revealed practically no fish (3 out of 1305 captured, and 1 out of 586)

with symptoms of GBD. These other two stations had Δt's ranging from 6.3-12.0^{o}C (11.2-21.6^{o}F) in winter, and N_2 saturation values exceeding 110% during only January.

5) Adair and Hains (1974) conclude that the primary cause of GBD and a fish kill at the Marshall Station in 1971 was the high Δt giving rise to N_2 saturations above 110% over a long period of time.

A second noted case of fish kills and GBD, centers about the substantial mortality of Atlantic menhaden in the discharge canal and plume of Boston Edison Company's Pilgrim Nuclear Power Station (Cape Cod Bay) during April 8-24, 1973 (Marcello and Fairbanks, 1976). The salient features of this case are:

1) discharge temperatures ranged from 13.9-22.8^{o}C (57-73^{o}F), and Δt's ranged from 7.2-12.2^{o}C (13-22^{o}F),

2) O_2 saturation values ranged from 123-142%, unfortunately the most important and likely critical parameters (N_2 saturation and total gas saturation) were not reported,

3) the primary species killed is a marine fish, Atlantic menhaden; studies are being conducted to establish

its tolerance to supersaturated waters, and elucidate possible modifying factors such as physiological stress.

4) a large school of menhaden encountered the same discharge for 1-day in July 1973 when temperatures ranged from 20-27.8°C (68-82°F) and O_2 saturation ranged between 124 and 146 percent. None of the several specimens examined in that study showed external signs of GBD and no deaths were observed in the area.

5.3.5 Potential for GBD at Ginna

Given the above discussion and conditions accompanying actual fish kills due to GBD in other thermal discharges, attention is now directed toward the potential for impacts due to GBD at thermal discharges in the Great Lakes, and in particular at Ginna.

A recent study was reported by Otto (1976) on work conducted at the Waukegan and Zion generating stations on Lake Michigan. Their objective was threefold: (1) determine O_2 and N_2 saturation levels in intake and discharge waters; (2) sample fish in the thermal discharge areas and observe for signs of GBD; and (3) determine experimentally, critical gas saturation levels for yellow perch and rainbow trout. The Waukegan is a fossil-fuel facility with a shoreline intake and discharge system (maximum Δt of 9°C (16.2°F));

Zion Nuclear Station has an offshore submerged intake (7M), and an offshore diffuser discharge (maximum Δt of $11^{o}C$ ($19.8^{o}F$). The following summarizes Otto's findings:

1) during mid-winter when lake waters are coldest ($0^{o}C$) and saturated with gases, supersaturation levels in the Waukegan and Zion discharge waters may be as high as 125 percent and 132 percent, respectively;

2) examination of fish captured in the vicinity of the Waukegan discharge, which included rainbow, brown, and brook trout species, plus coho salmon, northern pike, spottail shiners, carp, and white suckers, showed that all with the exception of carp did not have symptoms of GBD; this is interesting because shiners, carp and suckers inhabit the intake and discharge canals throughout the year. Otto attributes the absence of symptoms to fish having short residence times in the area of potential impact.

3) yellow perch tested in an experimental facility, using heat to produce supersaturation, were unaffected by gas saturation levels as high as 115 percent, and have an 8-day median lethal saturation level of 126 percent; rainbow trout were unaffected by saturation levels of 110 percent, and have an

estimated 8-day median lethal level of 119 percent.

Focusing on the potential for GBD at Ginna, the applicant has conducted fish studies in the winter (both gill netting and with TV monitoring in the discharge canal) (RG&E, 1976 a, 1976 b) to assess the types present and their relative abundance. The major species found in discharge waters during February 25, 1975 were lake chub, gizzard shad, and white perch; a few spottail shiners, one smelt, and one brown trout were also taken. TV monitoring during daylight in January and February revealed mainly gizzard shad, with an occasional cyprinid and white bass. It is obvious that the major winter fish at Ginna do not include those species associated with GBD kills at thermal discharges discussed above. This feature, in conjunction with a general low abundance of fish, and especially few sensitive salmonids, would tend to minimize the potential for GBD impact at Ginna.

None of fish sampled or observed during these two winter months at Ginna had signs of GBD. It is reasonable to assume, in the absence of actual measurements at that time, that discharge waters (temperature of 15.6-16.1°C) were supersaturated with oxygen and nitrogen as a result of decreased pressure (withdrawn from about 8m (26 feet)) and elevated temperatures (about 11-12°C). Yet the findings of no fish with external signs of GBD corroborate those reported by Otto (1976) for the Waukegan and Zion Stations on Lake Michigan. The applicant contends, based on supportive evidence, that relatively few fish occupy the discharge waters during critical winter months, and those few fish encountering the plume region do not occupy the discharge waters for a sufficient period of time to experience GBD.

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