2008 Gulf Island Pond Monitoring Program Report

Maine Department of Environmental Protection

JANUARY 2009

DEPLW-0960

EXECUTIVE SUMMARY

This report is prepared in accordance with Public Law 2005, chapter 409, An Act to Amend Water Quality Standards, which requires that, by February 1 annually from 2006 to 2011, the Maine Department of Environmental Protection (DEP) shall submit a report on the status of activities undertaken pursuant to this Act to the Joint Standing Committee on Natural Resources. In this regard, DEP's activities for 2008 focused on monitoring of the water quality of Gulf Island Pond in the Androscoggin River to assess attainment of Maine's Water Quality Standards, specifically dissolved oxygen criteria necessary to provide 'habitat for fish and aquatic life', and 'support of indigenous species of fish', as well as provide for 'recreation in and on the water' (swimming, i.e. presence of algae blooms).

Aerial flights and water quality monitoring of Gulf Island Pond (GIP) on Maine's Androscoggin River were undertaken by DEP in the summer of 2008. The primary goal of this activity was to continue monitoring initiated in prior years to determine compliance with dissolved oxygen criteria and the presence/absence of algal blooms.

No algal blooms were observed in 2008. The mean total phosphorus concentration was similar to that of 2007, both being significantly lower than in previous years. The mean chlorophyll-a concentration was similar to those of 2005-2007. The maximum chlorophyll-a concentration occurred on June 30 and was slightly above the threshold established for lakes (8 micrograms per liter) but below the interim threshold for GIP (10 micrograms per liter). The peak chlorophyll-a concentration was not contemporaneous with the peak total phosphorus, documenting the importance of additional factors. Secchi disk transparency (SD) readings were also taken, and the mean was similar to those for all prior years when measured, 2004-2007, and was above the 2 m threshold for blooms in lakes for all but one sampling event. A minimum Secchi Disk transparency of 1.7 meters on August 5 was correlated with high seasonal river flow and silt load.

Within Gulf Island Pond, minimum and monthly average dissolved oxygen criteria were met for all sampling dates at Turner Center Bridge and Upper Narrows sampling stations. One or both of the criteria were not met up to 21% of the time for other stations at various depths. Beginning in 2008, the monitoring strategy was changed to collect necessary profile data, measuring temperature and dissolved oxygen at one meter increments from top to bottom at the "deep hole" in Gulf Island Pond every two hours during the summer. Further refinements to dissolved oxygen monitoring will be needed in 2009 in order to accurately assessment attainment at the point of thermal stratification.

These results show improved water quality of Gulf Island Pond since 2004 due to reduced discharges from the mills and since 2007 due to higher river flows. Discharges of phosphorus from Rumford Paper Company continued to be lower than those in 2004, similar to those in 2005-2007, and well within permit limits. Discharges from Verso have are also lower than in 2004 and within permit limits, but have increased since 2007. Nevertheless, even though the phosphorus discharges from the mills are within permit limits, continued non-attainment of Maine's Water Quality Standards document the need for the additional instream aeration as specified in their MPDES permits and Florida Power and Light's Gulf Island Dam hydropower permit 401 water quality certification.

GULF ISLAND POND WATER QUALITY MONITORING REPORT, 2008

Introduction

Water quality monitoring of Gulf Island Pond (GIP) on Maine's Androscoggin River was undertaken by the Maine Department of Environmental Protection (DEP) in the summer of 2008. The primary goal of this activity was to continue monitoring initiated in 2004 and earlier to determine the attainment of Maine's water quality standards (WQS), specifically dissolved oxygen criteria necessary to provide 'habitiat for fish and aquatic life', and 'support of indigenous species of fish', as well as provide for 'recreation in and on the water' (swimming, i.e. presence of algae blooms). A second goal was to gather more data to help determine total phosphorus (TP) and chlorophyll-a (CHLa) thresholds for algal blooms in GIP. And a third goal was to determine the effect of recent reductions in point source discharges on increased attainment of WQS.

An algae bloom in Maine lakes is currently defined as a planktonic growth of algae which causes Secchi disk (SD) transparency to be less than 2 meters (DEP Regulation Chapter 581). However, in waters where color exceeds 30 platinum cobalt units (PCU), Secchi disk transparency may be significantly influenced by color as well as algae. Therefore, for colored waters, such as GIP, CHLa is a better measure of blooms. In lakes, blooms have been associated with CHLa concentrations greater than 8 micrograms per liter (ug/l). Given their higher current velocities, rivers may have higher thresholds of CHLa for blooms. Also, observations of a bloom by the general public include an aspect of visibility, which is affected by light, sky cover, and turbulence (velocity, wind and wave action) on the surface of the water. Although GIP is legally classified as a river, it sometimes acts like a lake or a hybrid of the two where the algae are not uniformly distributed as would be expected in a lake. Therefore, the CHLa threshold for a bloom in GIP may be different, possibly in the range of 8-12 ug/l. The total maximum daily load (TMDL) calculated for GIP, approved by the federal Environmental Protection Agency (EPA) on July 18, 2005, sets a pond average value of 10 ug/l CHLa as the interim threshold. For calculation of the pond average, CHLa will be included only at stations where a bloom has been observed. The TMDL also specifies that annual monitoring should continue to further refine a CHLa threshold for blooms.

Given the uncertainty in knowing the threshold for an algae bloom in GIP, water quality data specific to GIP were collected and correlated to observations of bloom conditions in 2004-2008. Aerial observations of bloom and scum layers were documented visually in conjunction with ambient monitoring of CHLa.

There were four separate monitoring studies in the 2008 program;

1) Aerial flight observations of the presence/absence of wide spread algal blooms,
2) Water quality sampling at the Lower Narrows station during the aerial flights by DEP,
3) Water quality sampling at several stations by the Gulf Island Pond Oxygenation Project (GIPOP) partnership, and
4) Continuous monitoring of temperature and dissolved oxygen at the Turner (Center) Bridge, the deep hole station, and dam station (Figure 1) also by the GIPOP Partnership.

Each of these studies is discussed below. Since studies 2 and 3 monitored the same parameters, they will be discussed together organized by parameter, first by phosphorus, chlorophyll-a, and Secchi disk and then by dissolved oxygen. Also, ancillary data for river flows, oxygen injection, and effluent discharge from other sources are discussed in the first or last sections.

1)._AERIAL FLIGHT OBSERVATIONS

During the summer of 2008, the Maine Department of Environmental Protection (DEP) conducted weekly aerial monitoring of Gulf Island Pond (GIP) and the Androscoggin River to determine the extent and conditions for algae blooms. The aerial monitoring was conducted by DEP staff from a commercial seaplane base on the Androscoggin River in Turner. A four-person, high wing single engine seaplane (SES) was utilized and afforded the opportunity to land on the river to collect water chemistry data at the Lower Narrows (LN) monitoring station and to also collect water column samples at other locations if bloom conditions occurred.

Aerial observations, water column samples and ambient temperature and DO data were collected during each of the weekly monitoring efforts conducted by the Department from June 3 through September 16, except for the weeks July 6 and August 17 when weather or scheduling conflicts prevented monitoring efforts entirely; August 26th and September 10th when water column samples and temperature/DO profile data were not obtained due to adverse weather conditions; and September 16th when water column samples were not collected during the September 16th monitoring event. The seaplane had a scheduled departure from Turner at 10 am and typically flew from Turner to Rumford prior to landing at the Lower Narrows (LN) monitoring station in order to collect water chemistry data. All data were recorded on a standard log sheet.

There were ten locations that were part of the aerial monitoring program (Figure 1). Moving from GIP dam upriver they are denoted as:

(1) Deep Hole-DH
(2) Gulf Island Pond #4-GIP4;
(3) Lower Narrows-LN;
(4) Upper Narrows-UN;
(5) Turner Center Bridge-TCB;
(6) Twin Bridges-TWB;
(7) Androscoggin Lake-AL, and
(8) Dead River Dam-DRD.
(9) Verso Paper discharge –VP
(10) Rumford Paper discharge- RPC

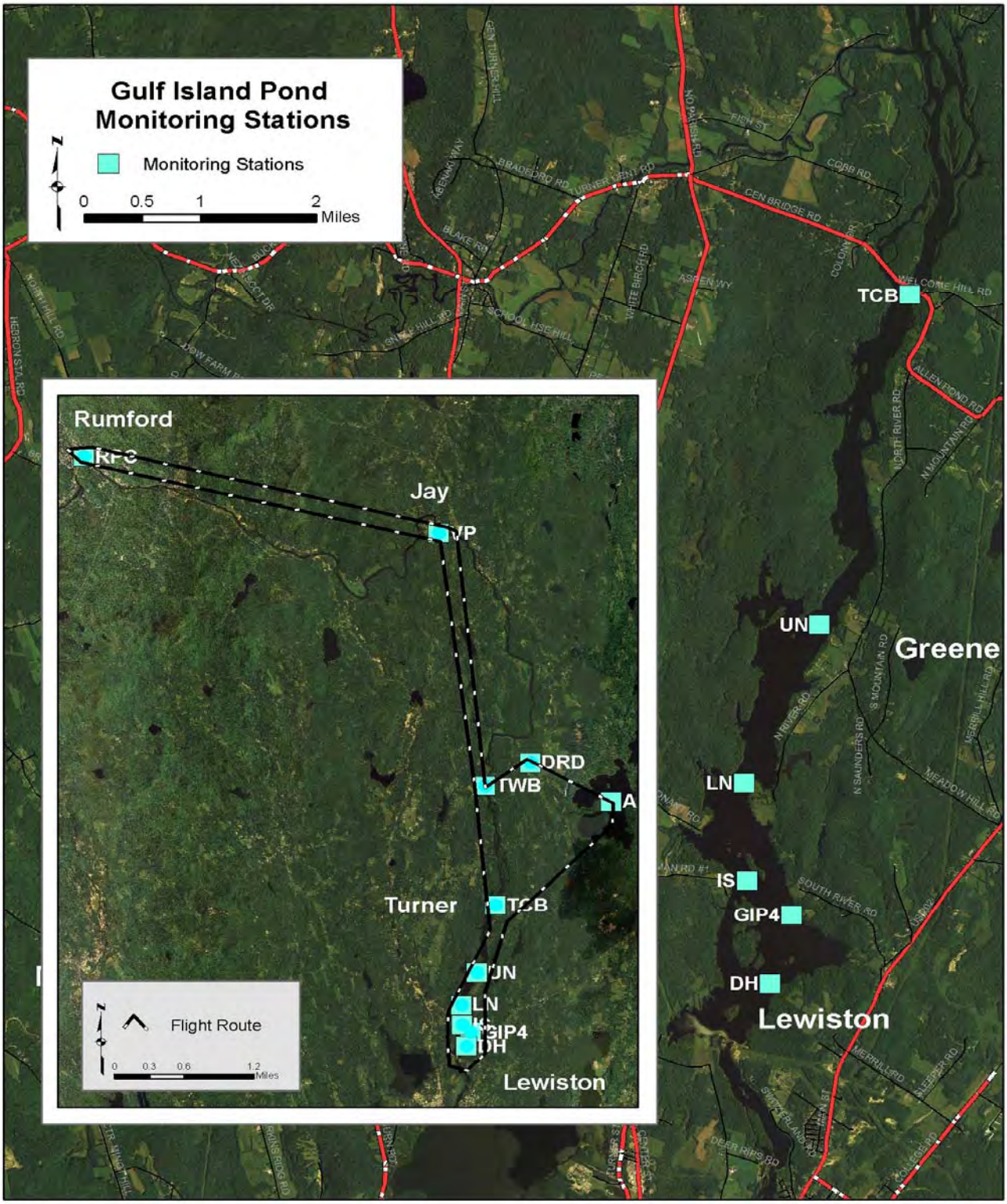
In addition, the monitoring effort included certain locations upriver from Gulf Island Pond in order to determine potential sources of nutrient loading to the watershed. The aerial survey route was northerly to the Upper Narrows monitoring station and northerly along the river to Center Bridge, Androscoggin Lake, Twin Bridges, and then to the paper mills in Jay and Rumford. A southerly route was then taken to the most southerly monitoring stations (Gulf Island Pond monitoring station #4 and to the Deep Hole). At these locations photographs were collected with various aspects in order to collect representative images of the monitoring locations and to collect additional water samples if needed and/or possible based on observations. Digital photographs of the mill discharge outfalls were also taken and compared with reported discharge levels (see the Department's website at http://www.maine.gov/dep/blwq/topic/gip/index.htm). These photos have documented the presence of visible plumes from dischargers on the Androscoggin River. These plumes could possibly represent non-attainment of the recreational designated uses in Maine's Water Quality Standards, which prohibits the *"Discharge of pollutants to waters of the State that imparts color, taste, turbidity, toxicity, radioactivity*

or other properties that cause those waters to be unsuitable for the designated uses and characteristics ascribed to their class;" (Title 38 Ch. 3 §464.4).

No algal blooms were documented from aerial observations during 2008. The river was muddy for many sampling dates when river flow was high.

During times of lower flow, plumes from the mills were evident. An effluent plume from Verso's outfall structure was visible during several of the routine aerial observation flights. Typically, a plume was not visible during periods of high river flow when suspended sediments in the water column were visibly similar to the levels that occur during spring runoff. Depending on the day, the visible plume could be observed from the point of discharge to a point between the north end of Pine Island and just above the Jay Dam. Additionally, an effluent plume from Rumford Paper's outfall structure was visible on several occasions but the observations are best described as "color" rather than suspended solids, which is what the Verso plume appears to be. The RPC plume typically extended to midway between the outfall structure and the footbridge and on one occasion extended to just below the footbridge.

Figure 1. Androscoggin River Aerial Monitoring Stations and Gulf Island Pond monitoring stations



River Flow

Summer of 2008 was wetter than normal. River flow (mean daily discharge) was above the long term median for essentially the entire summer (Figure 2). Although mean river flow for June was within the bounds of recent years, flows in July and August were well above those for all other years since 2004 (Figure 3). Consequently, the mean for the summer was higher than those for all other years since 2004 (Figure 4).

Figure 2. Mean daily discharge

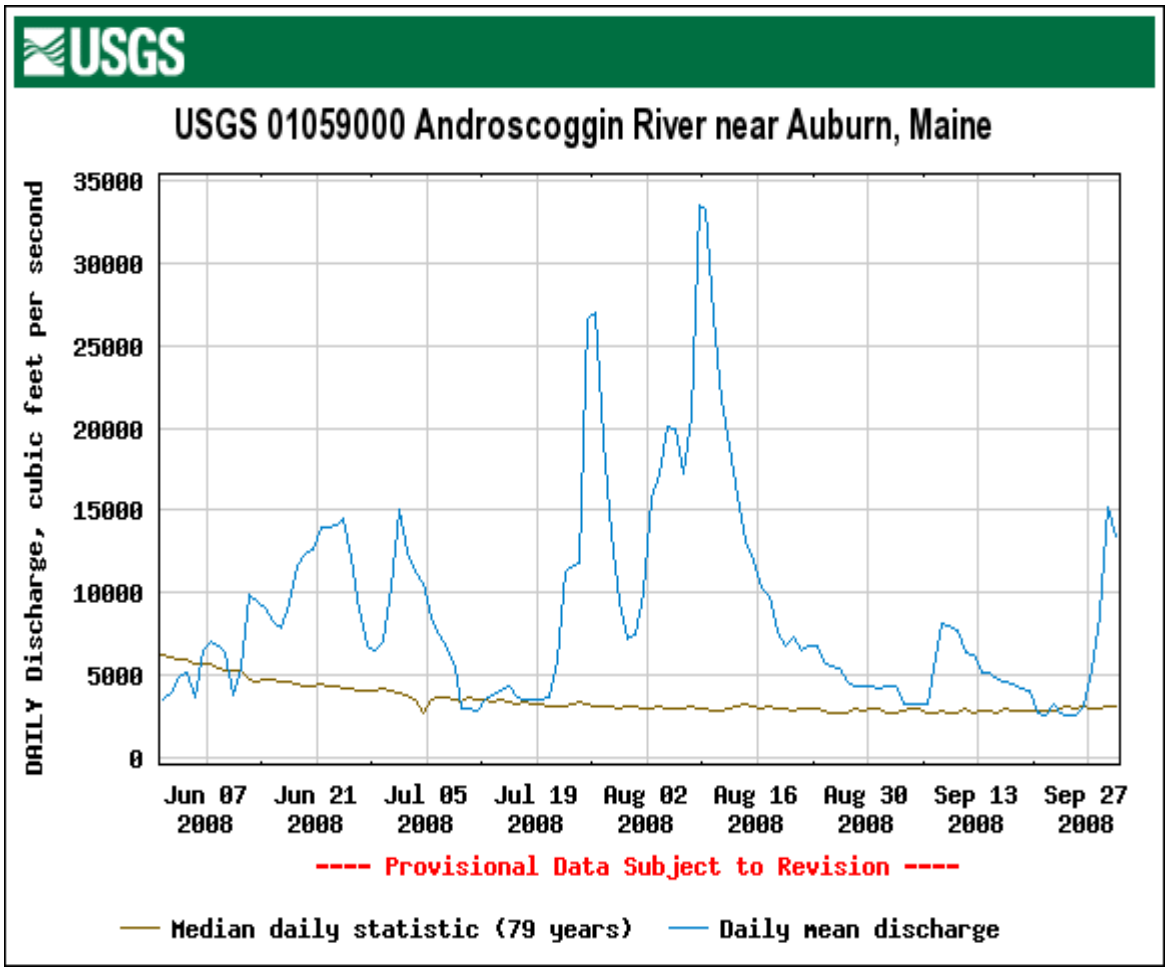


Figure 3. Mean monthly flows (Qr) of the Androscoggin River at Auburn 2004-2008

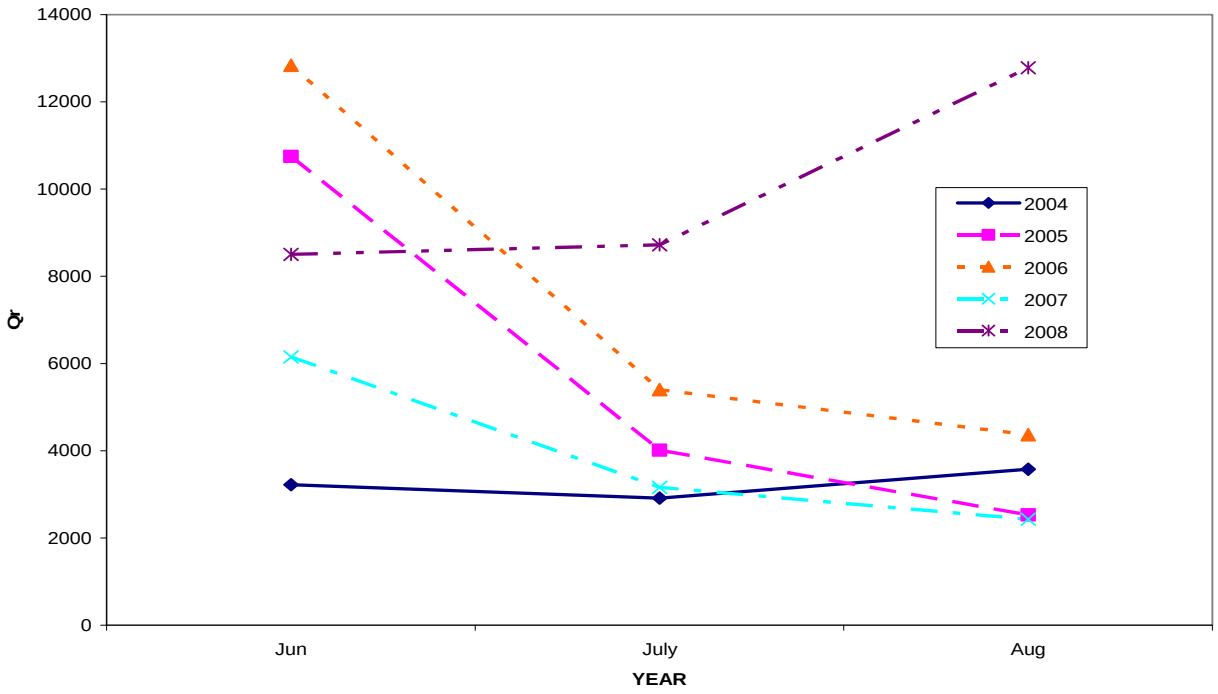
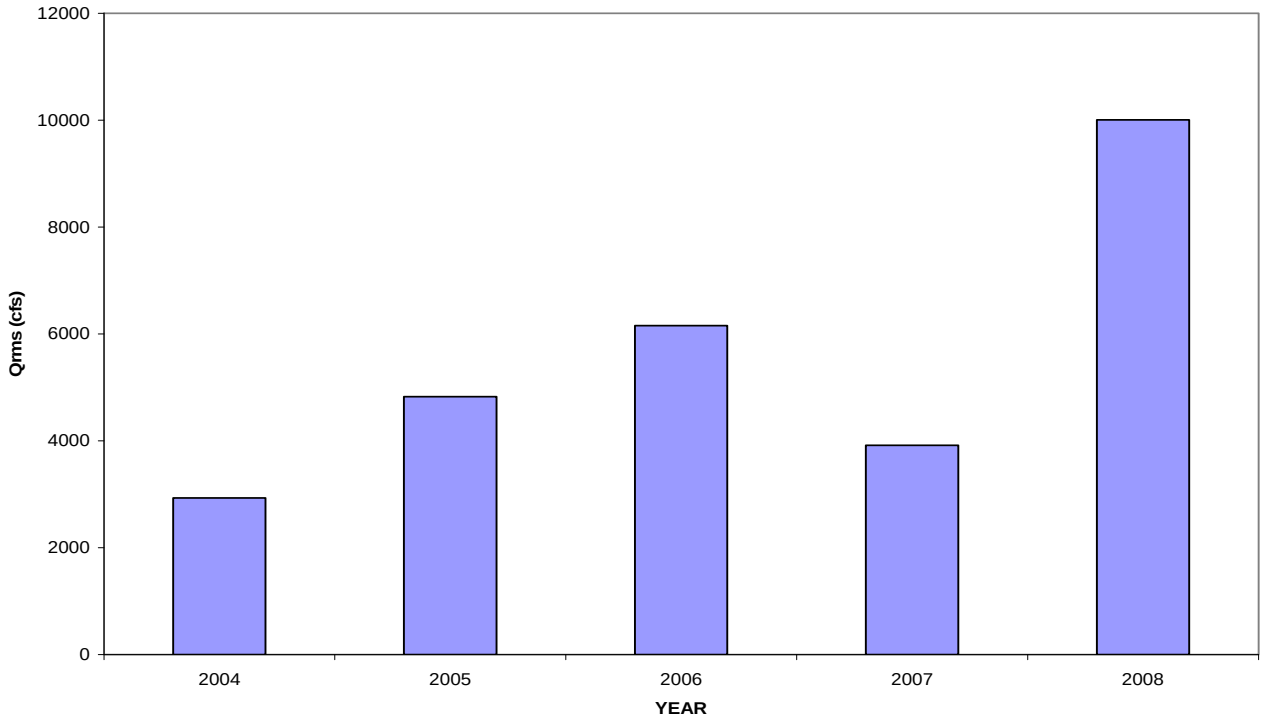


Figure 4. Mean summer flow (Qrms) of the Androscoggin River at Auburn, Maine, 2004-2008



2. RESULTS OF WATER QUALITY SAMPLING AT LOWER NARROWS BY DEP, and
3. RESULTS OF WATER QUALITY SAMPLING AT SIX STATIONS BY ACHERON/GIPOP PARTNERSHIP

Total Phosphorus

DEP Study

DEP collected samples for total phosphorus (TP) weekly at Lower Narrows (LN) during the aerial flights. Additional samples were to be collected at any other locations where a bloom was observed, but no blooms were observed in 2008. The highest TP concentration (24 ug/l) occurred on August 5 (Figure 5). This was coincident with a high runoff event, which might suggest the impact of non-point sources (NPS) of TP (Figure 2). Yet TP was not elevated at a previous high runoff event on July 22 when flow was higher than that on the August event on the respective days of sampling. Nor was TP elevated on July 29 when flows for the preceding week exceeded those for the week preceding the August 5 event. Of these three dates, impact of NPS would be expected to be greatest for the July 22 event, given the long dry antecedent conditions. Compared to uncolored lakes (<30 PCU), in colored lakes (>30 PCU) higher TP is usually required to cause a bloom due to chelation of TP by tannins and lignins responsible for the high color and also due to the limited depth of sunlight penetration to depth. GIP usually has color 40± PCU at summer flows due to the mill discharges. From a regression developed from Maine summer lakes data (n= 3819) with contemporaneous color, TP, and chlorophyll-a data, with a color of 40 PCU an average TP=19 ug/l and TP= 26 ug/l was needed to produce chlorophyll a of 8 ug/l and 10 ug/l (potential bloom levels) respectively, but the correlation coefficient was low, indicating that there is wide variability and that there may be other factors involved. Mean TP for 2008 (18 ug/l) was below both of these values. Mean TP for 2008 was also similar to that of 2007, both of which were slightly but significantly lower than those from 2005 and 2006, and all of which were well below that of 2004 (Figure 6). This is interesting given the higher flows in 2008, which, under constant inputs, should have resulted in higher TP, if NPS was significant, or lower TP from dilution if point-source loads were comparable to earlier years.

Figure 5. Total phosphorus (TP) concentration at Lower Narrows, GIP, 2008

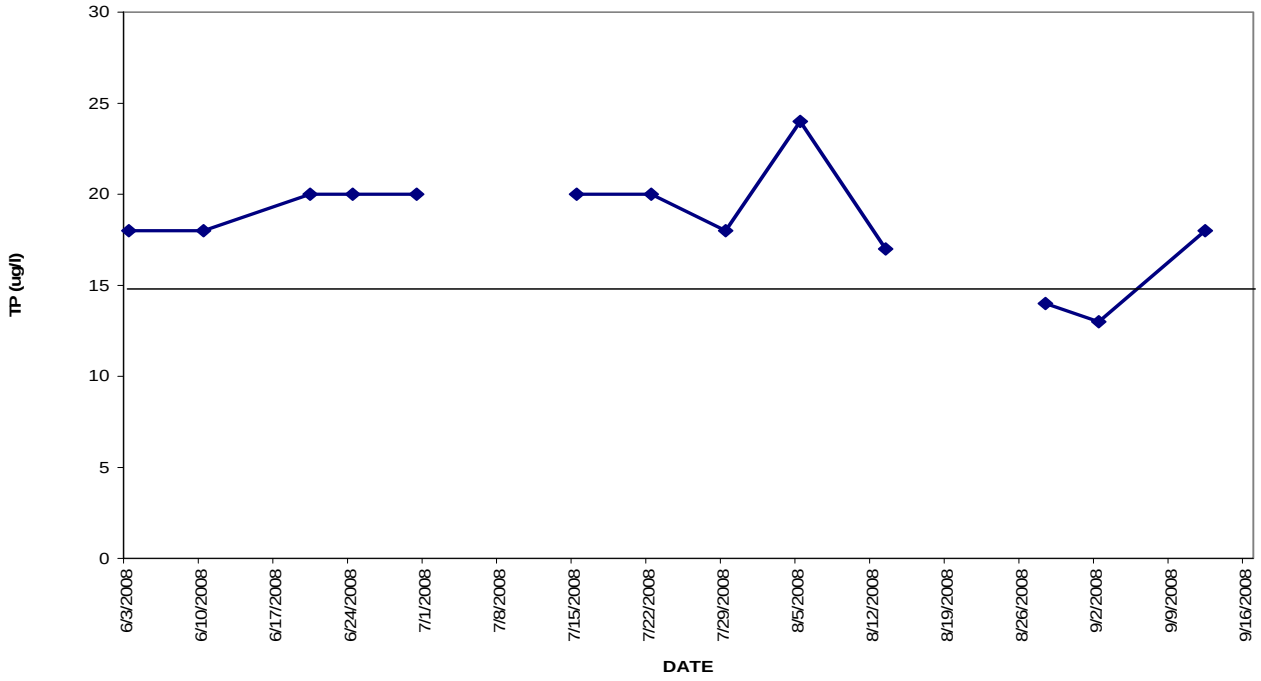
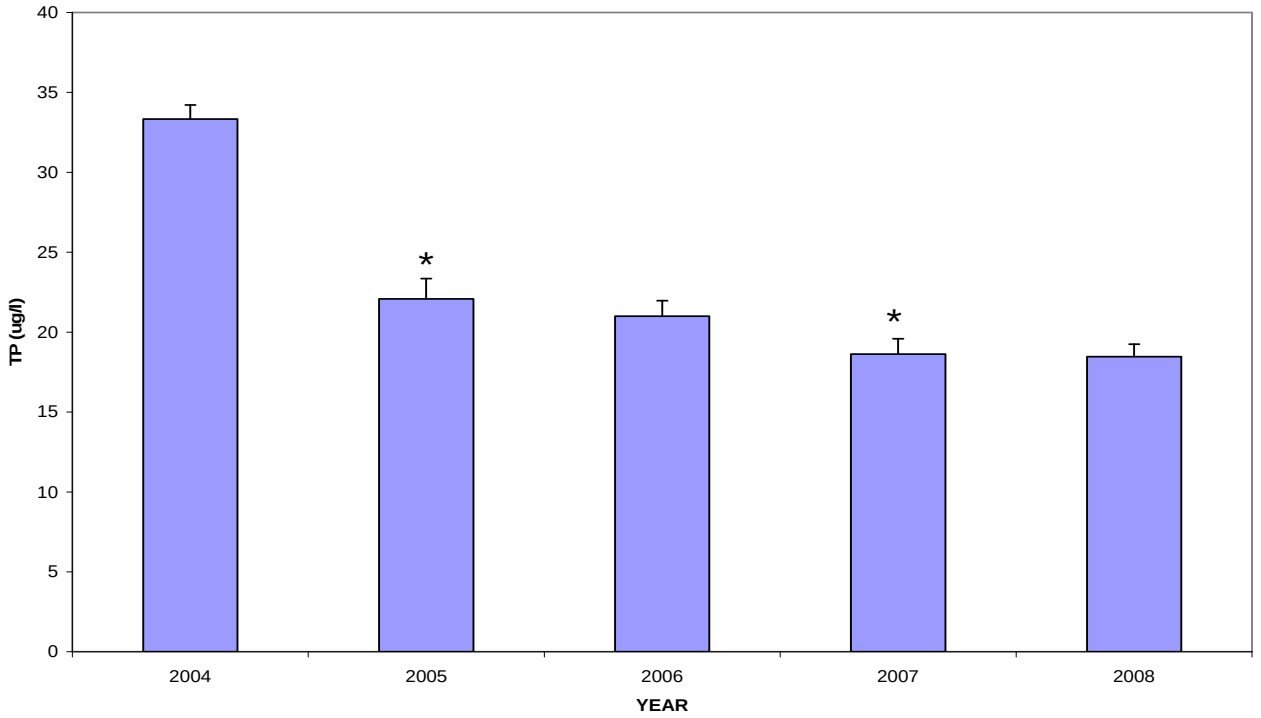


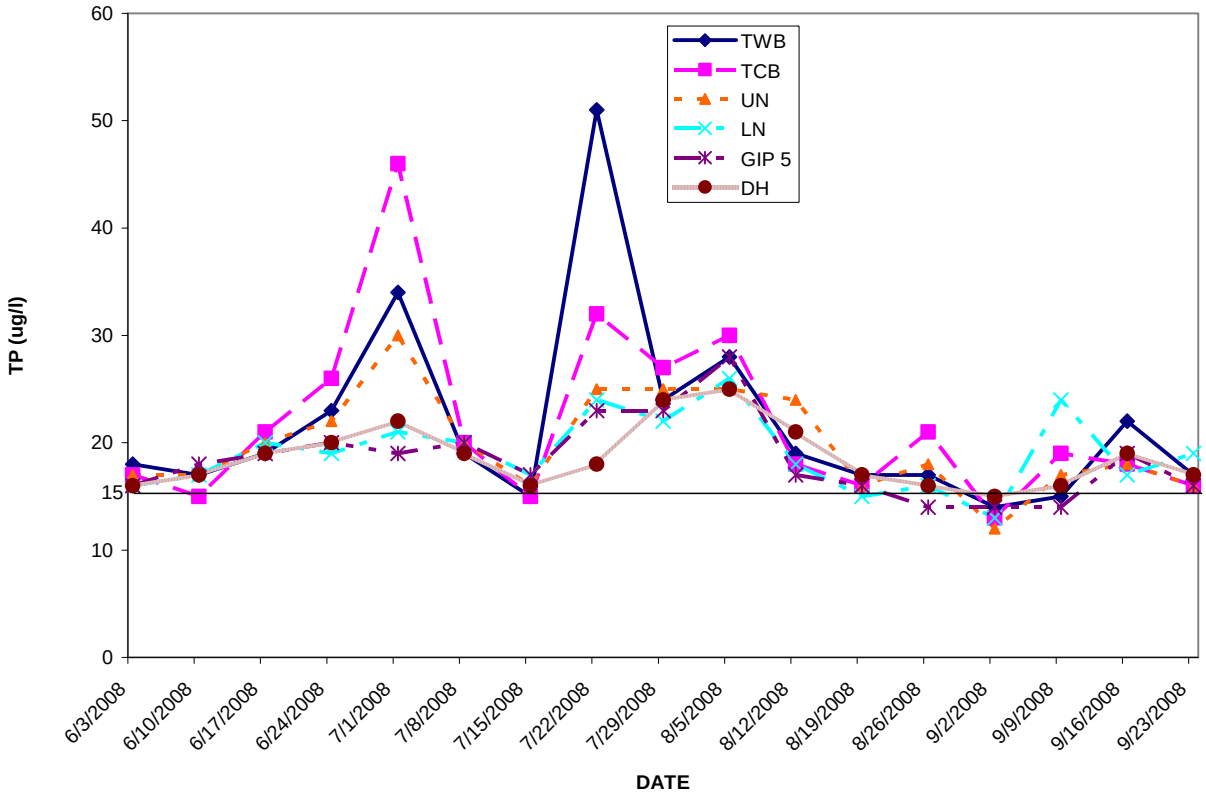
Figure 6. Mean total phosphorus (TP) concentrations at Lower Narrows, GIP, 2004-2008



Acheron/GIPOP study

Acheron collected and analyzed weekly samples for the GIPOP Partnership for Ortho-Phosphorus (OP), TP and chlorophyll a at the first six locations listed in DEP's aerial monitoring program. TP concentrations in the upper (euphotic) zone were higher than the general threshold for algal blooms in lakes (15 ug/l) for most stations for most of the summer (Figure 7). In general, concentrations were highest at the upstream stations and decreased downstream, perhaps due to dilution, algal uptake followed by sedimentation. The TP peaks on July 1 and 22 and August 5 corresponded with high river flows (Figure 2). The highest concentration (26 ug/l) on August 5 at Lower Narrows was similar to that measured by DEP (24 ug/l) at that location on the same day. There was good correspondence for mean summer TP at LN from the Maine Health and Environmental Testing Lab (HETL) (18.5 ug/l) and Acheron (19.1 ug/l) given that sampling days were not always the same. For most days differences were less than 1-2 ug/l with the maximum difference of 6 ug/l on September 12.

Figure 7. Total phosphorus (TP) at 6 stations in GIP, 2008

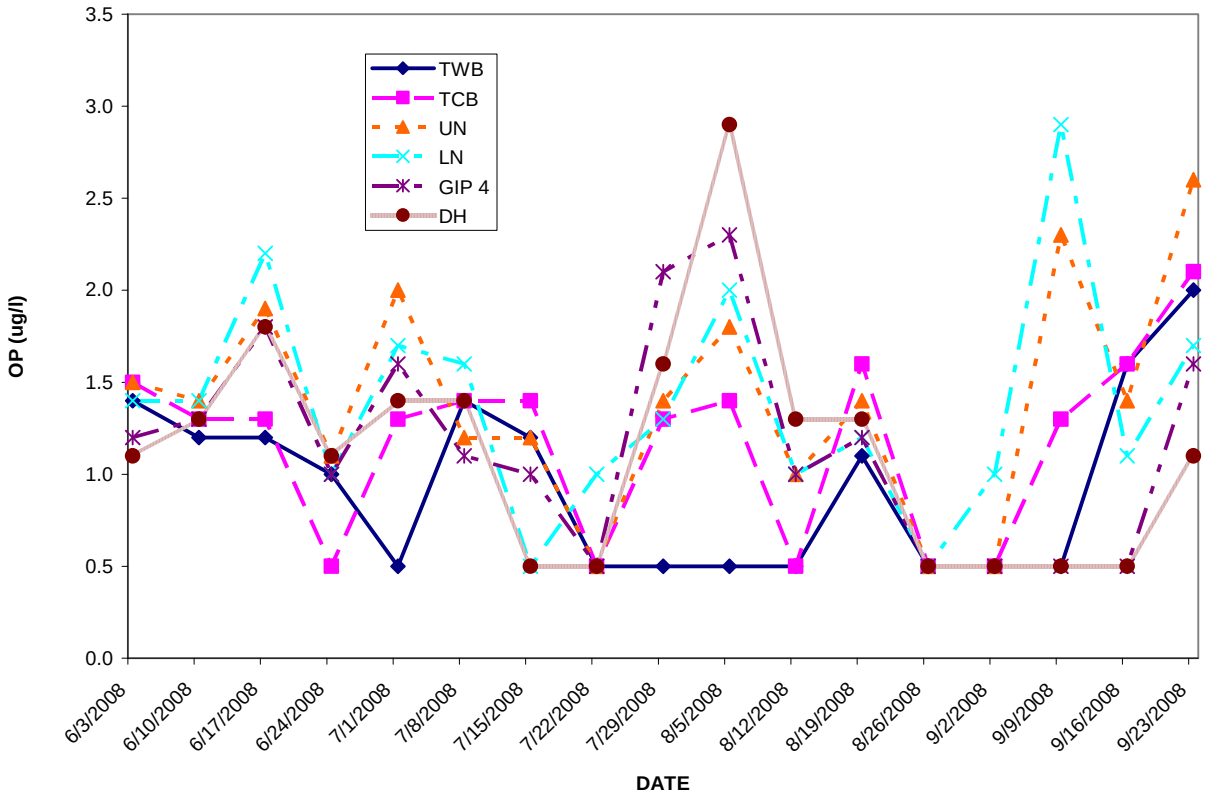


Ortho-phosphorus

Acheron/GIPOP study

Dissolved ortho-phosphorus (OP) values were quite low, but with more variability than TP (Figure 8, non-detects calculated at one half the detection limit at 0.5 mg/l). The peaks in early and late July occurred at the same time as those for TP, but the earlier and later peaks were not seen with TP. The range for OP is relatively small and may represent reduced uptake with cool temperatures near the ends of the growing season that may not be significant.

Figure 8. Dissolved orthophosphorus (OP) at 6 stations in GIP, 2008

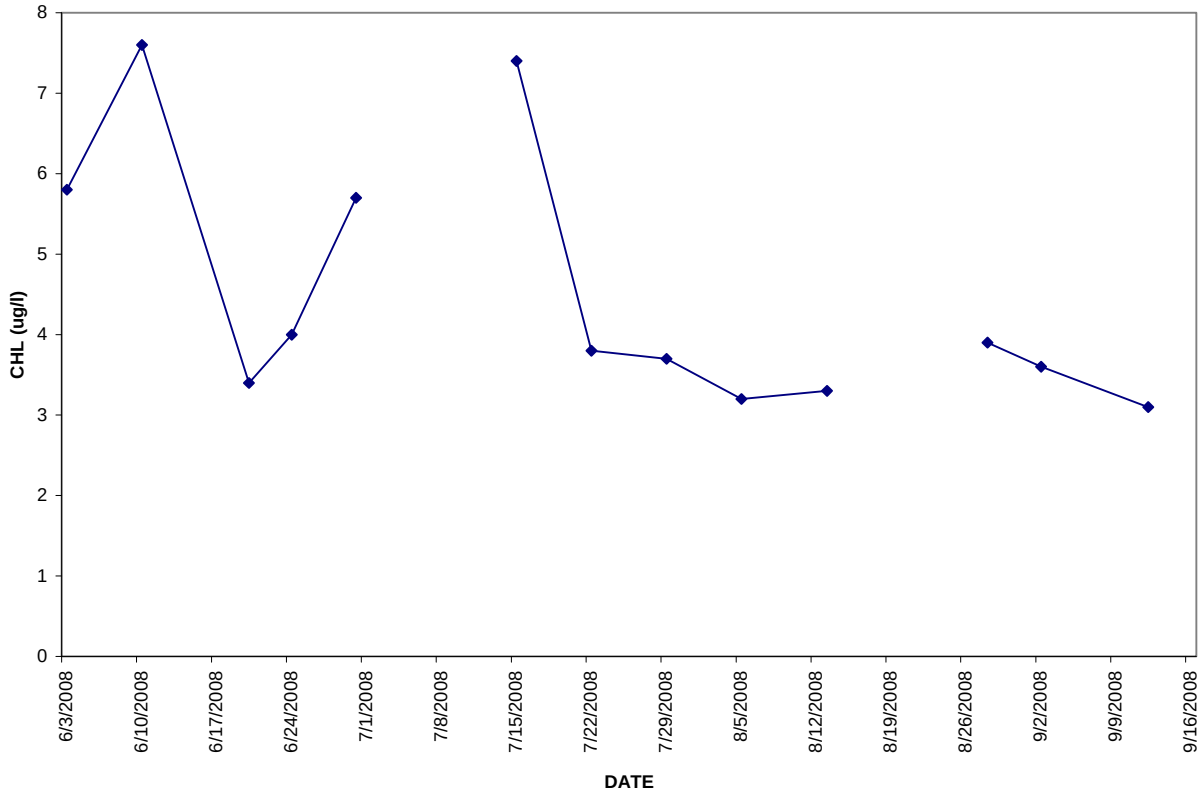


Chlorophyll-s (CHLa)

DEP Study

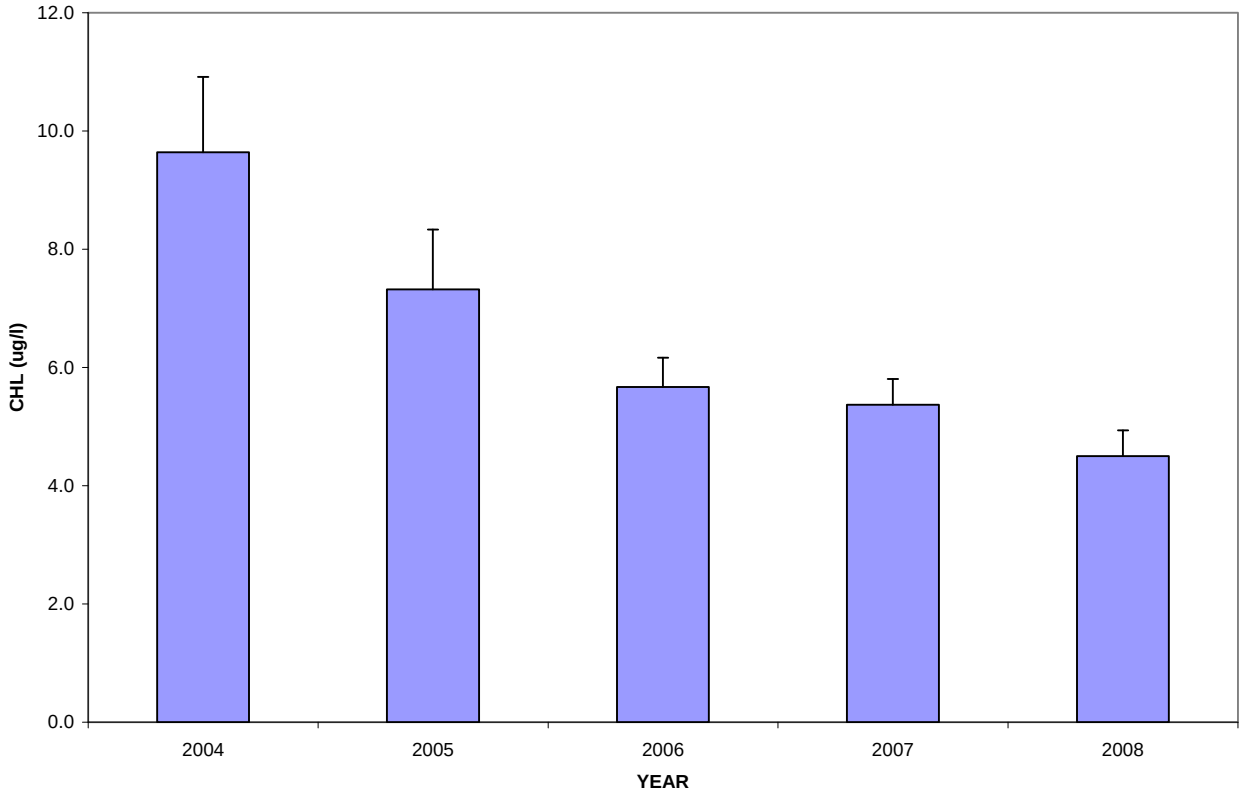
Uncorrected CHLa data are reported here unlike reports from previous years that reported corrected chlorophyll a, which can be biased high for some samples. This policy is similar to that used by DEP's lakes program, which has reported uncorrected CHLa for several years. DEP sampling at LN in 2008 resulted in a measurement of two peaks of CHLa just below the threshold used for lakes (8 ug/l) for defining a phytoplanktonic algae bloom and well below the interim threshold (10 ug/l) proposed for GIP (Figure 9). There was no observation of a bloom from the aerial flights on this or any other sampling date. TP on the date of the two peaks was no higher than it was for many other dates. CHLa was 3.2 ug/l on August 5, the date of the highest TP concentration, well below both thresholds and not correlated with TP.

Figure 9. Chlorophyll a concentrations at LN, GIP, 2008



In 2008 the mean summer CHLa concentration appeared lowest of all recent years measured (Figure 10). There appears to be a declining trend since first measured in 2004, although there is no statistically significant difference in concentrations between any one year and the next.

Figure 10. Mean chlorophyll a concentrations at LN, GIP, 2004-2008

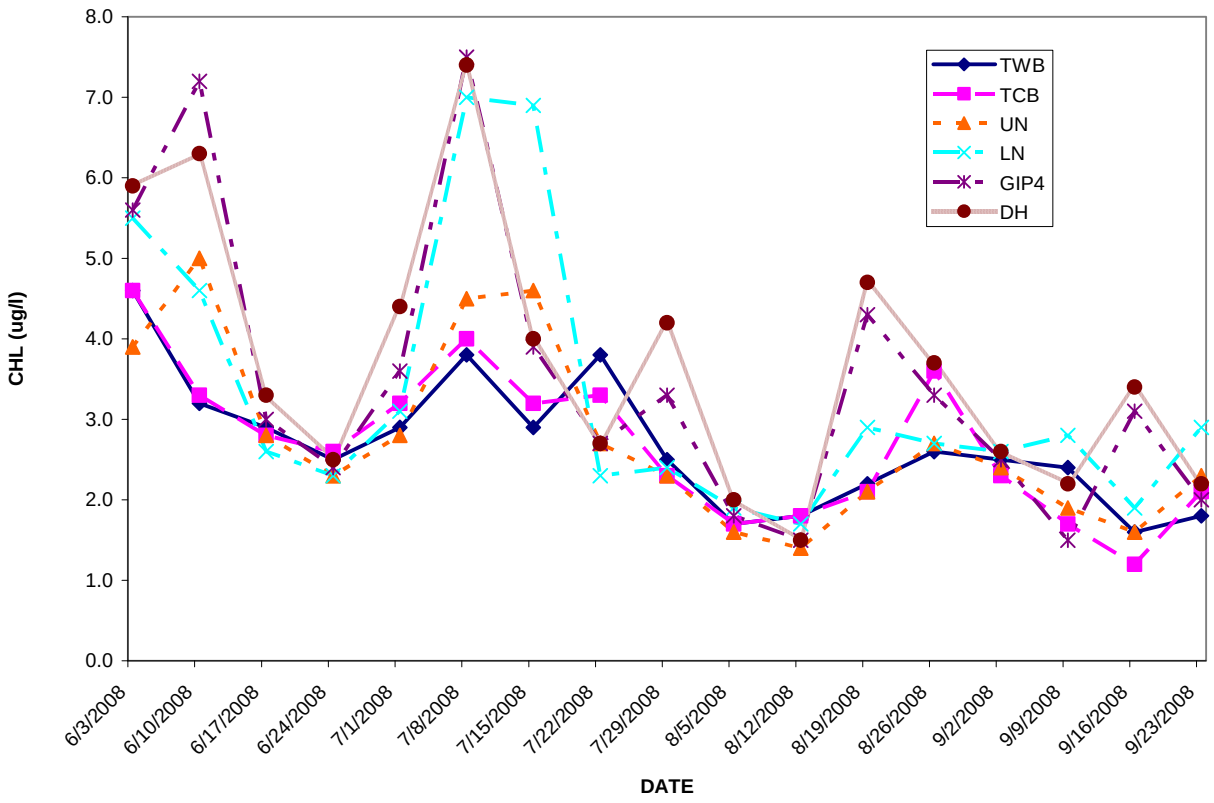


Acheron/GIPOP study

Three weekly samples from six stations collected by Acheron were split to be analyzed by three labs (Acheron, HETL, and the University of Maine Sawyer Environmental Chemistry Research Lab (SECRL). The results showed fairly good correspondence with uncorrected CHLa values among the three labs. There were significant discrepancies among the labs for corrected CHLa, and consequently those data were not used.

Acheron weekly sampling at six stations showed two events with CHLa approaching the 8 ug/l bloom threshold for lakes, in early June and early July (Figure 11). Peak concentrations were highest in the lower reaches of GIP (LN, GIP4, DH) which have longer residence times allowing algal populations to grow more than upstream more riverine stations. These peaks corresponded in both timing and magnitude to those measured by DEP (Figure 9). Mean summer CHLa at LN was slightly higher in HETL analyzed samples (4.5 ug/l) than those from Acheron (3.3 ug/l). No results exceeded thresholds for algal blooms, which is consistent with aerial observations.

Figure 11. Chlorophyll a (CHL) concentrations at 6 stations in Gulf Island Pond, 2008

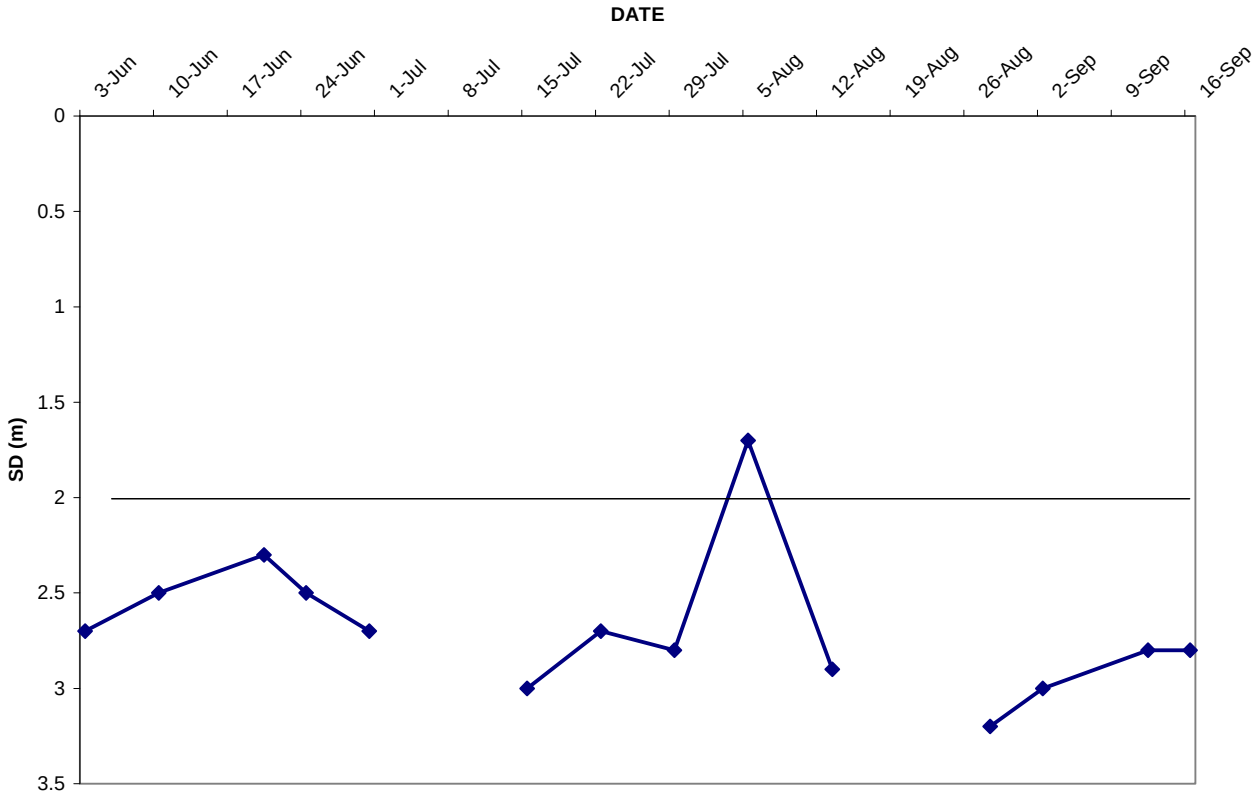


Secchi Disk Transparency (SD)

DEP Study

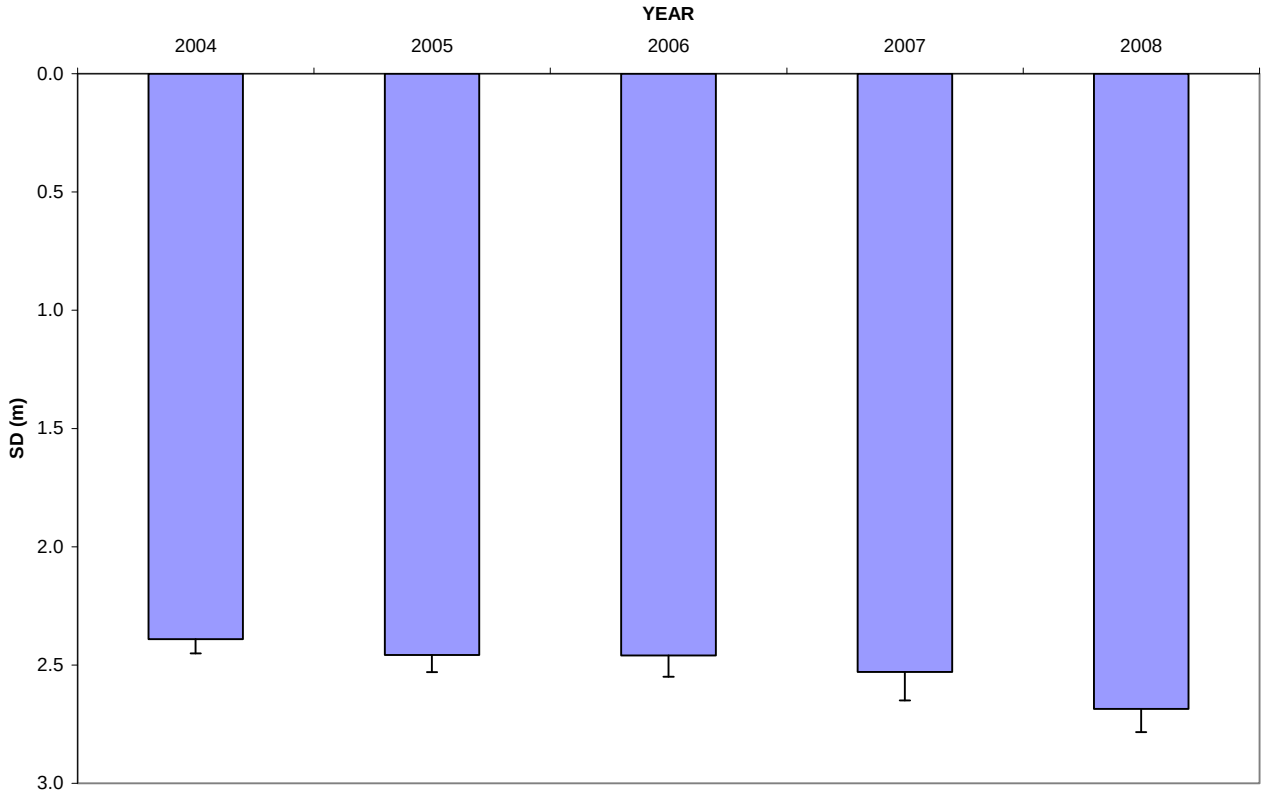
DEP sampling in 2008 at LN documented a Secchi disk transparency less than 2 m (meters), the definition of a bloom in uncolored lakes, only on August 5 (Figure 12), which was the date of the highest TP reading as well. But since CHLa was not unusually high on this date, the low Secchi disk transparency was not a result of an algal bloom. This date was during a high runoff event and the river was very muddy, however, and Secchi transparency was likely affected by inorganic solids from upstream soil erosion.

Figure 12. Secchi disk (SD) transparency at Lower Narrows, GIP, 2008



Mean summer Secchi disk transparency was not significantly different than it has been since the present monitoring strategy began in 2004 (Figure 13). Secchi disk transparency is not the most sensitive measure of algal biomass in GIP, however, due to elevated color and silt that also reduce the Secchi disk transparency.

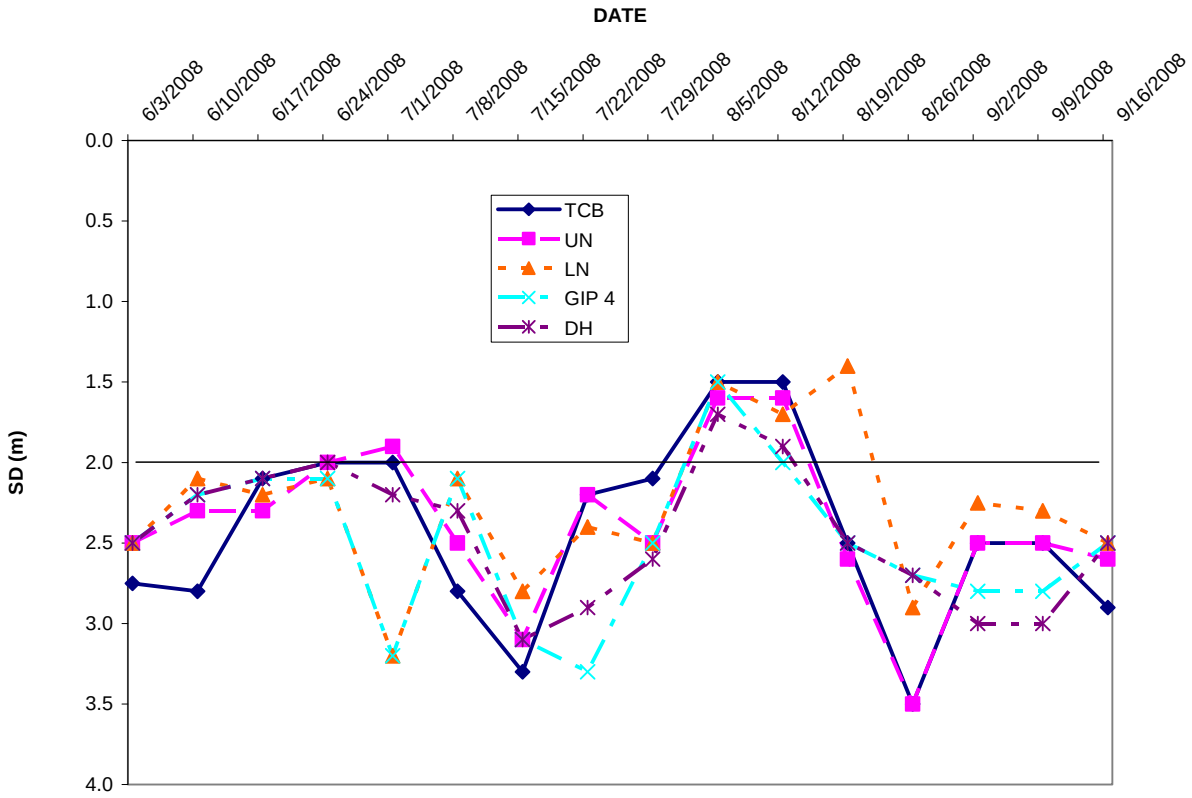
Figure 13. Mean Secchi disk (SD) transparency at Lower Narrows, GIP, 2004-2008



Acheron/GIPOP study

Acheron sampling in 2008 documented Secchi disk transparency >2 m at all stations beginning August 5 (except for one earlier reading of 1.9 m at UN) and extending for one or two weeks for some stations (Figure 14). No one station consistently had greater or lower Secchi disk transparency, although TCB had the highest Secchi disk transparency most often. This is not unexpected as the TCB station is upstream and more riverine than the other two stations, which would allow algae less ability and time to maintain position in the water column to develop than at the two lower stations. At LN Acheron measured Secchi disk transparency <2 m for three consecutive weeks, whereas DEP monitoring measured Secchi disk transparency <2m for only the first week, Secchi disk transparency = 2.9 m for the second week, which shows the effect of observer variability. DEP made no reading for the third week. Chlorophyll a concentrations were well below the bloom threshold for these three weeks, indicating that Secchi disk transparency readings were not the result of increased algal densities. Field observations identified these dates as dates of high flows with a high silt load, which reduced Secchi disk transparency readings.

Figure 14. Secchi disk transparency (SD) at 5 stations in GIP, 2008



Temperature and Dissolved Oxygen

In order to meet Maine's Water Quality Standards, particularly the narrative criteria which requires that Maine waters'provide habitat for fish and aquatic life… and … support indigenous species of fish' with respect to measurement of dissolved oxygen in riverine impoundments, Maine statute at 38 M.R.S.A. §464.13, specifies the following:

Measurement of dissolved oxygen in riverine impoundments. Compliance with dissolved oxygen criteria in existing riverine impoundments must be measured as follows.

A. Compliance with dissolved oxygen criteria may not be measured within 0.5 meters of the bottom of existing riverine impoundments.
B. Where mixing is inhibited due to thermal stratification in an existing riverine impoundment, compliance with numeric dissolved oxygen criteria may not be measured below the higher of:

(1) The point of thermal stratification when such stratification occurs; or

(2) The point proposed by the Department as an alternative depth for a specific riverine impoundment based on all factors included in section 466, subsection 11-A and for which a use attainability analysis is conducted if required by the United States Environmental Protection Agency.

For purposes of this paragraph, "thermal stratification" means a change of temperature of at least one degree Celsius per meter of depth, causing water below this point in an impoundment to become isolated and not mix with water above this point in the impoundment.

C. Where mixing is inhibited due to natural topographical features in an existing riverine impoundment, compliance with numeric dissolved oxygen criteria may not be measured within that portion of the impoundment that is topographically isolated. Such natural topographic features may include, but not be limited to, natural deep holes or river bottom sills.

Notwithstanding the provisions of this subsection, dissolved oxygen concentrations in existing riverine impoundments must be sufficient to support existing and designated uses of these waters. For purposes of this subsection, "existing riverine impoundments" means all impoundments of rivers and streams in existence as of January 1, 2001 and not otherwise classified as GPA. (emphasis added).

Thermal stratification typically results in three vertical zones or layers;

1) the epilimnion (top layer which is relatively homothermous,),
2) the metalimnion or thermocline (middle layer of thermal transition) and
3) the hypolimnion (bottom layer which is relatively homothermous).

The thermocline is defined as the zone where the temperature decreases at least one degree Celsius per meter of depth. Typically this zone is several meters thick, and therefore, to determine compliance with the statute in thermally stratified riverine impoundments, it is necessary to choose one depth within this zone as the 'point' of compliance. As defined in statute and in consideration of the last paragraph as the overall controlling section, DO levels must be sufficient to support designated and existing uses of the waterbody, which requires the protection of a cold water zone providing habitat for indigenous species of

fish, i.e. some amount of water cold enough with enough oxygen to support cold water fish. After consultation with the Department of Inland Fisheries and Wildlife, the Commissioner of DEP stated in a letter of January 23, 2007 to the Gulf Island Pond Partnership (GIPOP Partnership), that for thermally stratified impoundments, "the Department will consider the point of thermal stratification to be the bottom of the first meter segment in the thermal profiling data where the temperature gradient is one degree Celsius or greater per meter". The intention of this clarification is to ensure that there is at least one meter of cold water within the thermocline with enough oxygen so that the narrative water quality criteria are met.

DEP Study

In 2008, DEP measured temperature and dissolved oxygen (DO) at Lower Narrows (LN) weekly in vertical profiles at one meter (m) increments. Maximum depth at LN is approximately 15 m, and varies weekly by 1-2 m due to drawdown for hydropower generation at the Gulf Island Dam. Although not the deepest part of GIP, LN exhibited thermal stratification on 1 of 14 dates for which there are samples, on September 12 at the deepest depth, where DO was 7.3 mg/l (Appendix 2). There were excursions below the minimum DO criterion of 5 mg/l during 3 non-stratified sampling events on June 3, August 28, and September 2 (Figures 15-17). Given that these dates were single sampling events, assumed to be representative of all the days between the dates, and assuming a linear transition in DO levels between adjacent weekly sampling dates, then there is about 21% of the summer sampling period when DO did not attain the minimum criterion at LN.

Figure 15. Temperature (T) and dissolved oxygen (DO) at LN in GIP, June 3, 2008

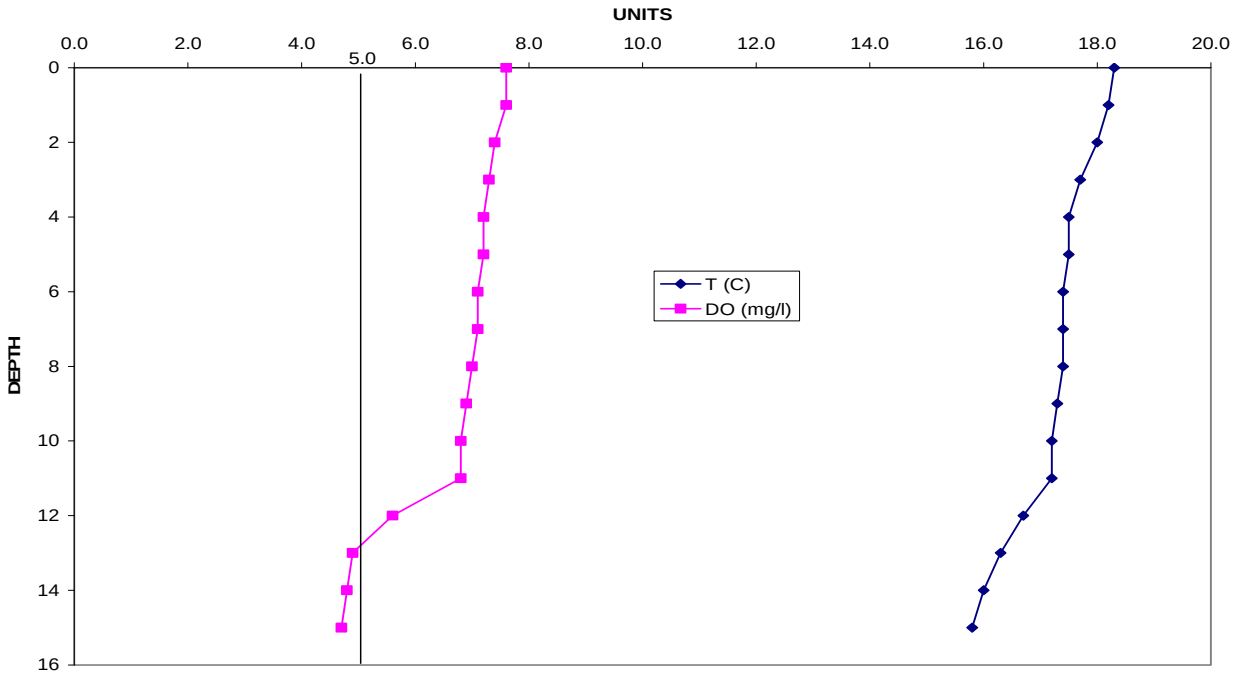


Figure 16. Temperature (T) and dissolved oxygen (DO) at LN in GIP, August 28, 2008

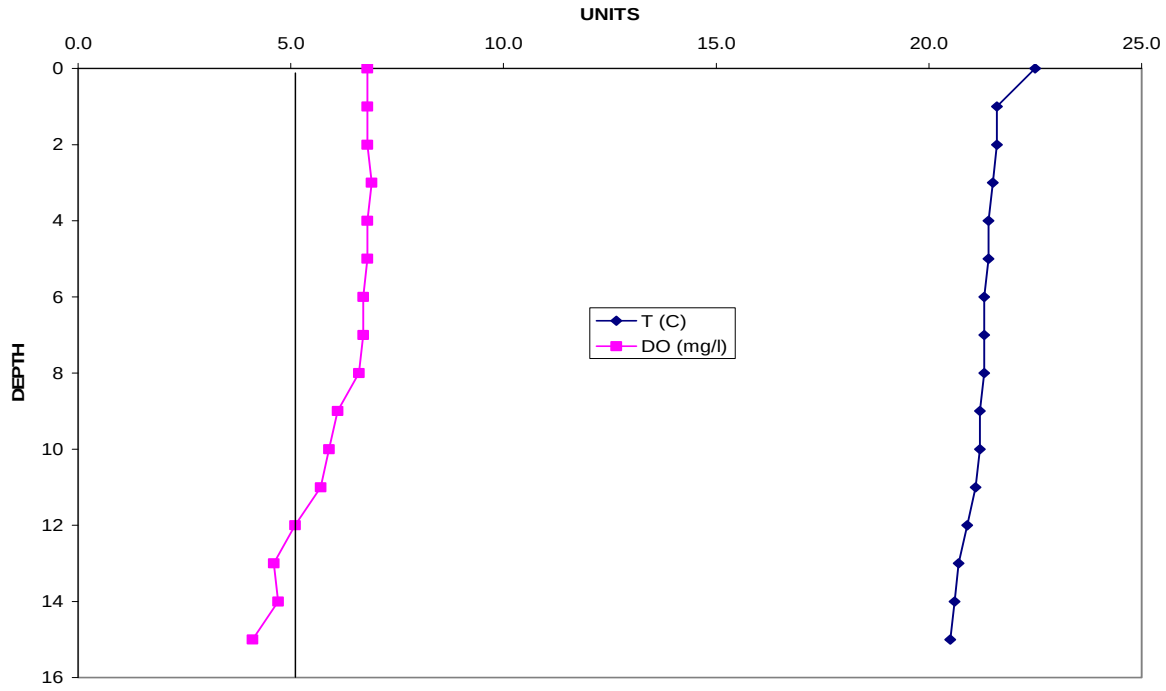
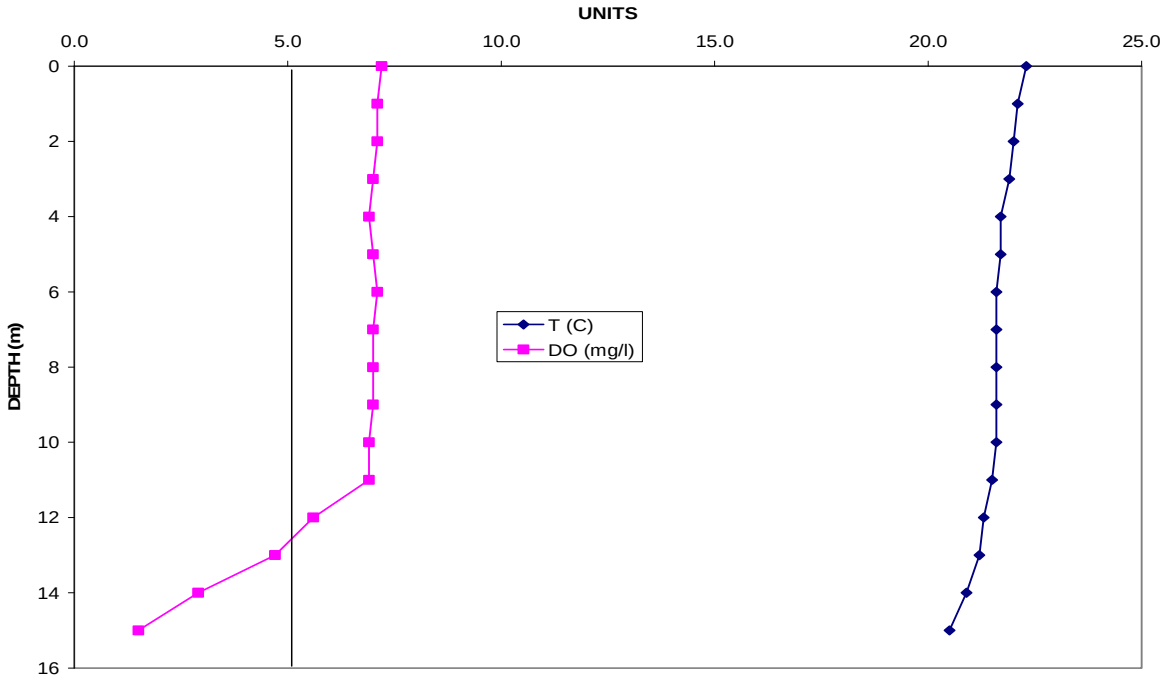
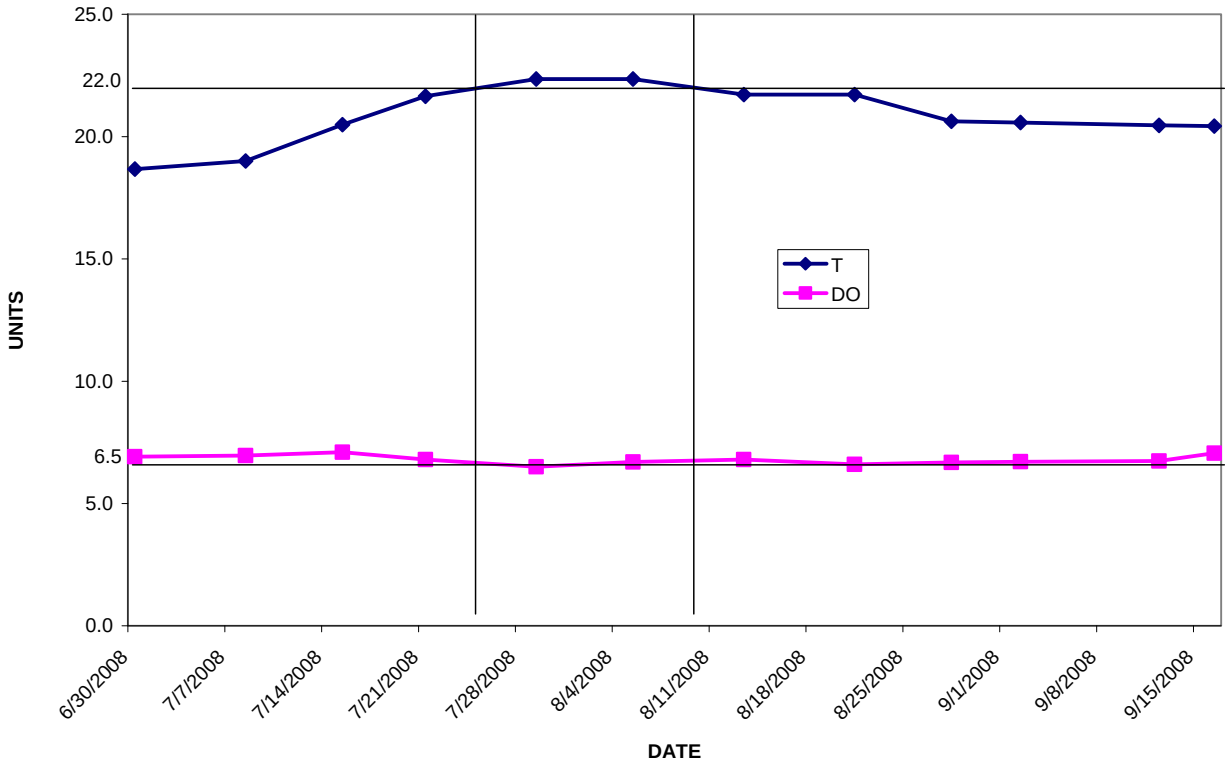


Figure 17. Temperature (T) and dissolved oxygen (DO) at LN in GIP, September 2, 2008



The rolling monthly average DO criterion of 6.5 mg/l applies when temperature is 22°C or below (38 MRSA § 465 (4)(B)). The rolling monthly average (RMA) DO was calculated for each sample date as the depth integrated mean for all data in the previous four weeks where the mean temperature was less than or equal to 22°C at the point of thermal stratification. Where there are no measurements at 22°C or less, temperature at the second deepest depth and associated DO are plotted (between the two vertical lines), but DO on those dates would not count as non-attaining. In 2008 at Lower Narrows there were no dates with non-attainment of the 6.5 mg/l monthly average criterion regardless of temperature (Figure 18).

Figure 18. Rolling monthly average temperature (T°C) and dissolved oxygen (DO mg/l) at LN, GIP, 2008



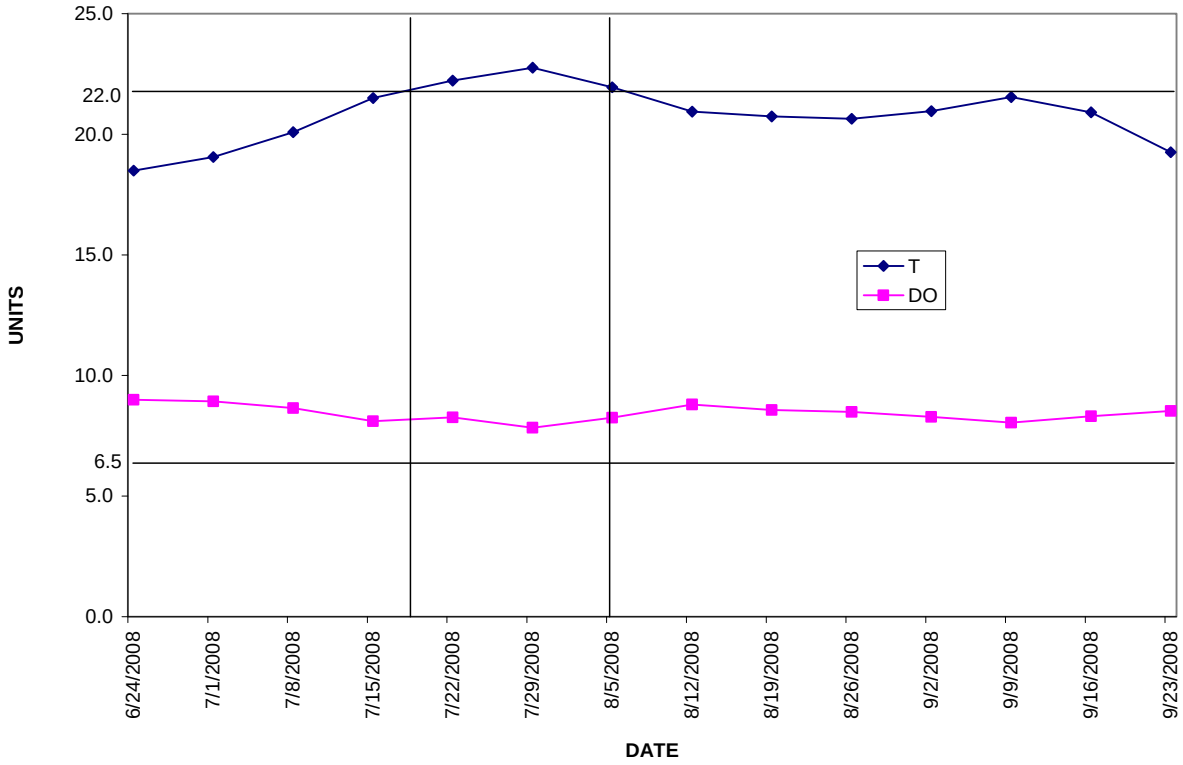
Acheron/GIPOP study

Weekly temperature and DO profile measurements made at five GIP stations by Acheron are available for viewing in paper copy or on CD at DEP or on the web at http://www.maine.gov/dep/blwq/topic/gip/ . There were measurements taken in both the morning and afternoon on 17 weeks. Examination of the data reveals the findings that follow, by stations. The bottom most reading is not counted as it is difficult to determine if the probe is in the sediments and the reading may reflect DO of the sediment rather than DO of the water.

TCB Station

TCB is too shallow with too much current to stratify thermally. DO concentrations were greater than the 5.0 mg/l minimum criterion for all sampling dates (Appendix 1). The rolling monthly average (RMA) DO was above the 6.5 mg/l monthly average criterion for all sampling dates regardless of whether the temperature exceeded 22°C (between vertical lines) or not (Figure 19).

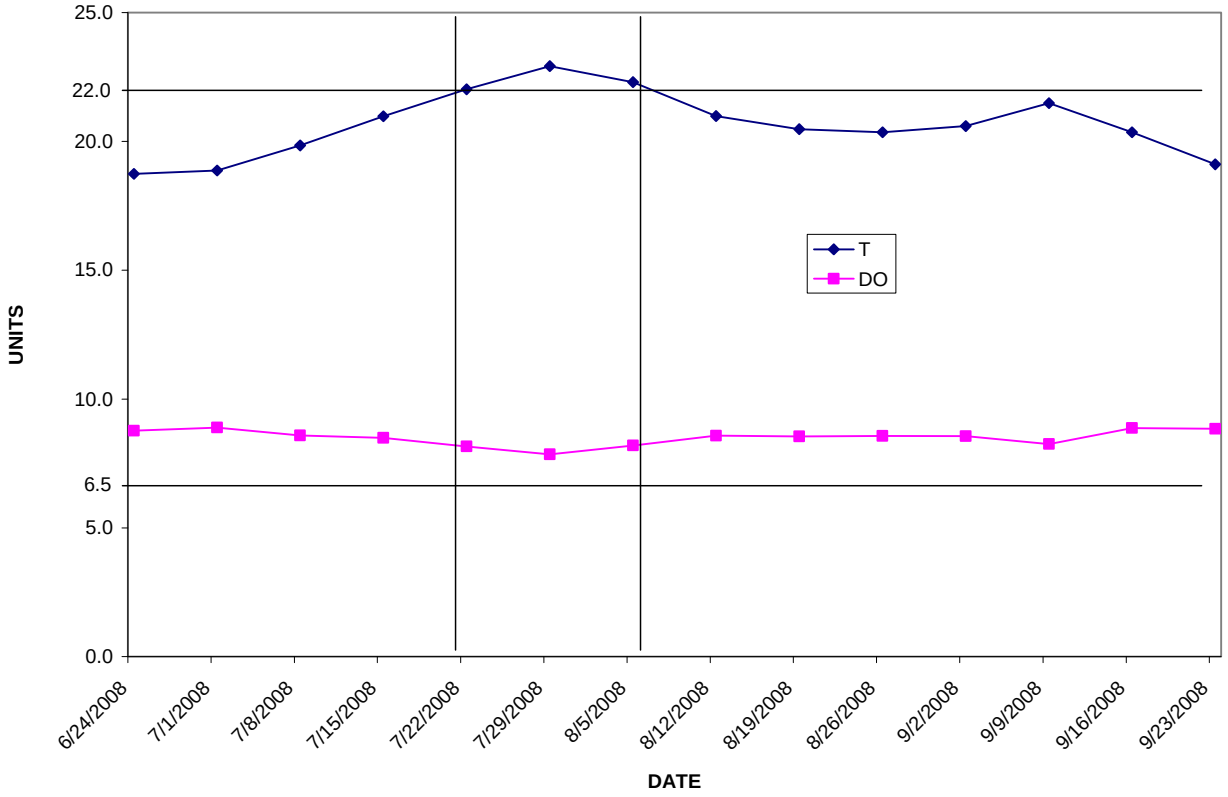
Figure 19. Rolling monthly average temperature (T°C) and dissolved oxygen (DO mg/l) at TCB, 2008



UN Station

At UN there were no sampling dates when DO was in non-attainment of the minimum DO criterion of 5 mg/l (Appendix 1), nor were there were any calculated RMAs that were below the 6.5 mg/l criterion regardless of temperature (Figure 20). These results would not be unexpected, since this station is immediately below the point of oxygen injection into the river.

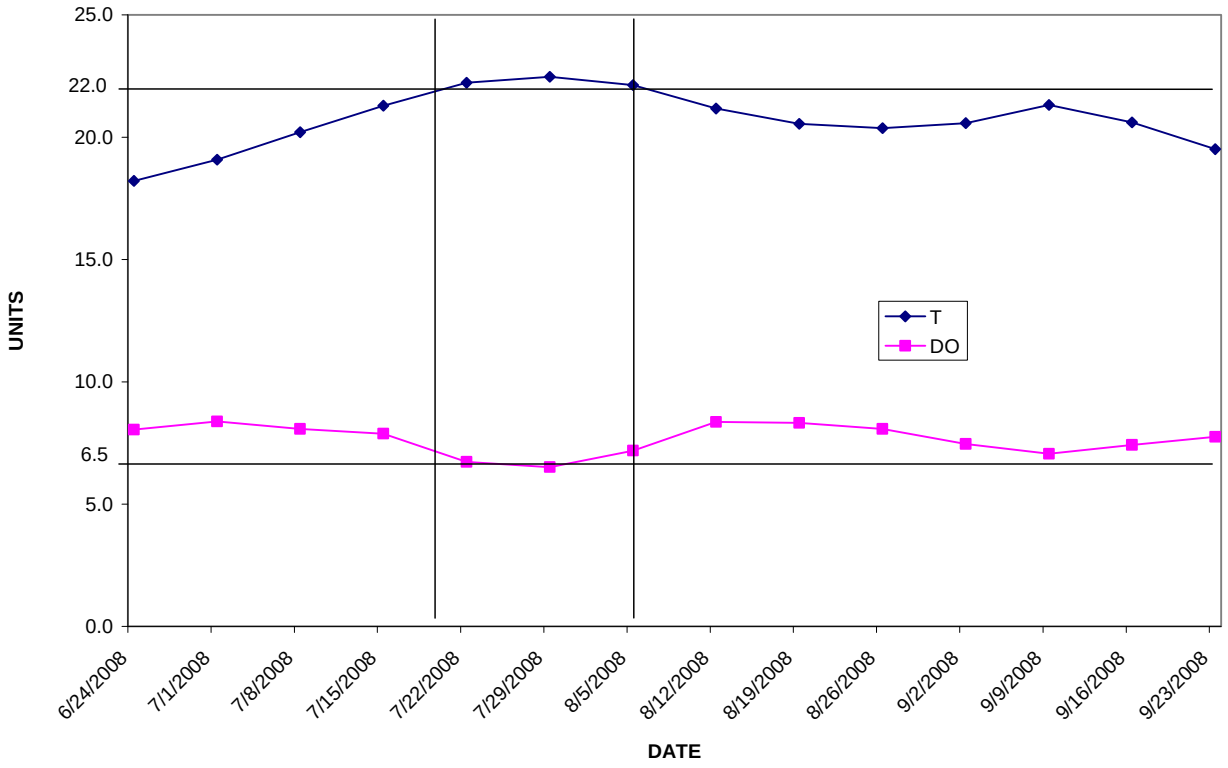
Figure 20. Rolling monthly average temperature (T°C) and dissolved oxygen (mg/l) at UN, 2008



LN Station

At LN there were 3 of 14 sampling dates (June 3, July 15, September 2), representing 21% of the summer, when DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both (Appendix 1). The RMA DO, however, was not below below the monthly average 6.5 mg/l criterion (Figure 21). These data are quite similar to those collected by DEP (Figure 18). Slight differences are likely due to several factors. The Acheron data were collected in the early morning and afternoon whereas DEP data were collected around mid-day, which can make a difference in both the temperature and DO. Also Acheron collects data from an anchored boat whereas DEP collects data from a float plane where it is more difficult to stay at the exact same point.

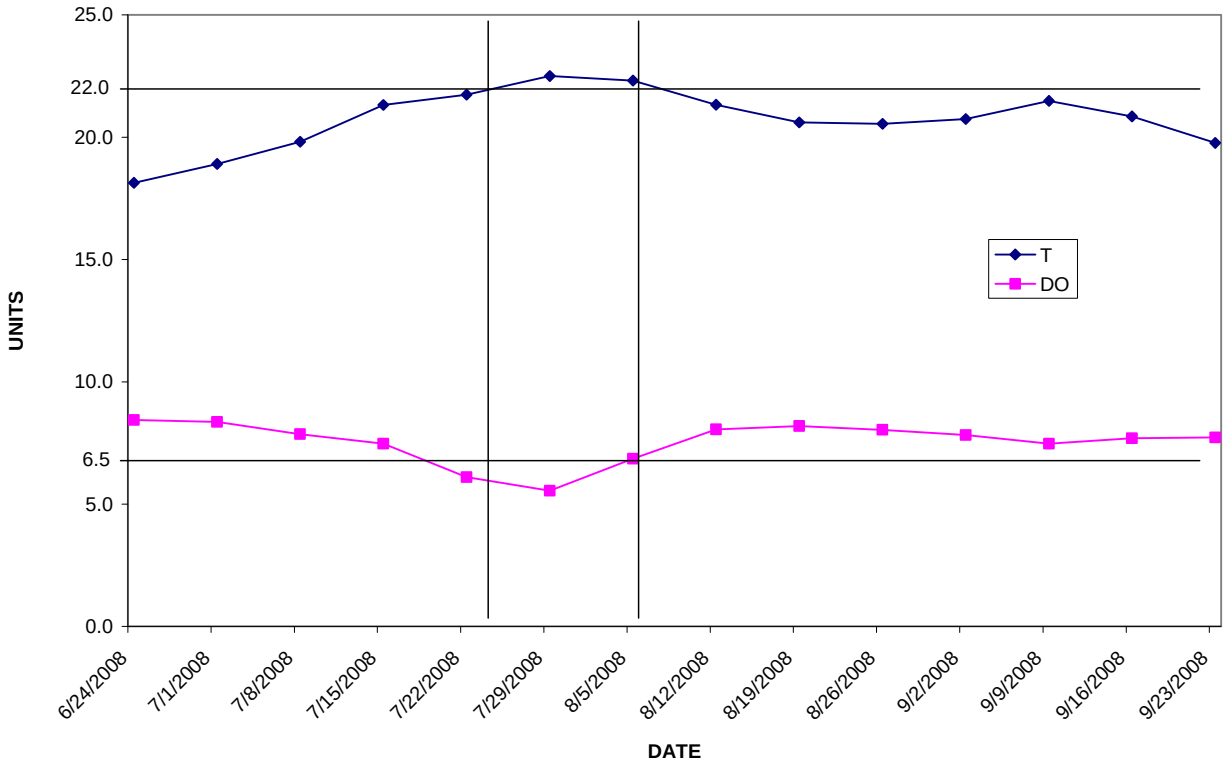
Figure 21. Rolling monthly average temperature (T°C) and dissolved oxygen (DO mg/l) at LN, 2008



GIP 4 Station

At GIP 4, on 1 of 14 sampling dates (July 8), or about 7% of the summer, DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both. The RMA DO was below the monthly average 6.5 mg/l criterion from about July 19 to August 4, or about 17% of the summer sampling period for which the RMA was calculated (Figure 22). But the temperature was greater than 22°C, when the monthly average criterion does not apply (shown below between the two vertical lines) from about July 24 to August 4, leaving only about 6% of the period when the monthly average criterion was not attained.

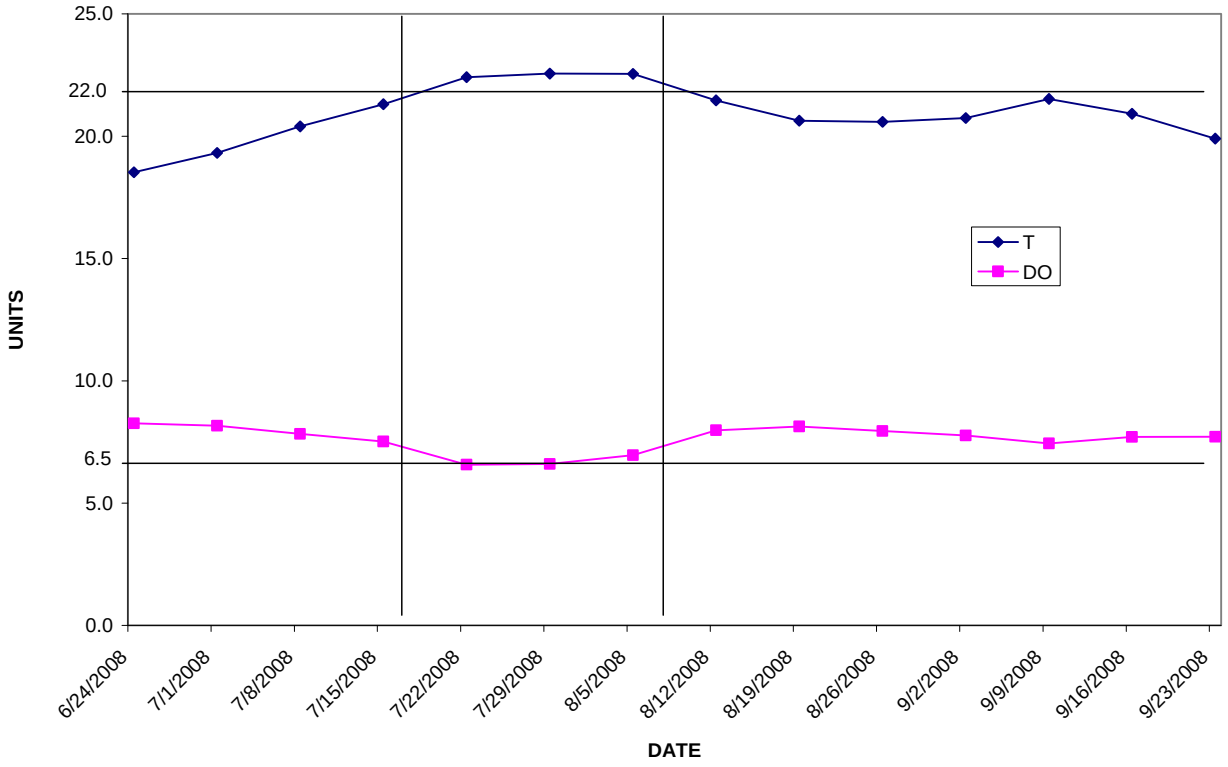
Figure 22. Rolling monthly average temperature (T) and dissolved oxygen (DO mg/l) at GIP4, 2008



DH Station

At the DH station, on 1 of 14 sampling dates (July 15), representing about 7% of the summer, DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both (Appendix 1). The rolling monthly average DO was not below the monthly average 6.5 mg/l criterion (Figure 23).

Figure 23. Rolling monthly average temperature (T°C) and dissolved oxygen (DO mg/l) at DH, 2008



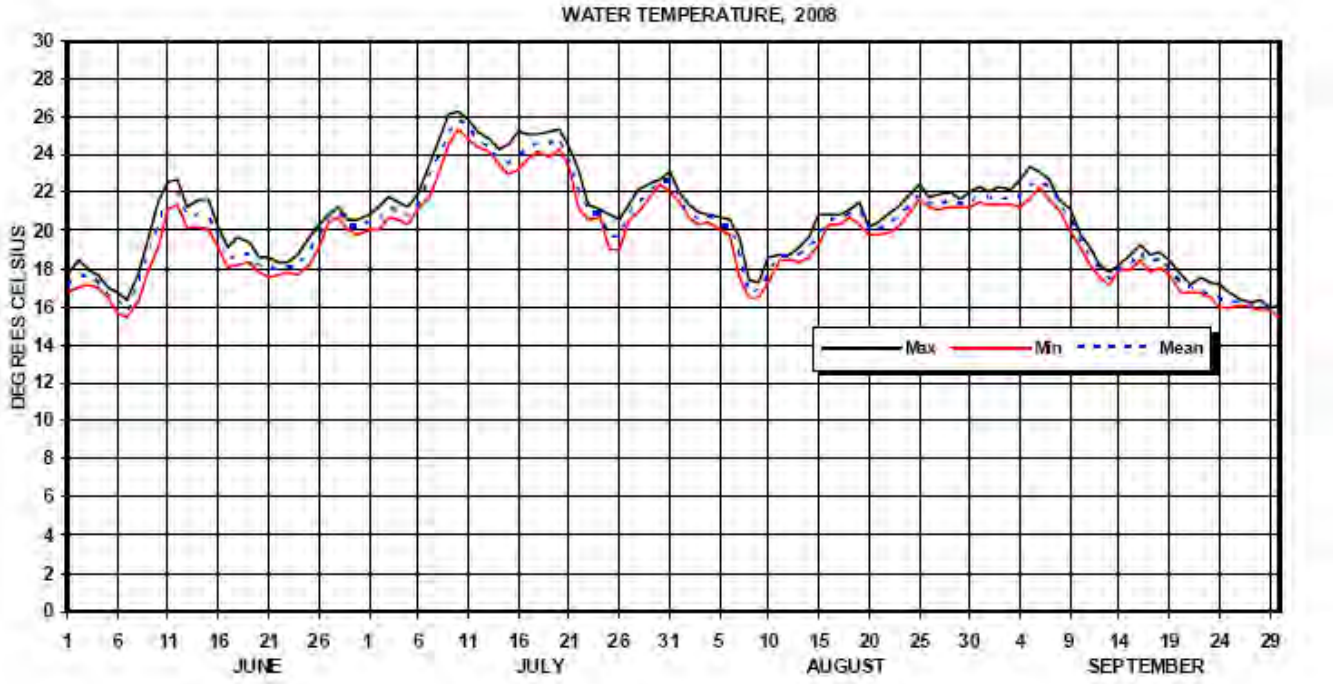
4. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN DATA

The continuous monitoring data, gathered and reported by Water Monitoring Services, Inc. on behalf of the GIPOP, provide additional information about temperature and DO. For 2008, DEP approved a modification of the continuous monitoring study plan from that of previous years. The station 0.2 miles above the dam was eliminated. Temperature and DO monitoring was increased at the Deep Hole (DH) station, from monitoring every hour at one fixed depth, as it was in prior years, to monitoring every two hours in a profile from top to bottom at one meter increments in 2008. Temperature and DO at Turner (Center) Bridge (TB = TCB) was monitored every hour at a fixed depth near the bottom as in previous years.

Results show improved water quality in 2008 compared to that of previous years. At TCB, minimum and monthly average DO was greater than the 5.0 mg/l minimum criterion and 6.5 mg/l monthly average criterion at all times regardless of temperature (Figure 24a). At DH there were fewer days than in previous years (estimated from limited data) when minimum DO was less than 5.0 mg/l, but still there were several days of similarly low DO at various depths. For example, at 18 m there were several days in July, late August and early September when DO was less than 5.0 mg/l (Figure 24b). For some of the days in mid-July, temperature was greater than 22° C when the monthly average criterion does not apply. This figure does not show thermal stratification, nor, therefore, the extent of non-attainment. Examination of all the temperature data demonstrates that the DH stratified on many days and that there were several where the minimum criterion is not attained. Detailed discussion of hourly or daily data is beyond the scope of this report, but the data are available at the Department for review.

As demonstrated by the 2008 monitoring data, daytime air temperatures and exposure to summer sunlight can result in a large temperature gradient in the upper portion of the pond that is not indicative of thermal stratification. For example, on June 7, there were several readings where the temperature dropped by more than 1^{o} C in the top two meters of the pond, but temperature and dissolved oxygen were virtually unchanged from there to a depth of 22 m. This demonstrates that the pond was well mixed and was not stratified. It is the DEP's position that, on this date and other dates in 2008 with similar temperature/dissolved oxygen profiles, mixing was not inhibited and compliance with numeric dissolved oxygen criteria is required.

Figure 24a. Continuous measurement of the temperature and DO at TCB, 2008
(data collected by Water Monitoring Services on behalf of GIPOP)



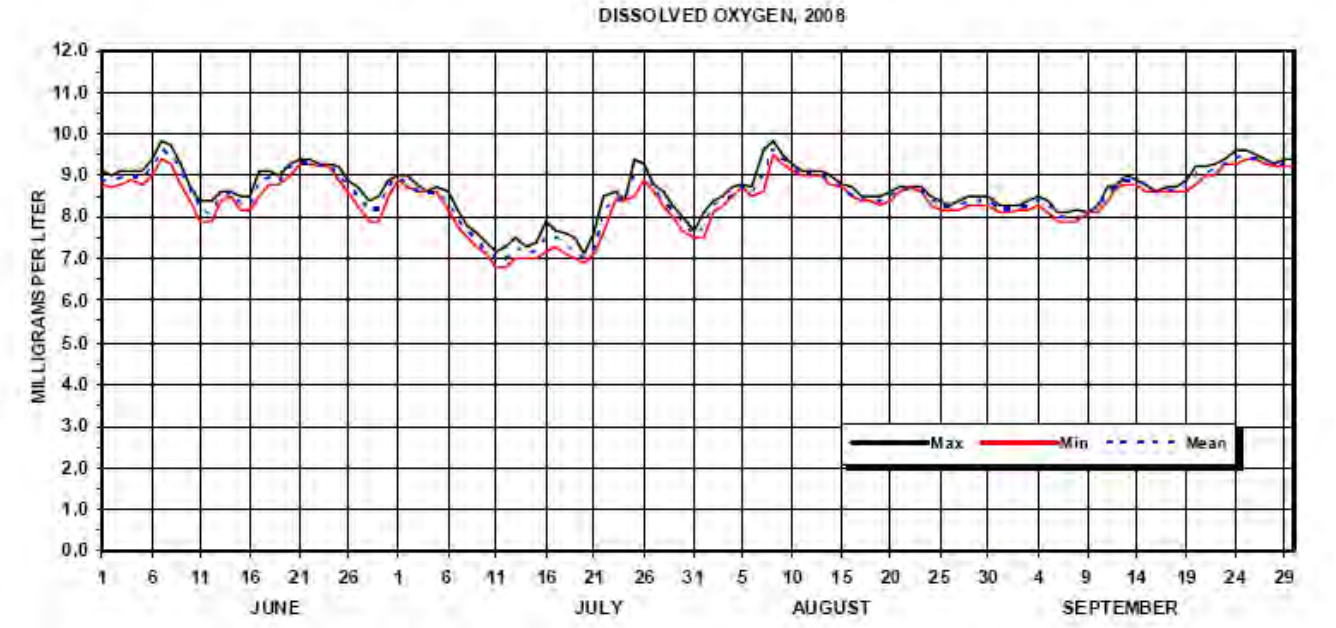
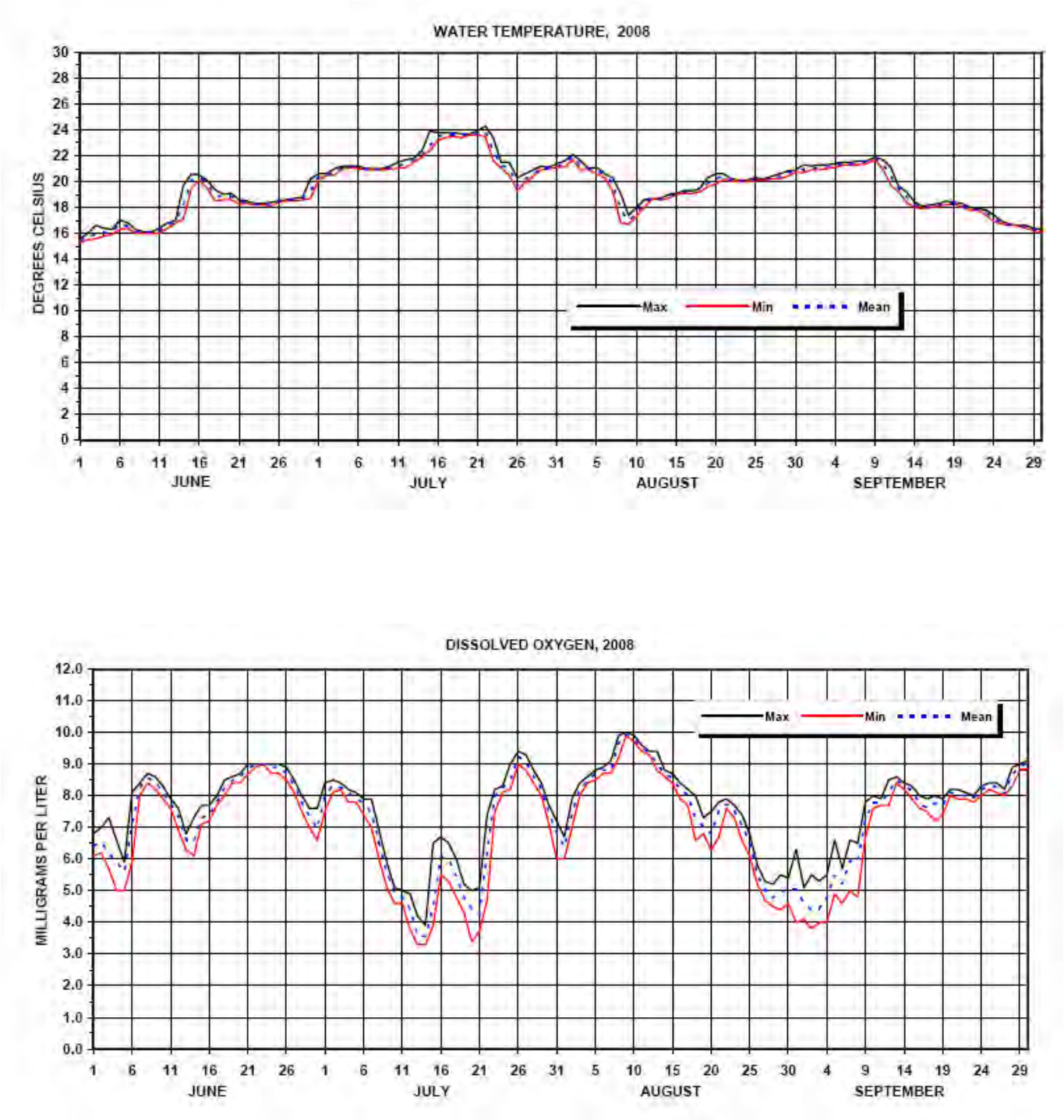


Figure 24b. Continuous measurement of the temperature and DO at 18 M at DH, 2008
(data collected by Water Monitoring Services on behalf of GIPOP)



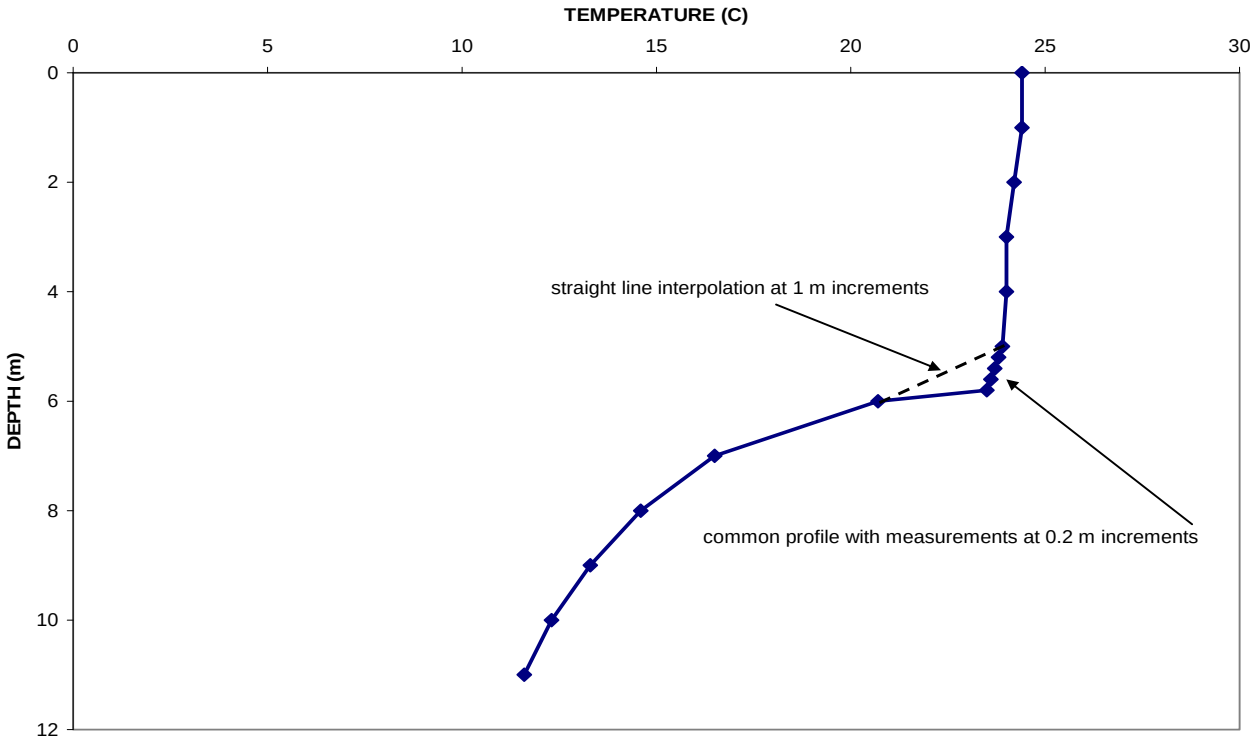
ANCILLARY DATA

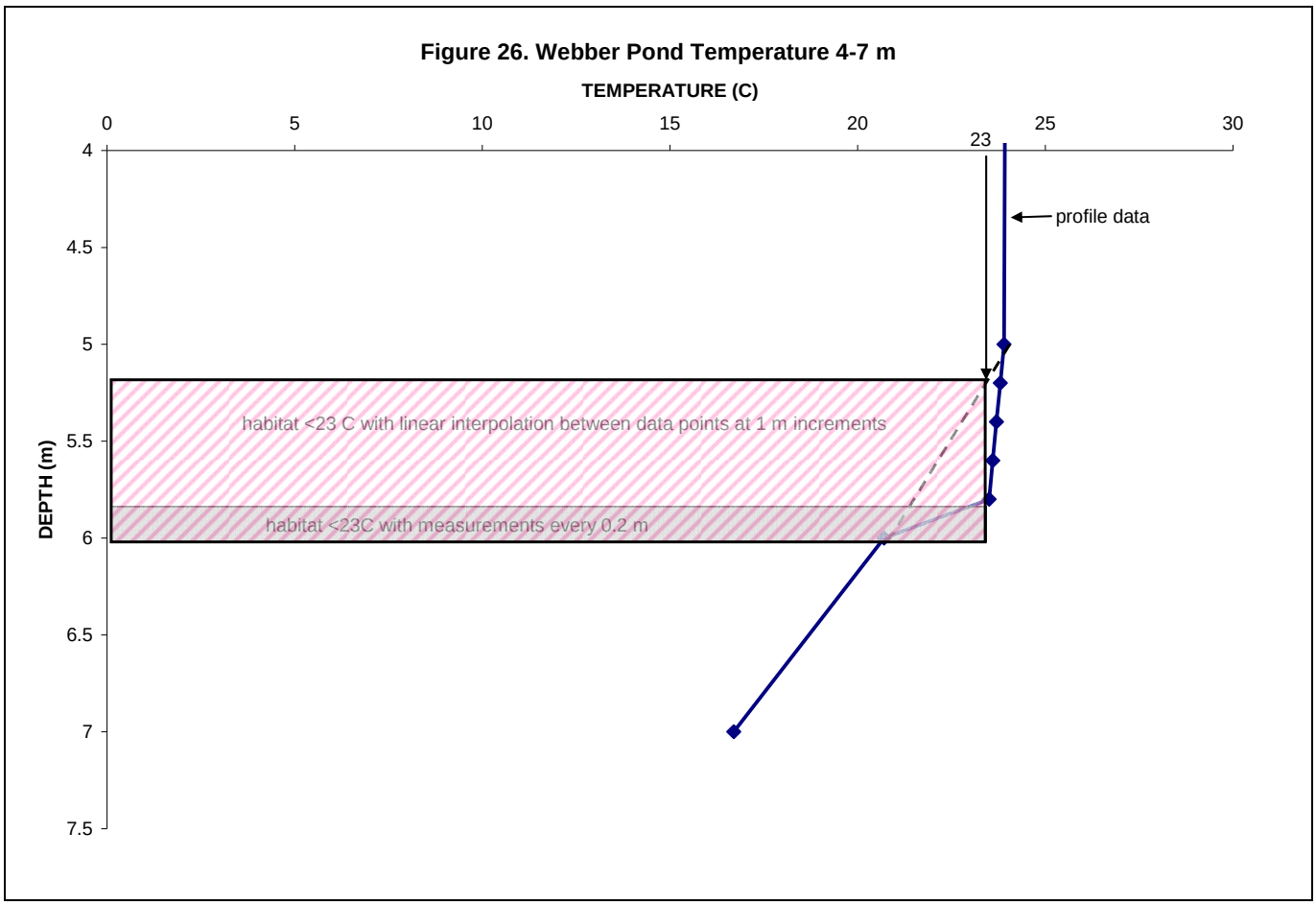
Point of Thermal Stratification (POTS)

As stated in Commissioner Littell's January 23, 2008 letter to the GIPOP Partnership, "the Department will consider the point of thermal stratification to be the bottom of the first meter segment in the thermal profiling data where the temperature gradient is one degree Celsius or greater per meter" and " this approach is designed to ensure the existence of an oxygen enriched area where cold water species of fish can retreat to during warm weather that will provide the statutory dissolved oxygen level for cold water fish for at least one meter of depth, and is consistent with both the statute's clear language and purpose".

While a literal view might be that the POTS in a thermally stratified body of water is the shallowest depth where temperature is one degree Celsius cooler than the temperature one meter above in the water column, DEP's extensive experience with lakes reveals that this depth may not always guarantee at least one meter of cold well-oxygenated water. In strongly stratified waters, temperature can change by more than one degree within a depth increment as little as ~0.2 m (< 1 foot) as shown below for some data from Webber Pond based on measured values at 1 m increments (Figure 25). An expanded view of the segment between 5 and 6 m overstates the suitable habitat (~5.2-6 = 0.8 m) (e.g. temperature less than 23°C) when measurements are made at only 1 m increments with a straight line interpolation (Figure 26). Actual suitable habitat is much less (~5.8-6 = 0.2 m) if more frequent measurements were made as shown by a synthesized example of typical observations at more frequent increments (0.2 m here).

Figure 25. Temperature profile Webber Pond 8/16/01





As a consequence, there may be only a fraction of a meter of suitable habitat for cold water fish, which is not enough to support the population as required by statute. In these cases, it would be necessary to meet the DO requirements to a greater depth. The continuous monitor data collected by the GIPOP Partnership has been at 5 foot increments until 2008, insufficient to determine the POTS. In 2008, at the request of DEP, measurements were made at 1 m depth increments, which provide better data but is still insufficient to determine the POTS and whether the minimum habitat within the thermocline has been provided. The weekly monitoring by Acheron is also collected at 1 m depth increments. In 2009, DEP will collect data at more depths within the thermocline in order to determine a more accurate determination of the POTS.

Gulf Island Pond Oxygenation Project (GIPOP)

The GIPOP system is just upstream of the Upper Narrows sample location. The system's operating parameters are outlined in Rumford Paper Co. and Verso's (formerly International Paper Co.) discharge permit as follows:

Begin GIPOP at Upper Narrows operation when the 3-day average temperature(1) at the Turner Bridge is greater than 18°C in June.

Oxygen Injection Thresholds	% Normal Capacity	Oxygen Injection* (lb/day)
Q(2) > 3500 cfs	Idle	8,000
T<24°C & 3,000 < Q ≤ 3,500	50%	36,500
T<24°C & 2,500 < Q ≤ 3,000	75%	54,750
T<24°C & Q < 2,500	100%	73,000
T≥24°C & Q ≤ 3,500	125%	91,000

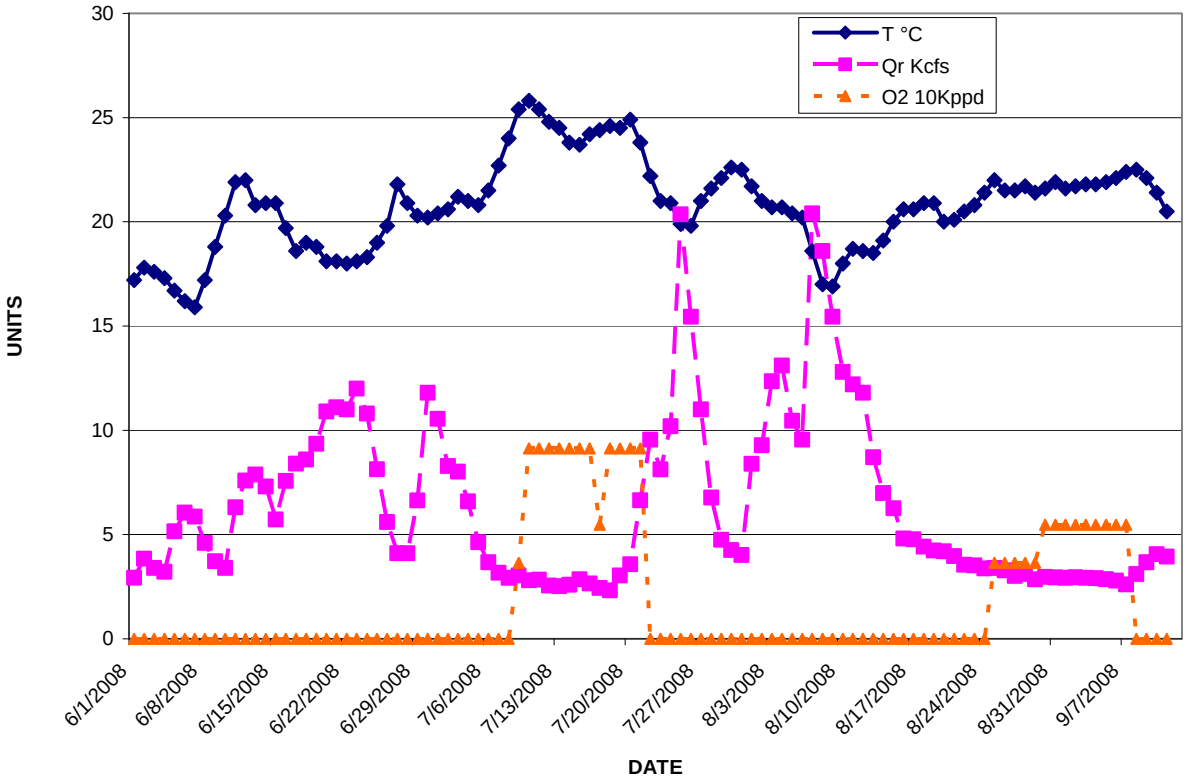
(1)All temperature (T°C) measurements shall be obtained from the continuous temperature monitor at Turner Bridge and shall be expressed as a 3-day rolling average. Because the monitor records maximum and minimum temperatures for a given day, the daily average temperature will be defined as the arithmetic mean of the maximum and minimum temperatures for any given day. The 3-day rolling average is defined as the arithmetic mean of three daily average temperature values.

(2)All flow measurements (Qr, Kcfs=thousand cubic feet per second) shall be obtained from the USGS gage at Rumford and shall be expressed as a 3-day rolling average. The flow gage does record average daily flows; thus the 3-day rolling average is defined as the arithmetic mean of the three daily average flow values.

Actual river temperatures and flows and oxygen injection rates (O2, Kppd=thousand pounds per day) are shown below (Figure 23). Because of relatively high river flows, the oxygen injection system was operated for many fewer days during the summer of 2008 than in previous years. Even with high flows, low DO occurred on some of the days when oxygen was injected, underscoring the need for planned increases in oxygen injection.

DEP has approved plans for an upgrade to the GIPOP system that will increase the oxygen transfer efficiency of the system in order to increase dissolved oxygen levels in the pond. The system is scheduled to be operational by June 1, 2009. Once the upgraded system has been in operation for a year, the current operating parameters for the system should be re-evaluated to determine if changes can be made to insure that oxygen is injected when it will do the most good.

Figure 27. Temperature (T), river flow (QrKcfs), and oxygen injection rate (O210Kppd) at UN, 2008



Mill Effluent Ortho-Phosphorus (OP) and Total Phosphorus (TP)

The Maine Pollutant Discharge Elimination System (MPDES) permit for the Rumford Paper Co. in August 2006 requires that the discharge not exceed 97 and 152 ppd of OP and TP respectively by 2008. The Rumford Paper Co. has reduced its discharge of OP and TP by more than 50% since 2004 and is well within its permit limits (Figures 28 and 29).

Figure 28. Mean summer monthly ortho-phosphorus (OP, pounds per day) discharged from Rumford Paper Co., 2004-2008

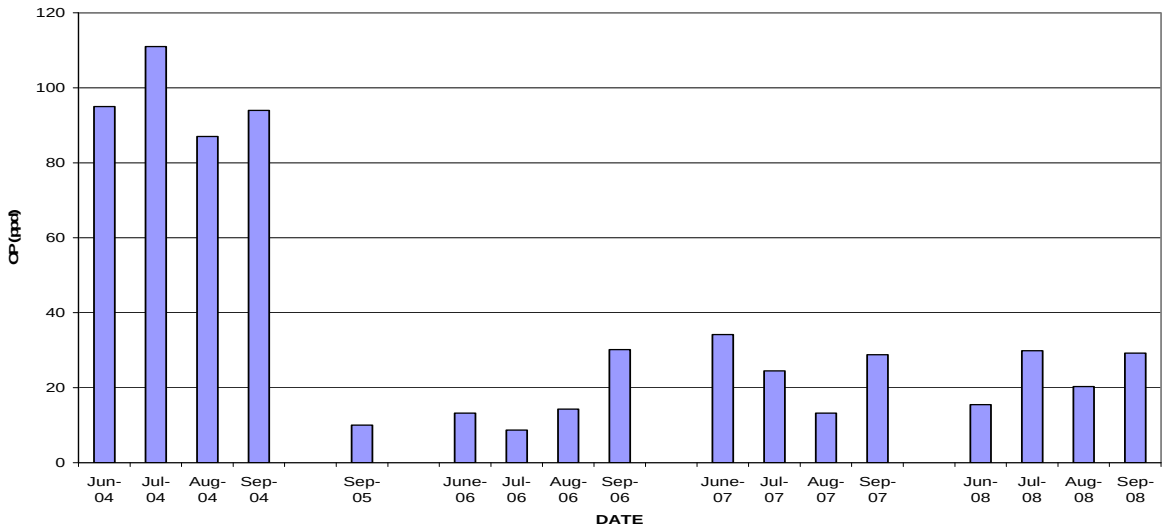
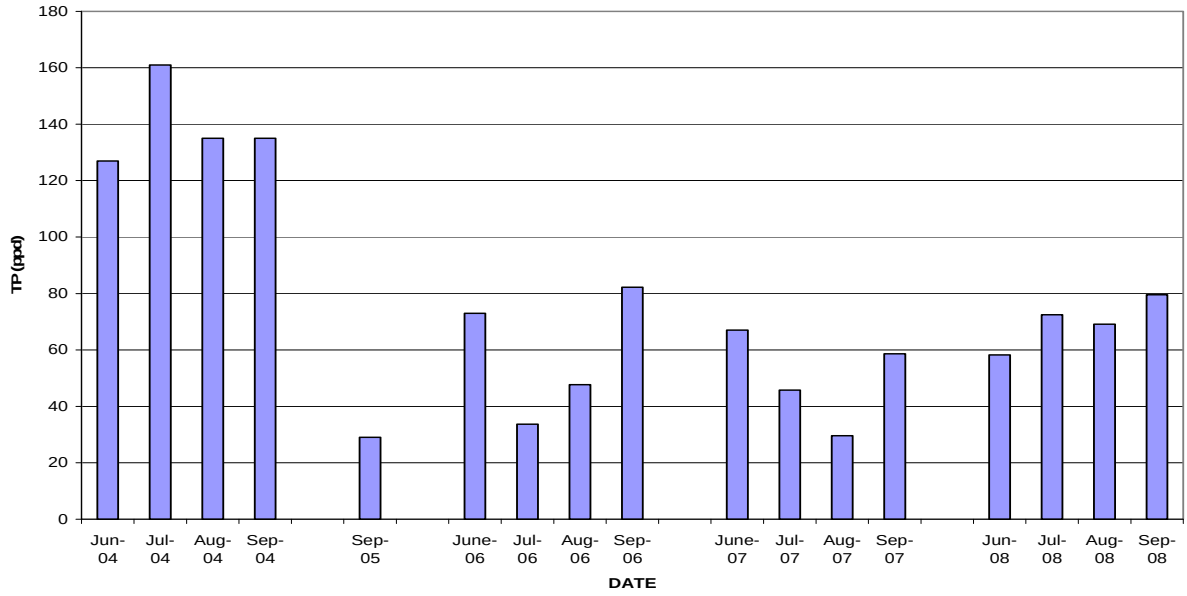


Figure 29. Mean summer monthly total phosphorus (TP, pounds per day) discharged from Rumford Paper Co., 2004-2008



The MPDES permit issued in September 2005 and new Board of Environmental Protection order issued February 2008 for Verso Paper Co. requires that the summertime discharge of OP and TP not exceed 33 and 150 ppd respectively by June 1, 2008 and 22 and 130 ppd respectively by June 1, 2010. The discharge of OP and TP from Verso has been reduced by approximately 50% since 2004 and has met the 2008 and 2010 limits since, although discharge of TP increased in 2008 since late 2005 (Figures 30 and 31).

Figure 30. Mean summer monthly orthophosphorus (OP, pounds per day) discharged from Verso Paper Co., 2004-2008

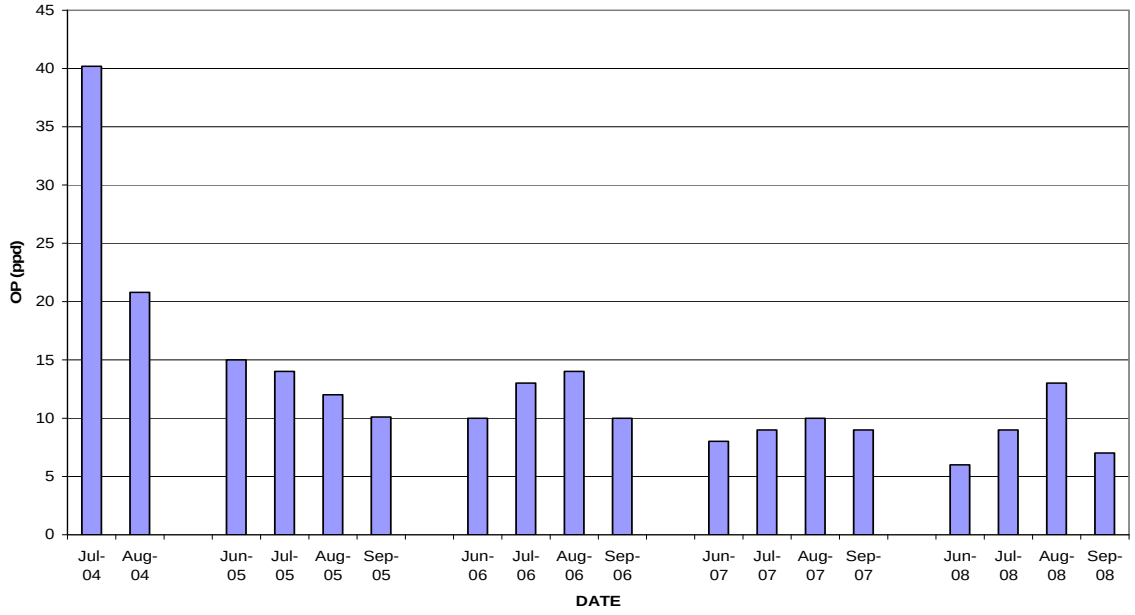
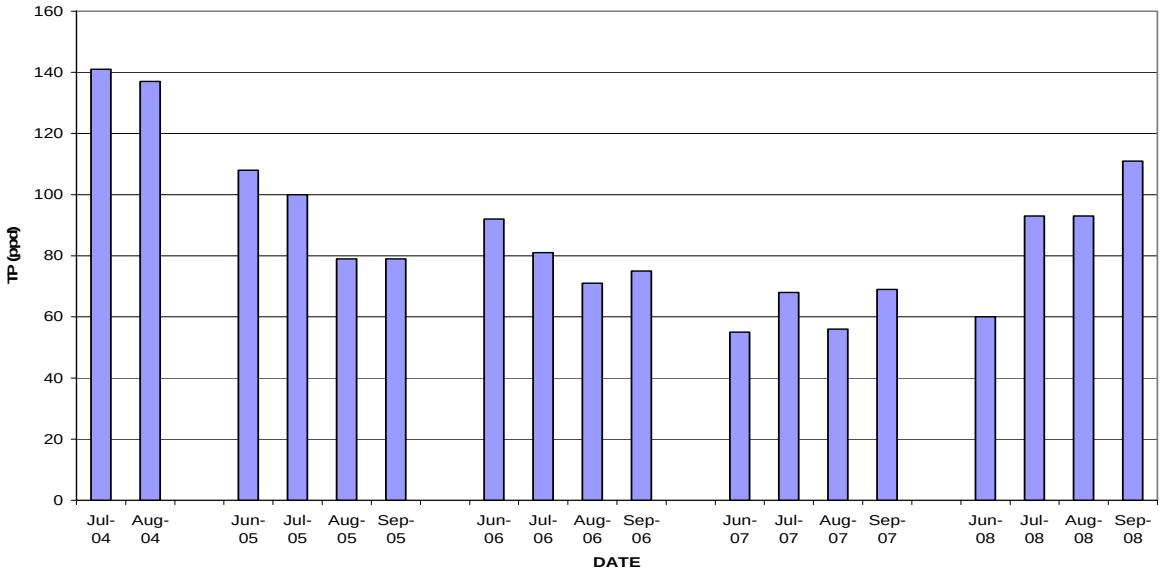


Figure 31. Mean monthly summer total phosphorus (TP) discharged from Verso Paper Co., 2004-2008



CONCLUSIONS

In 2008, water quality of Gulf Island Pond was improved over that of recent years. Aerial observations did not detect an algal bloom at Gulf Island Pond in 2008. Total phosphorus at Lower Narrows was similar to that of 2007 and lower than in all previous years since the present monitoring strategy began in 2004. Chlorophyll-a concentrations did not exceed the threshold for blooms in lakes (8 ug/l) nor the interim threshold for Gulf Island Pond (10 ug/l) and there appears to be a declining trend since 2004.

Dissolved oxygen concentrations were below both the minimum criterion of 5 mg/l and monthly average criterion of 6.5 mg/l (at a temperature of 22°C or less) for up to 21% of the summer in the deeper portions of various stations in Gulf Island Pond. Although the mills met their phosphorus discharge limits, these data validate the need for additional remediation, such as reduced discharge limits and increased oxygen injection in Gulf Island Pond, as required in the current permits for Rumford Paper Co, Verso Paper, and Florida Power and Light .

In 2008 water quality of Gulf Island Pond was the best since recent studies began in 2004. This is no doubt partly due to reductions in discharges at the Rumford Paper Co. mill in Rumford, Verso Paper Co. mill in Jay, and to a lesser extent the closure of the Fraser Pulp mill in Gorham, New Hampshire since 2004. The improvement in water quality in 2008 was also due to a relatively wet summer and, hence, increased river flows and dilution of wastewaters. Monitoring needs to be continued to determine compliance with Maine's Water Quality Standards. Measurements at additional depths within the thermocline are needed and will be measured by DEP in 2009.

References

Acheron , 2008. Androscoggin River and Gulf Island pond Water Quality Monitoring Report, 2008. Submitted to the Maine Department of Environmental Protection, Augusta, Maine, November 30, 2008.

Water Monitoring Services, 2008. Final Report of Water-Quality Monitoring Data, June-September 2008. Submitted to the Maine Department of Environmental Protection, Augusta, Maine, January 2009.