2-1-2010

Gulf Island Pond Monitoring Program Report

Maine Department of Environmental Protection

2009 Gulf Island Pond Monitoring Program Report

Maine Department of Environmental Protection

February 2010

DEPLW-1109

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 2009 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 2009. 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 2009. The mean total phosphorus concentration at DEP's reference station at Lower Narrows was similar to those of 2007 and 2008, all being significantly lower than in 2004. The 2009 mean summer chlorophyll-a concentration was similar to that of 2008. In 2009 peak chlorophyll-a concentrations occurred in mid June and July and were slightly below the threshold established for lakes (8 micrograms per liter) and well below the interim threshold for GIP (10 micrograms per liter). The peak chlorophyll-a concentration was contemporaneous with the June peak total phosphorus, but the second peak chlorophyll-a concentration occurred at a lower total phosphorus concentration. Mean Secchi disk (SD) transparency for the entire summer was slightly lower than those for all prior years when measured. SD transparency was above the 2 m threshold for blooms in lakes for most sampling dates. Exceptions were early June at the deep hole, during high flow event in late June at all stations, and on August 5 at Lower Narrows, all 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 2010 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 total phosphorus from Rumford Paper Company continued to be lower than those in 2004, similar to those in 2005-2007, while the discharge of orthophosphorus increased in 2009. Both are well within permit limits. Discharges of orthophosphorus from Verso increased in 2009 while discharges of total phosphorus have increased since 2007. Both are still within 2008 permit limits, but orthophosphorus in August 2009 would exceed the 2010 permit limit. 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 mitigation, such as 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, 2009

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 2009. 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 statutorily 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 2004-2009. 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 2009 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 2009, 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 on June 3rd, June 16th, July 28th, August 4th, August 11th, August 18th, August 25th, and September 1st (total of eight successful monitoring events). Planned monitoring events for other weeks in June and July could not be successfully completed due to adverse weather conditions (e.g., rain/fog) or scheduling conflicts. Based on observed ambient river conditions (temperature, flow, DO profile, etc.) and cooling weather conditions, the Department did not conduct aerial monitoring events after September 1st. 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;
(8) Dead River Dam-DRD;
(9) Verso Paper discharge –VP; and
(10) Rumford Paper discharge- RPC.

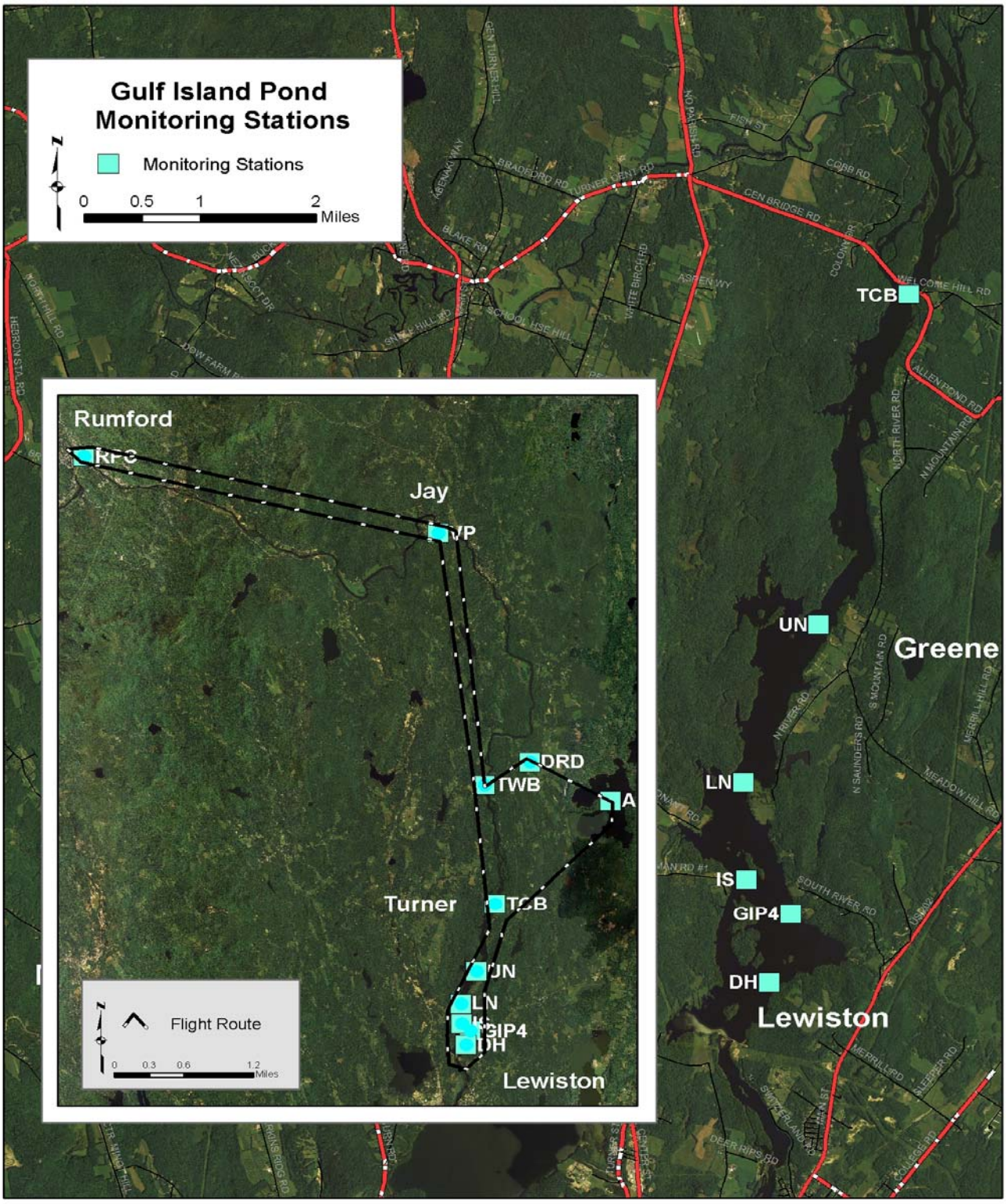
In addition, the monitoring effort included certain locations upriver from Gulf Island Pond in order to determine potential sources of nutrient loading to the watershed. The aerial survey route was northerly to the Upper Narrows monitoring station and northerly along the river to Center Bridge, Androscoggin 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 within the Androscoggin River from aerial observations during 2009. However, on August 11, 2009, the Department observed a significant algal bloom in a waterbody known as Cherry Pond that is adjacent to, but physically isolated from, the main stem Androscoggin River by an earthen causeway. Cherry Pond is located in the Town of Greene just north and due east of Lower Narrows. On August 11, 2009, Department staff conducted ground observations of Cherry Pond and collected surface grab samples for algae identification. During the ground observation effort, Department staff did not observe the presence of culverts or other structures that would allow the free exchange of surface waters from Cherry Pond to the Androscoggin River. Department staff did not observe any discoloration or bloom type conditions in the river immediately adjacent to Cherry Pond. During routine aerial observations conducted on August 25, 2009, Department staff observed that the algae bloom in Cherry Pond had greatly diminished, and conditions observed during the September 1st aerial observation effort appeared "normal."

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 and appears to be attributed to suspended solids. 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.. 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 2009 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, mean flow in July was the highest of all years and mean flow in August was well above those for all other years except 2008 (Figure 3). Consequently, the mean for the summer was higher than those for all other years since 2004 except 2008 (Figure 4).

Figure 2. Mean daily discharge June to September 2009

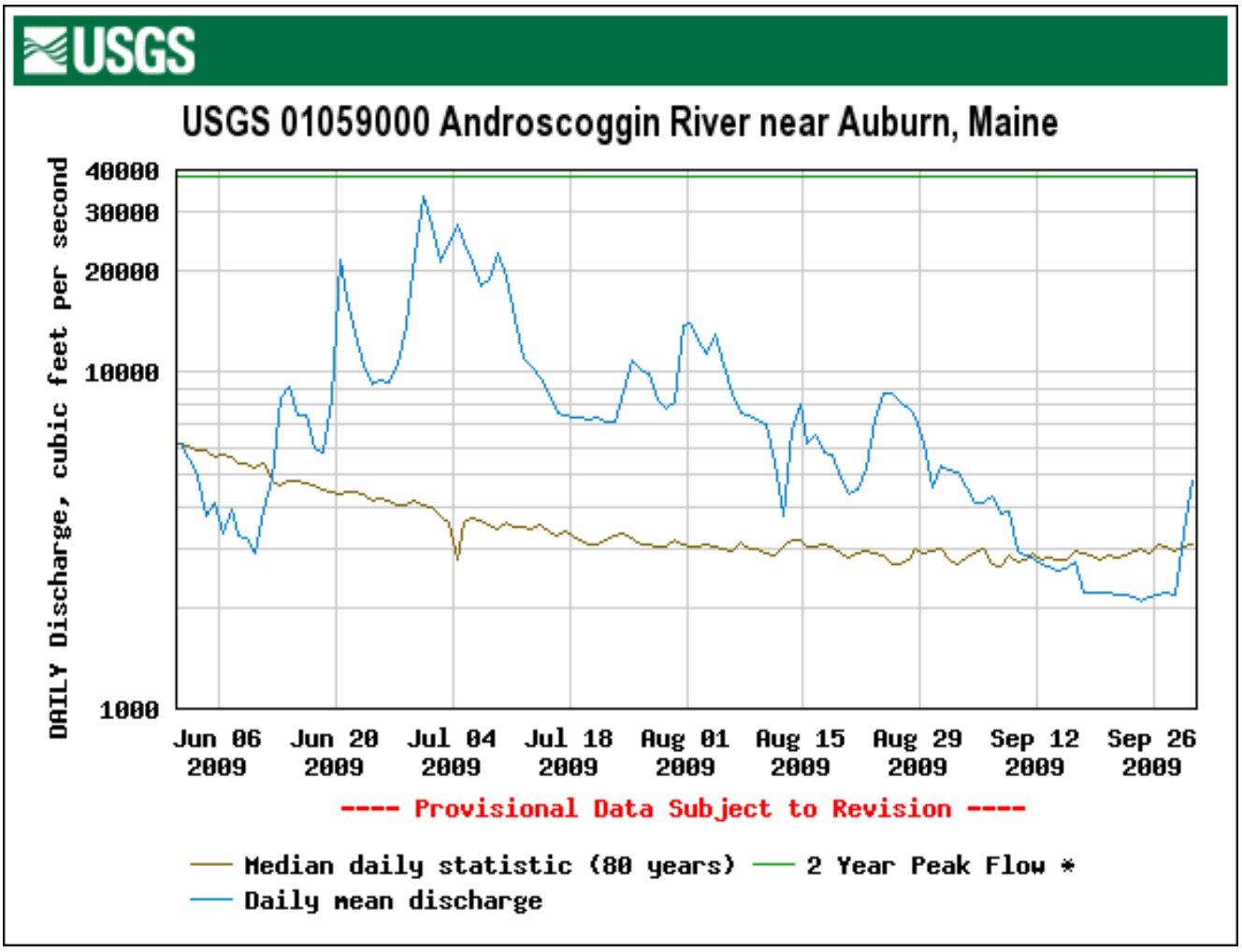


Figure 3. Mean monthly flows (Qr, cfs) of the Androscoggin River at Auburn, 2004-2009

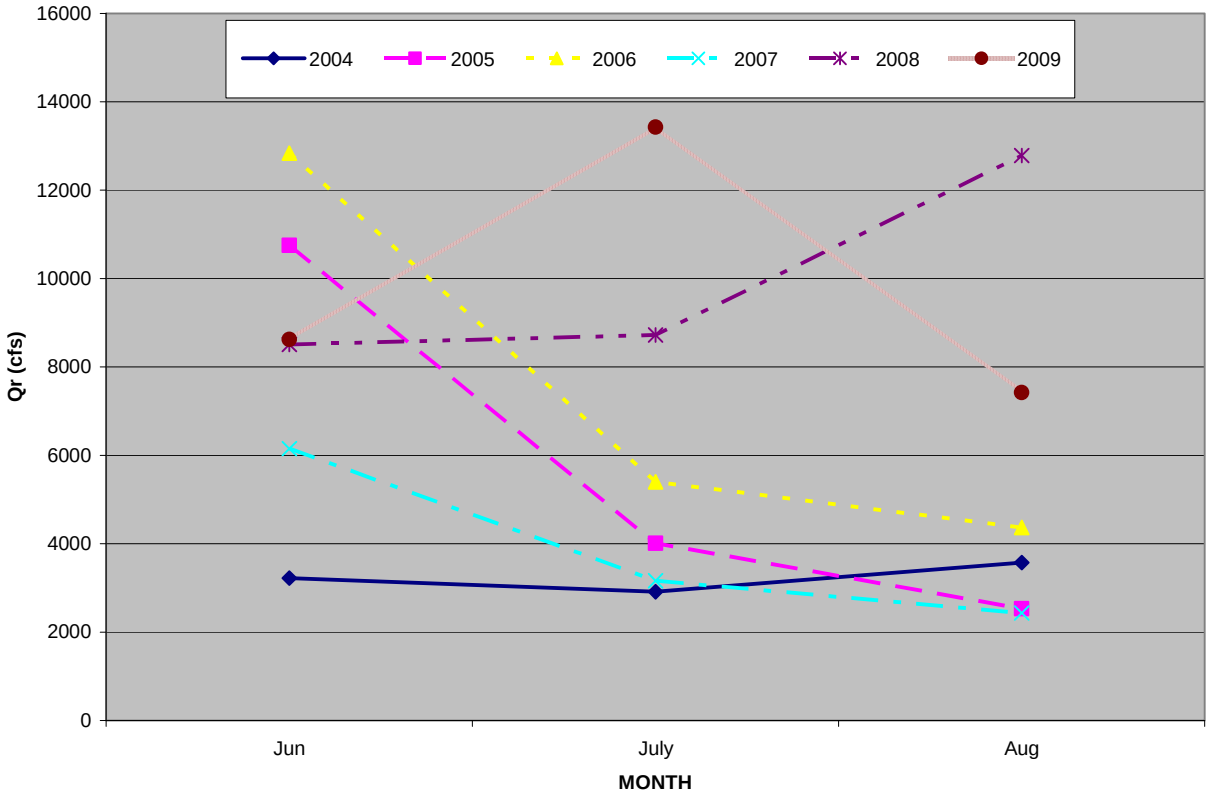
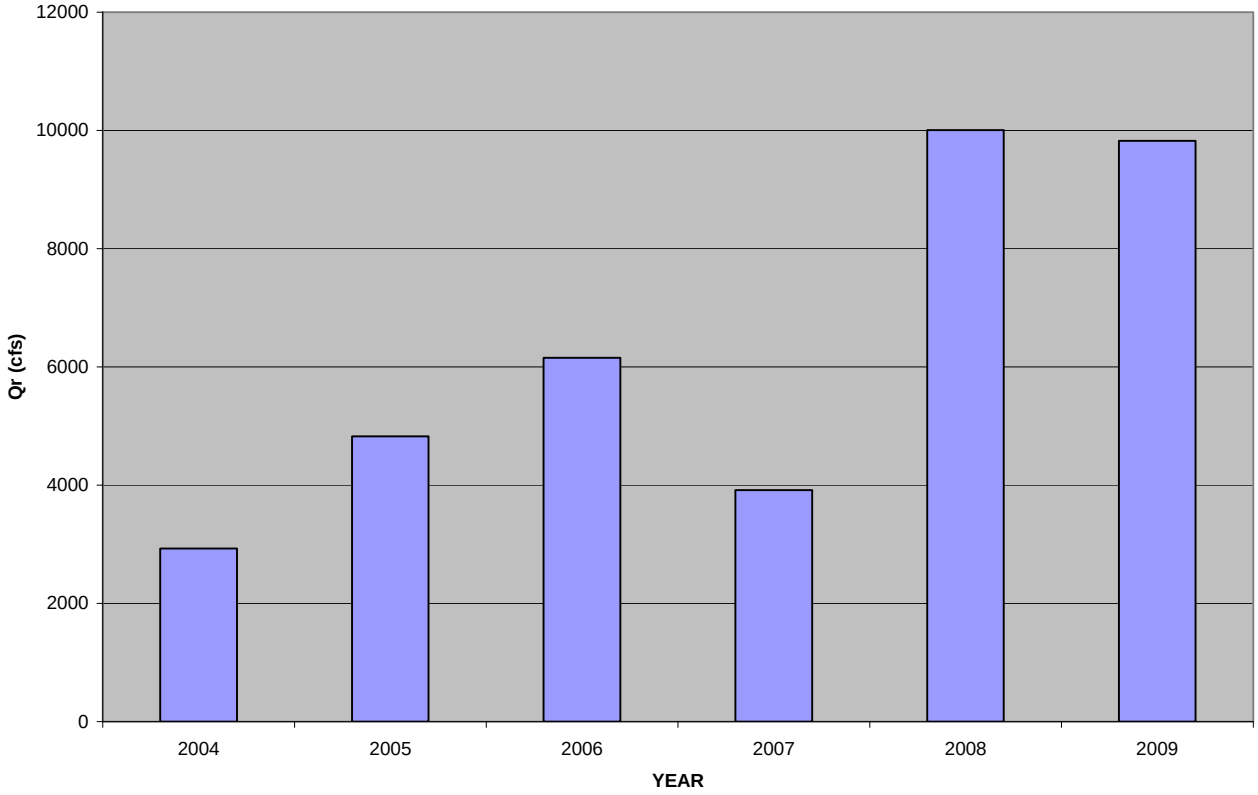


Figure 4. Mean summer flows of the Androscoggin River at Auburn, 2004-2009



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 2009. The highest TP concentration (22 ug/l) occurred on June 16 but concentrations did not vary much throughout the summer (Figure 5, Appendix 1). This was coincident with the first of the high runoff events during the summer of 2009, which might suggest the impact of non-point sources (NPS) of TP (Figure 2). Yet TP concentrations were lower in late July and early August when river flows were similar or higher. All TP concentrations exceeded the general threshold for blooms in uncolored lakes (15 ug/l). Compared to uncolored lakes (<30 PCU), however, higher TP is usually required in colored lakes (>30 PCU) 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 2009 (19 ug/l) was at the lower threshold, and essentially similar to that of 2007 and 2008, all of which were slightly but significantly lower than those from 2005 and 2006 and 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 dominant and comparable to earlier years.

Figure 5. Total phosphorus (TP) concentrations at Lower Narrows, GIP, 2009

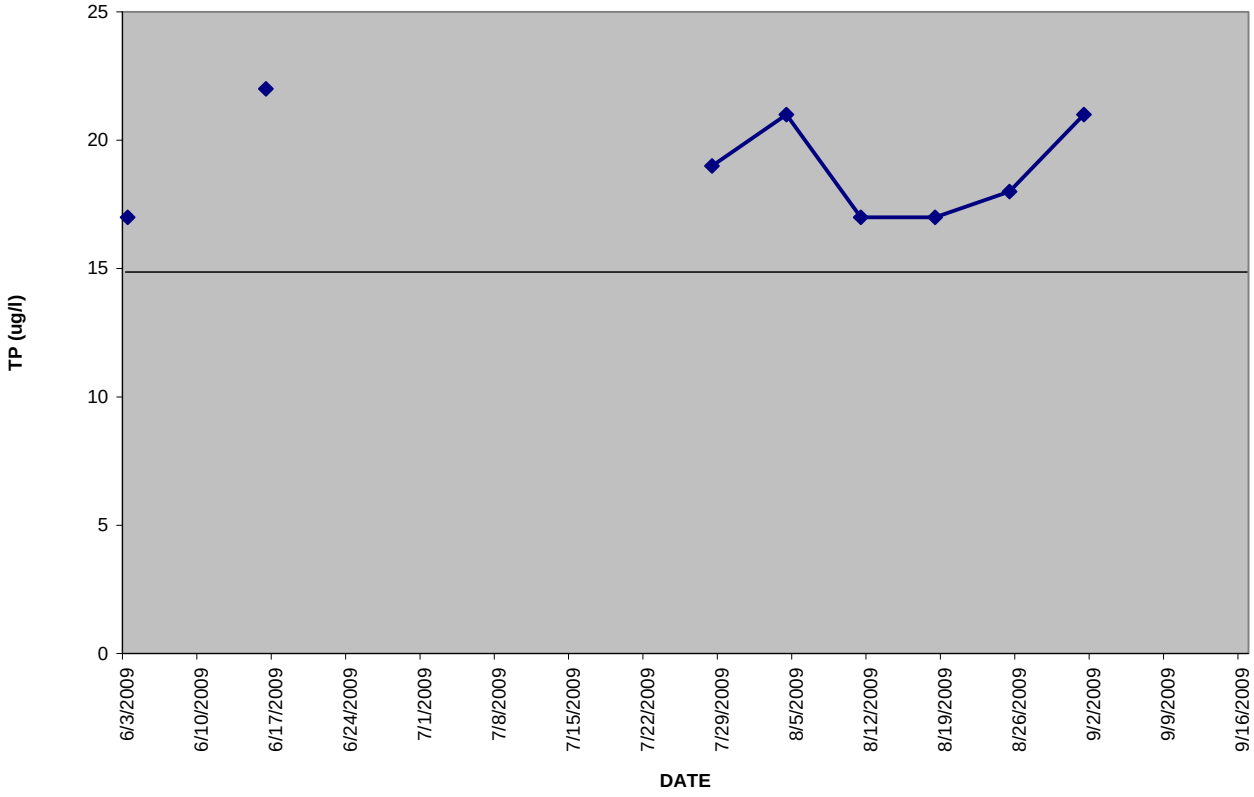
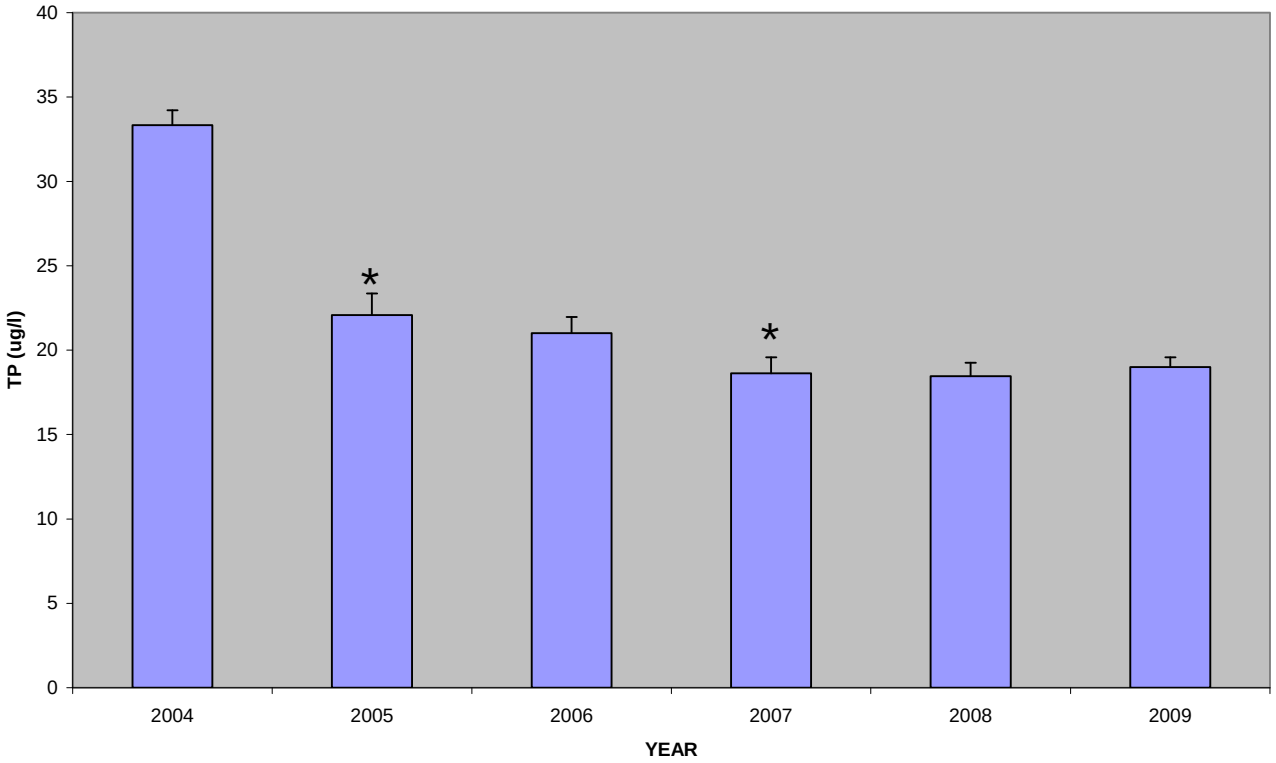


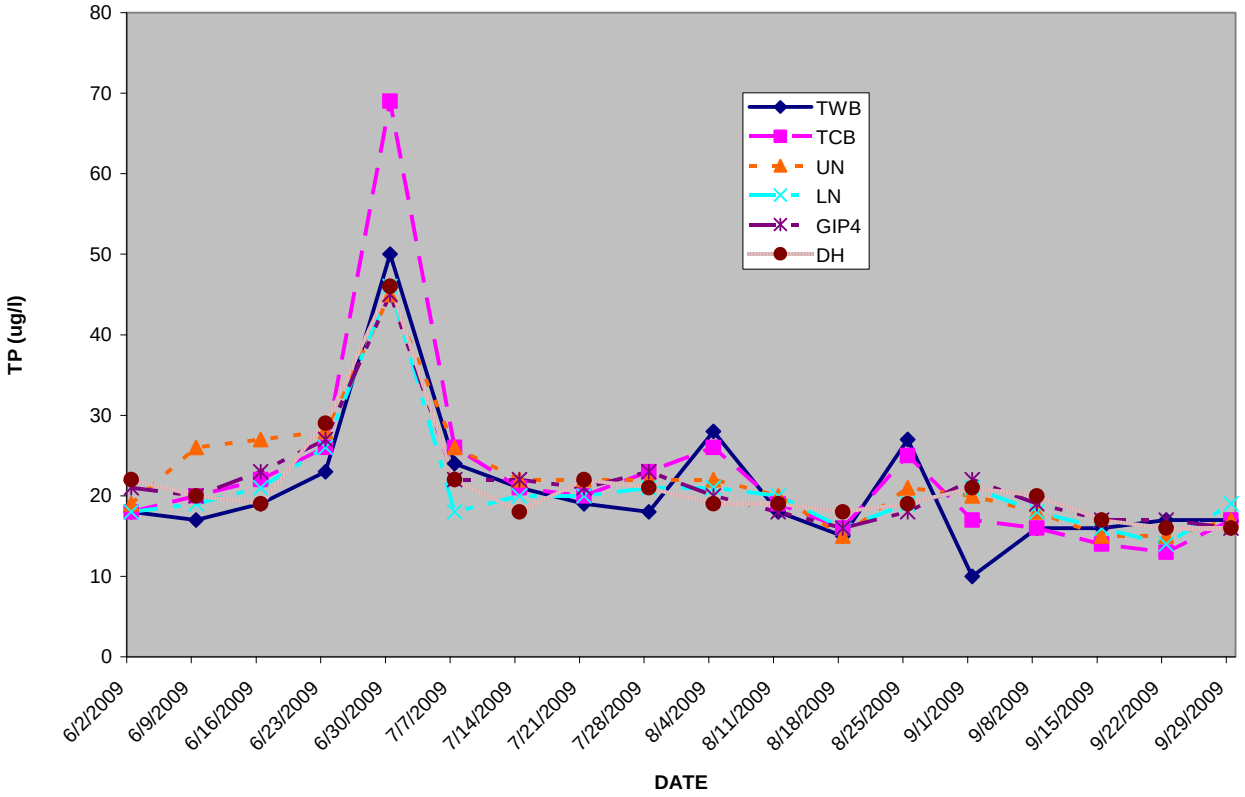
Figure 6. Mean summer total phosphorus (TP)concentrations at Lower Narrows, GIP, 2004-2009



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, Appendix 2). In general, concentrations were highest at the upstream stations and decreased downstream, perhaps due to dilution, algal uptake, or sedimentation. The unprecedented TP peak on June 30 at all stations followed two large precipitation events resulting in high river flow exceeding 30,000 cfs (Figure 2). Field observations noted that the storm events "caused a notable change in water quality of the Androscoggin River and Gulf Island Pond for several weeks after the storm…..For the time period during and following the stormy period in late June and early July, the water in the Androscoggin River and Gulf Island Pond had a muddy, brown appearance with a notable amount of organic debris floating on the surface and suspended in the water column near the surface". There were no samples collected by DEP during this period. For the rest of the summer, there was good correspondence for mean summer TP at LN from the Maine Health and Environmental Testing Lab (HETL) (19 ug/l) and Acheron (20 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 3 ug/l on August 11. Mean TP values from Acheron (21 ug/l) for the entire summer, were higher than those from HETL (19 ug/l) for the limited period because of relatively high TP during the high flow events when DEP did not sample.

Figure 7. Total phosphorus (TP) at 6 stations in GIP, 2009

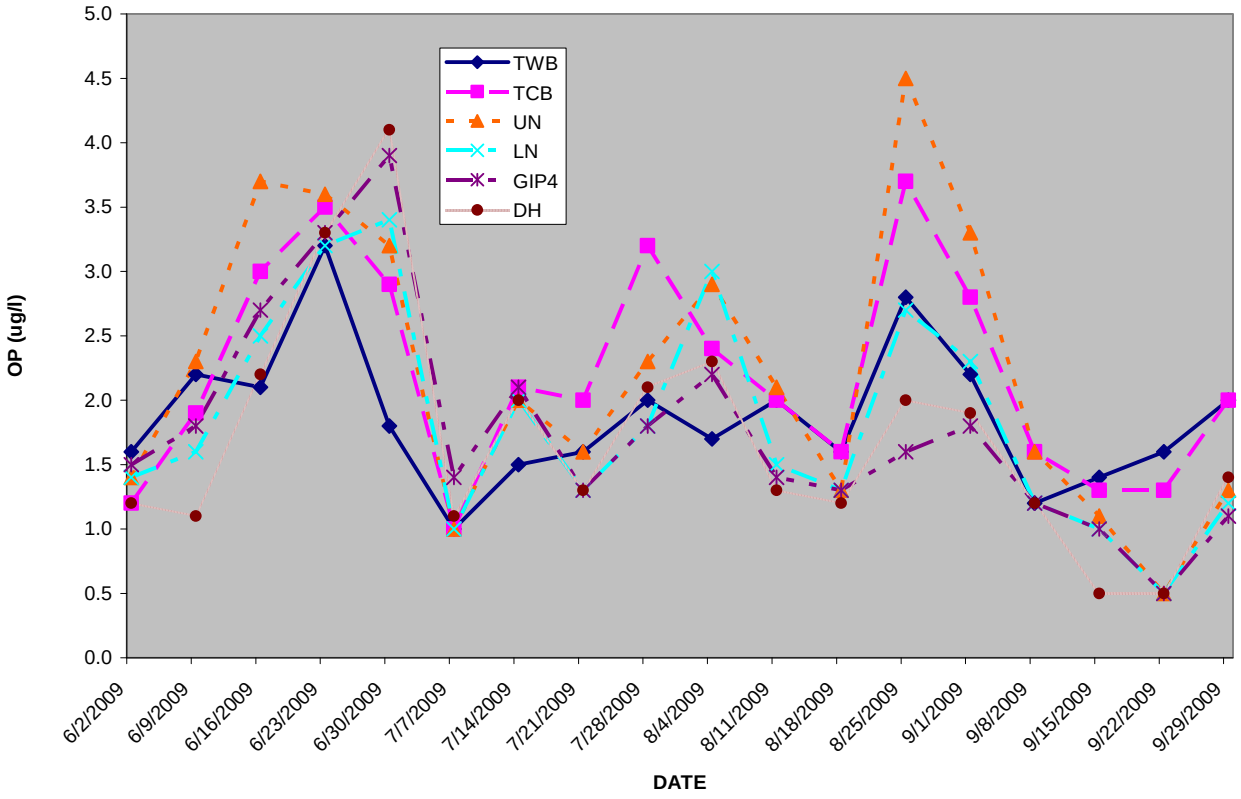


Ortho-phosphorus

Acheron/GIPOP study

Dissolved ortho-phosphorus (OP) values were quite low, but with more variability among stations than TP (Figure 8, non-detects calculated at one half the detection limit at 0.5 mg/l; Appendix 2). The peak in late June, occurred at the same time as that for TP. The later peaks were much more pronounced for OP than for TP. The late July OP peak preceded the TP peak at TCB. The range for OP is relatively small compared to that of TP. OP was often lowest at the most downstream stations, especially during the latter part of the summer, documenting that most TP was taken up quickly by plants, once river flows lowered.

Figure 8. Orthophosphorus (OP) at 6 stations in GIP, 2009

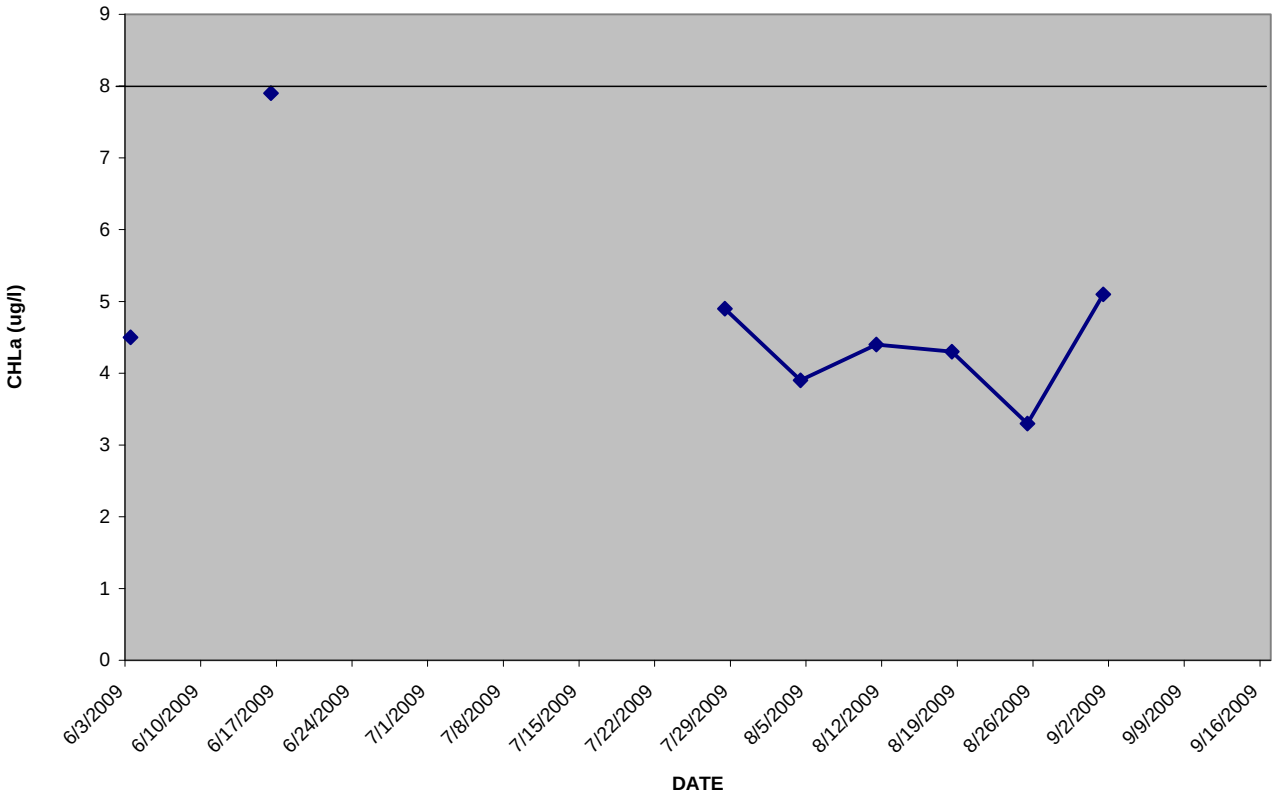


Chlorophyll-a (CHLa)

DEP Study

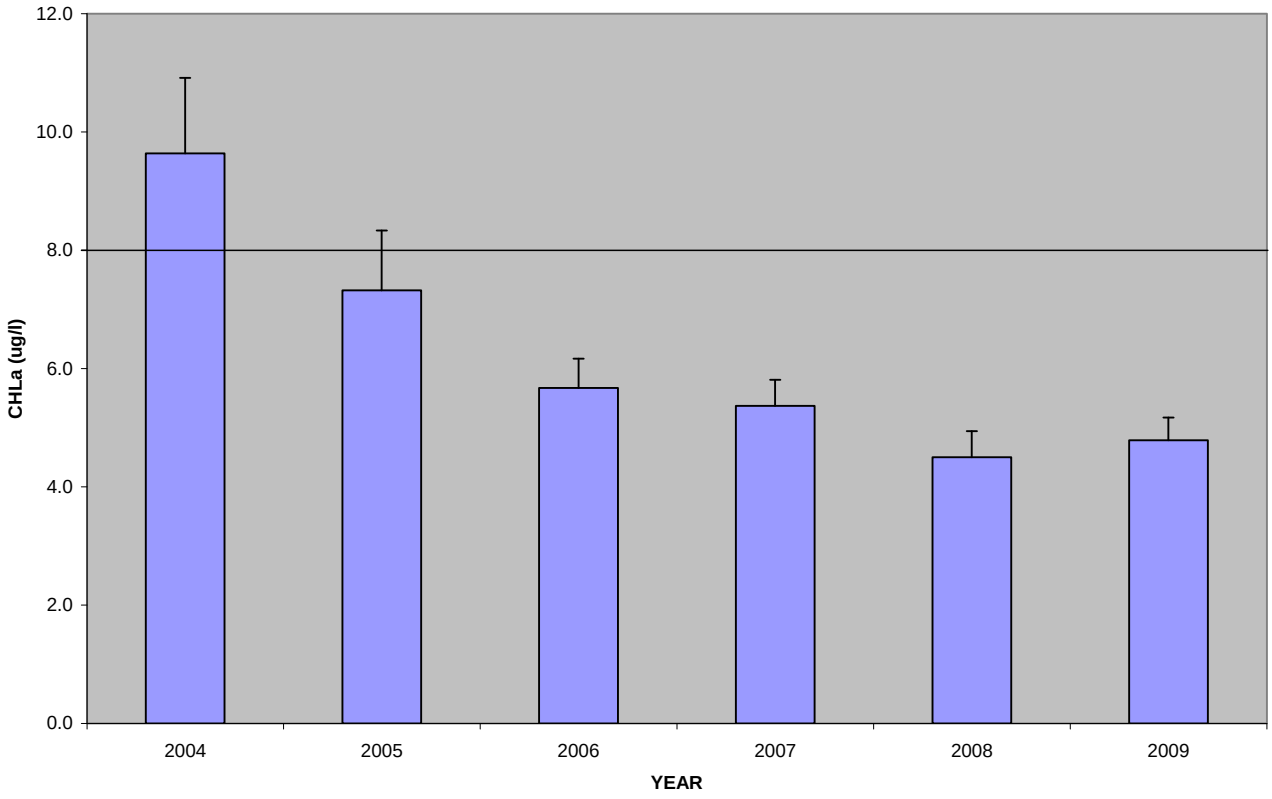
Uncorrected CHLa data are reported here for 2009 and all previous years, unlike reports from years prior to 2008 showing corrected chlorophyll a, which is determined by a different method that can result in a high bias.. Uncorrected chlorophyll a has been used by DEP's lakes program for several years. DEP sampling at LN in 2009 was limited by weather and high flows. The highest CHLa was on June 16, 2009; it was 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, Appendix 1). There was no observation of a bloom from the aerial flights on this or any other sampling date. June 16 was also the date of the peak TP for the summer which not much higher than it was for many other dates when CHLa was much lower.

Figure 9. Chlorophyll a (CHLa) concentrations at LN, GIP, 2009



In 2009 the mean summer CHLa concentration appeared second lowest of all recent years measured (Figure 10). There appears to be a declining trend from 2004, when first measured, to 2008, although there is no statistically significant difference in concentrations between any one year and the next.

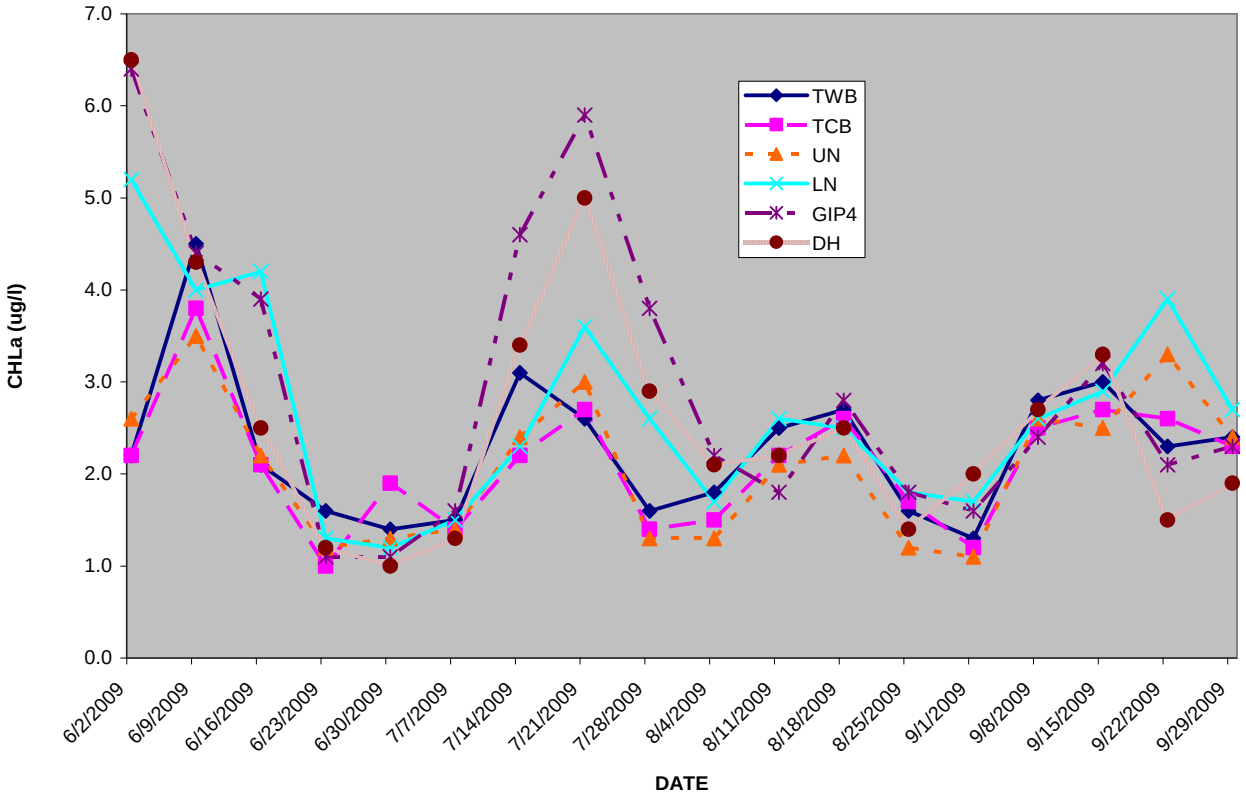
Figure 10. Mean summer chlorophyll a (CHLa) concentrations at LN, GIP, 2004-2009



Acheron/GIPOP study

Acheron weekly sampling at six stations showed corrected CHLa with two major peaks, one in early to mid June and a second in late July, both below 8 ug/l bloom threshold for lakes, in early June and early July (Figure 11, Appendix 2). 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. The June peak corresponded in timing to the peak measured by DEP (Figure 9) but Acheron's corrected CHLa was lower than the uncorrected CHLa measured by HETL. Mean summer uncorrected CHLa at LN was higher in HETL analyzed samples (4.8 ug/l) than corrected CHLa from Acheron (2.2 ug/l). No results exceeded thresholds for algal blooms, which is consistent with aerial observations.

Figure 11. Chlorophyll a (corrected) (CHLa) concentrations at 6 stations in GIP, 2009

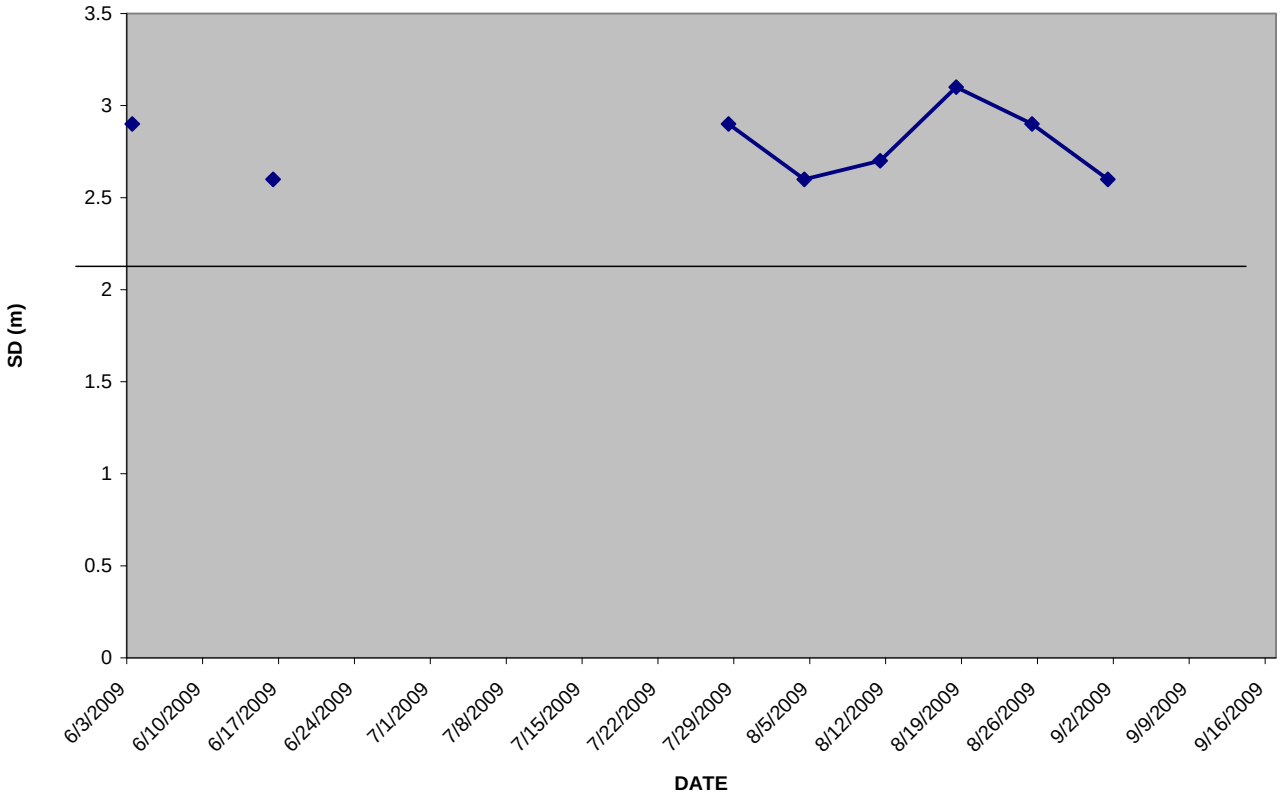


Secchi Disk Transparency (SD)

DEP Study

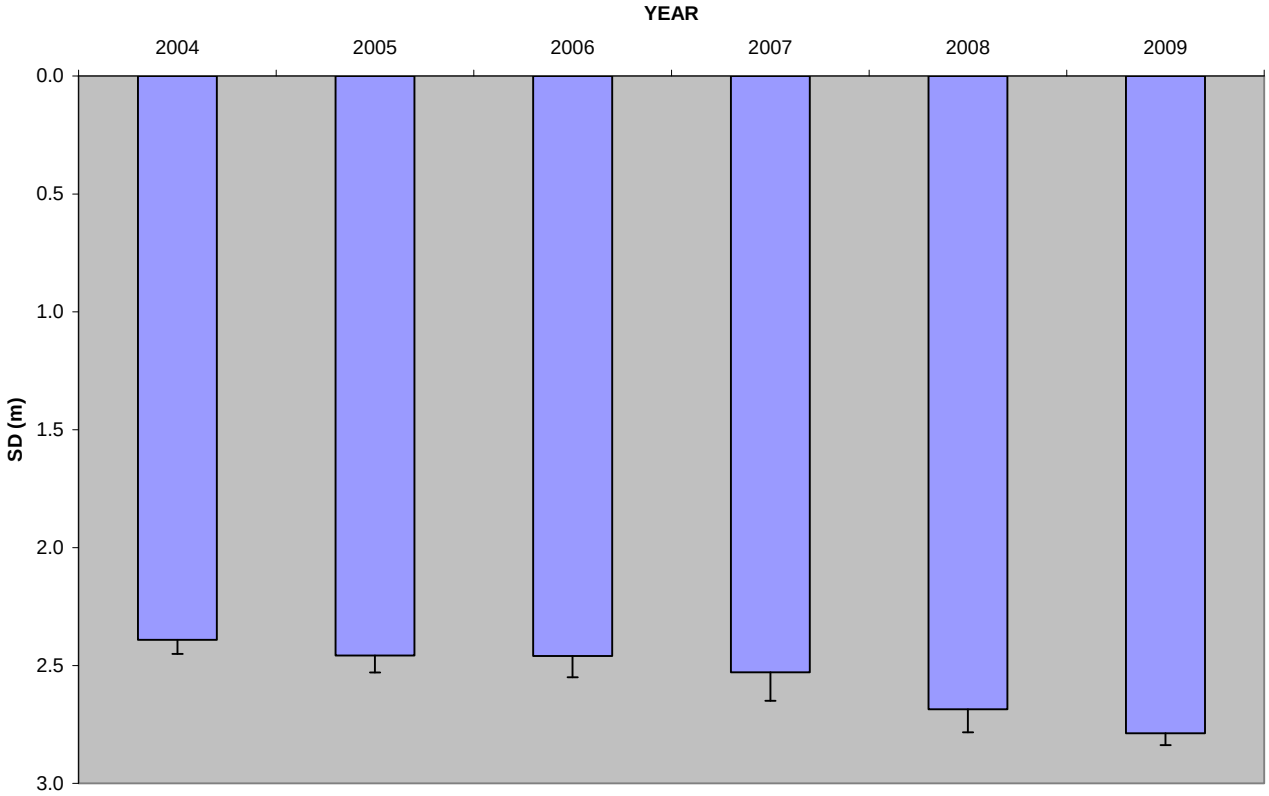
DEP sampling in 2009 at LN documented no events when Secchi disk transparency was less than 2 m (meters), the definition of a bloom in uncolored lakes (Figure 12, Appendix 1). There was no sampling from mid June to late July due to weather and high flows, but any reductions in Secchi disk transparency during that time would likely have been due to suspended sediment from high river flows.

Figure 12. Secchi disk (SD) transparency at LN, GIP, 2009



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.

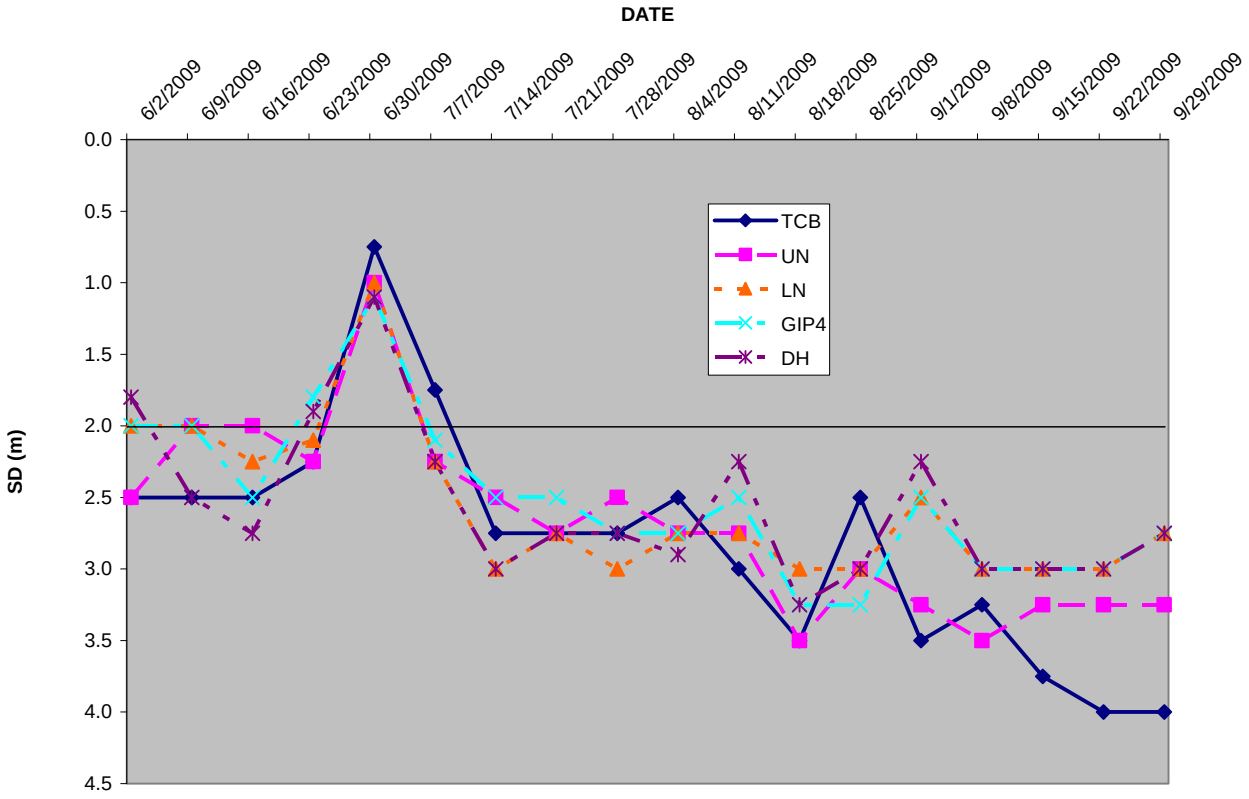
Figure 13. Mean summer Secchi disk (SD) transparency at LN, GIP, 2004-2009



Acheron/GIPOP study

Acheron sampling in 2009 documented Secchi disk (SD) transparency <2 m at all stations for the late June high flow event (Figure 14, Appendix 2). CHLa concentrations were low and field notes confirm that the river was full of suspended solids for that date. Stations in the upper impoundment generally had slightly greater SD transparency than stations in the lower impoundment, similar to the CHLa results. 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 for optimum light levels and to develop than at the two lower stations. Mean SD transparency at LN was similar for both Acheron and DEP sampling events for the same time period, but lower with Acheron data when averaged over the entire summer, which included the high flow events when DEP did not sample.

Figure 14. Secchi disk (SD) transparency at 5 stations in GIP, 2009



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).

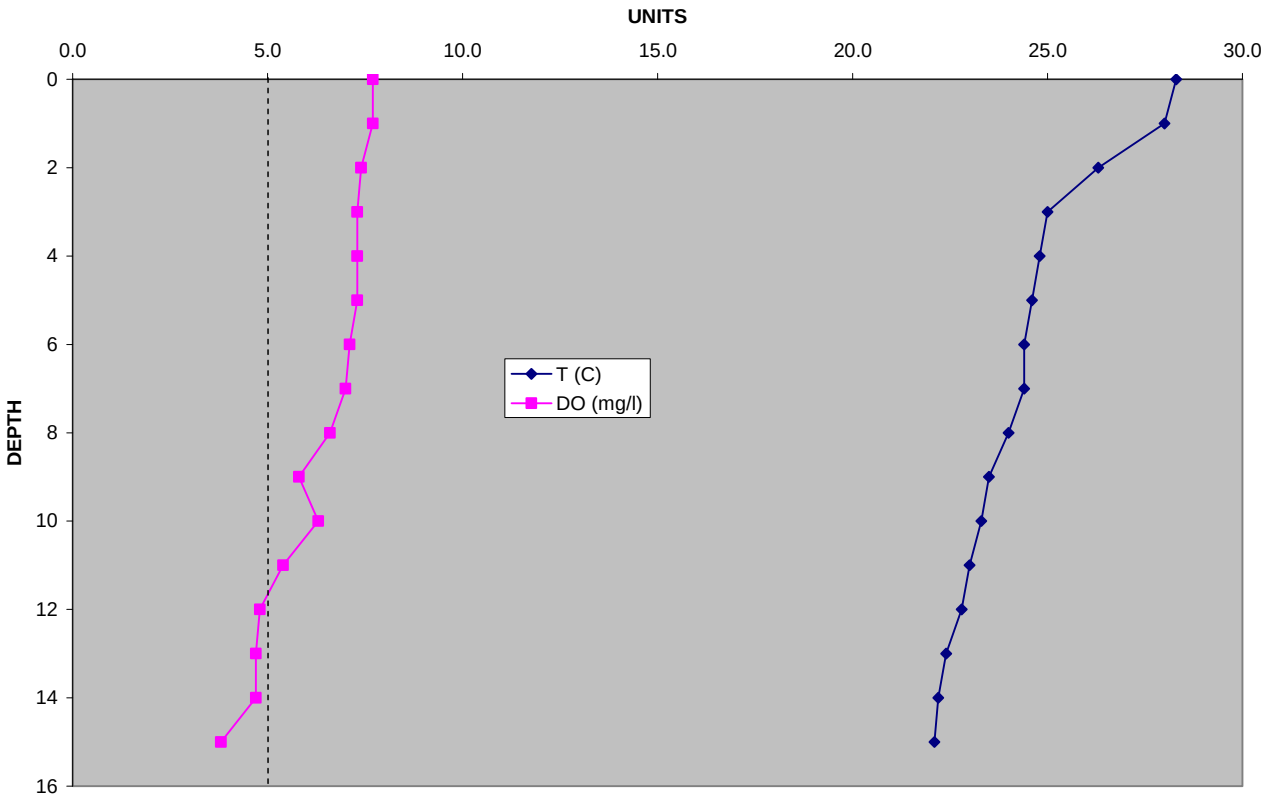
The thermocline is defined as the zone where the temperature decreases at least one degree Celsius per meter of depth. Typically this zone is several meters thick, and therefore, to determine compliance with the statute in thermally stratified riverine impoundments, it is necessary to choose one depth 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

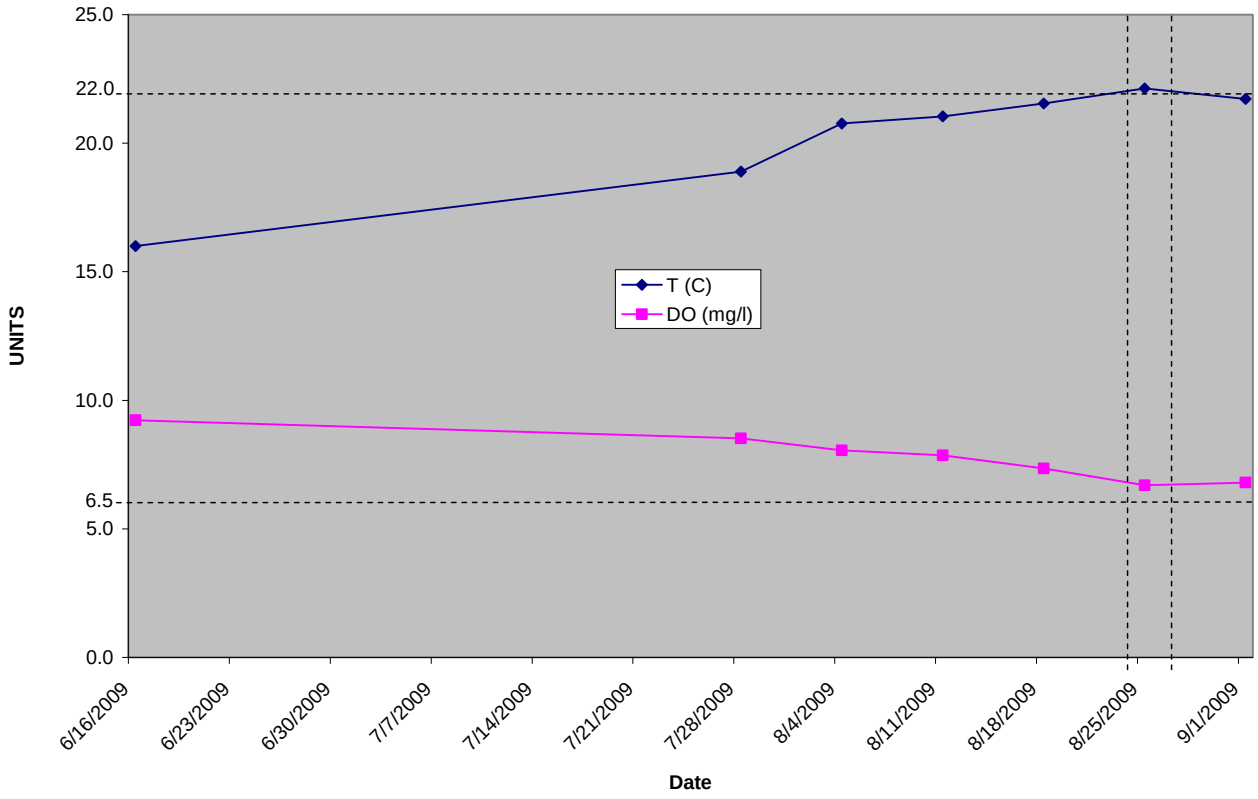
In 2009, DEP measured temperature and dissolved oxygen (DO) vertical profiles at one meter (m) increments at Lower Narrows (LN) weekly in early June and from late July to September 1. Maximum depth at LN is approximately 15 m, and varies weekly by 1-2 m due to storm events and drawdown for hydropower generation at the Gulf Island Dam. There was no thermal stratification on any sampling date. There was an excursion below the minimum DO criterion of 5 mg/l during 1 non-stratified sampling event on August 18 (Figure 15, Appendix 1). Given that sampling events are 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 was about 7% of the summer sampling period when DO was lower than the minimum criterion at LN.

Figure 15. Temperature (T) and dissolved oxygen (DO) at LN, August 18, 2009



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 from the depth where the mean temperature was equal to or less than 22°C down to the point of thermal stratification or 0.5 m above the bottom where there was no thermal stratification. Where there are no measurements at 22°C or less, temperature and associated DO at the second deepest depth or point of thermal stratification are plotted (between the two vertical lines), but DO on those dates would not count as non-attaining. In 2009 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) and dissolved oxygen (DO) at LN, 2009



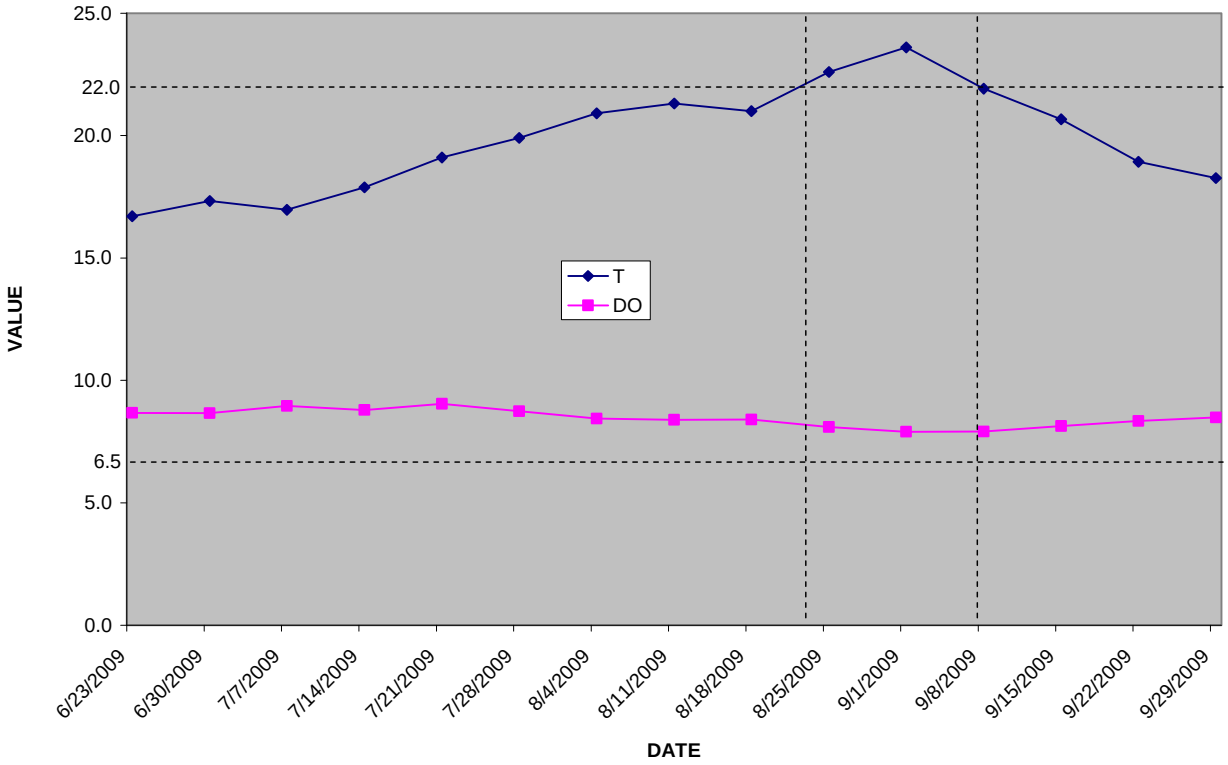
Acheron/GIPOP study

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 the morning for 18 weeks. Examination of the data reveals the findings that follow, by stations. The bottom most reading is not counted as it often within 0.5 m of the bottom where by statute DO will not be measured for attainment of the DO criteria. Also it is difficult to determine exactly where the interface is between water and soft sediments to know if the sampling point is within 0.5 m of the bottom.

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 3). 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).

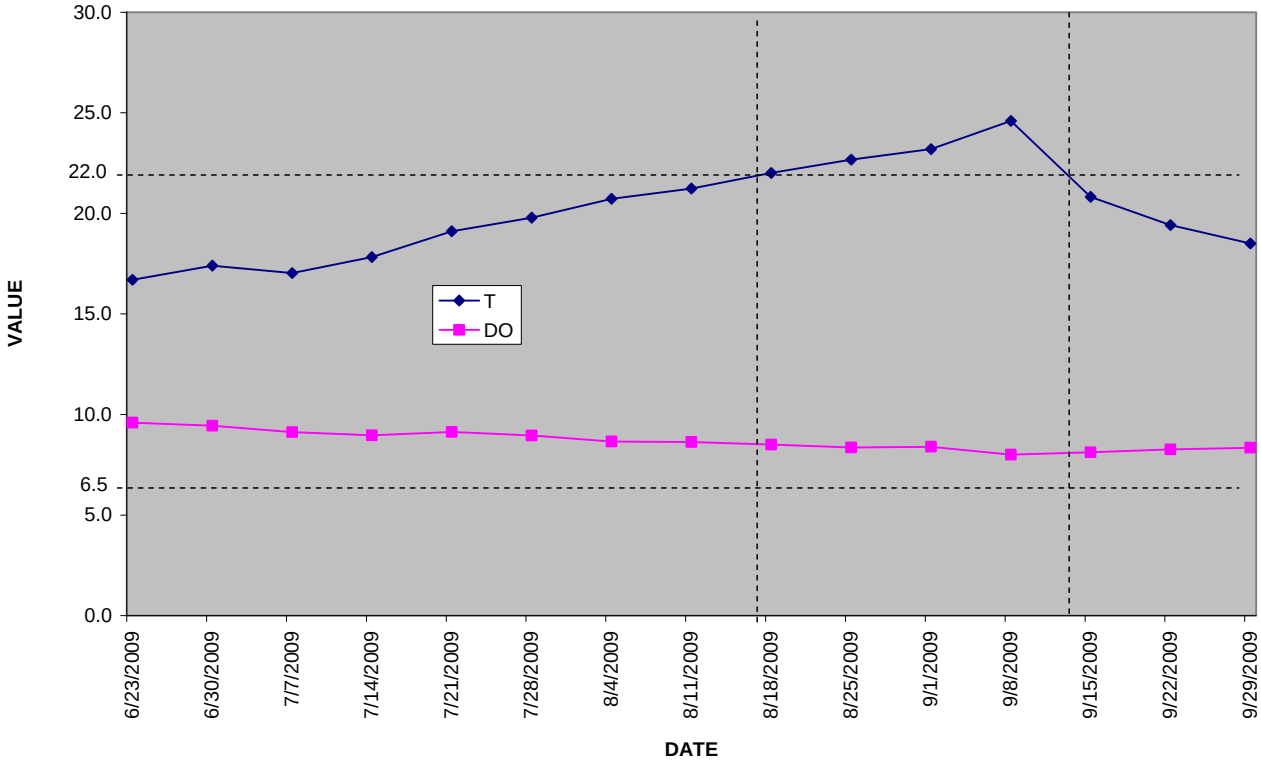
Figure 19. Rolling monthly average temperature (T,°C) and dissolved oxygen (DO, mg/l) at Turner Center Bridge (TCB), 2009



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 3), 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.

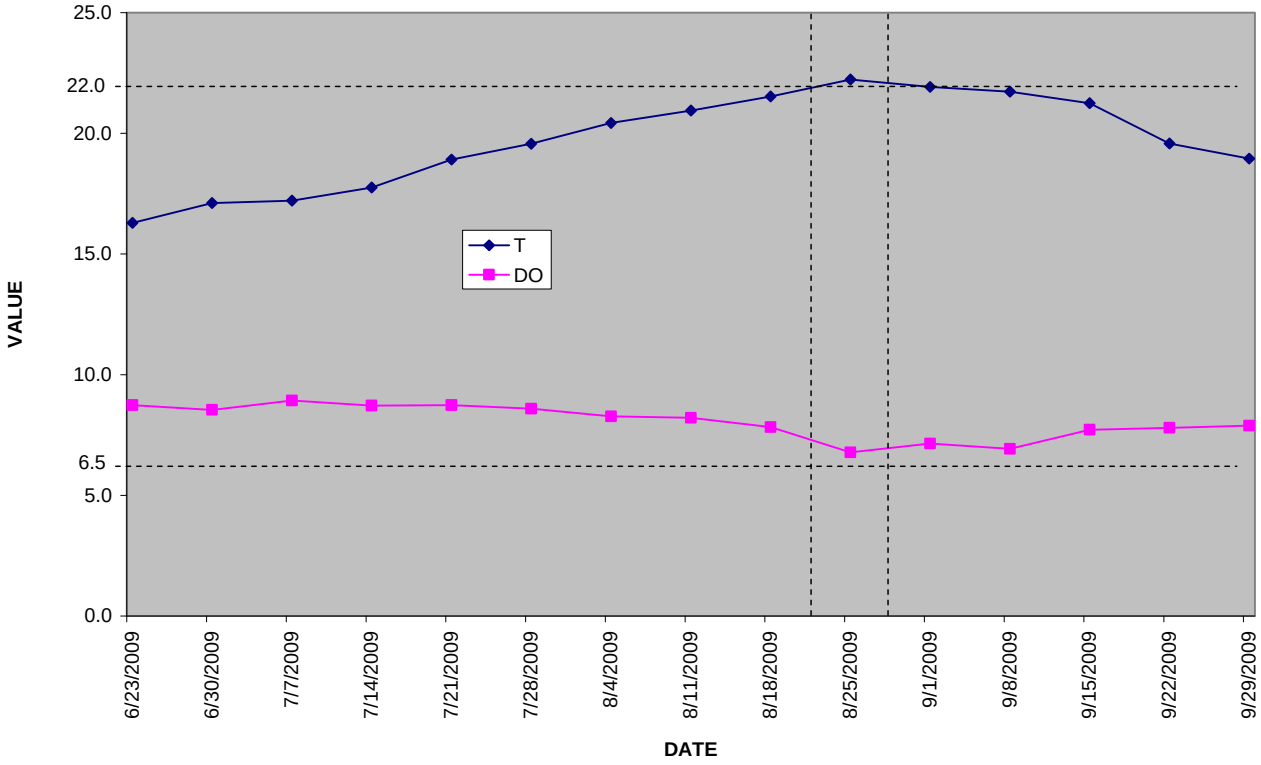
Figure 20. Rolling monthly average temperature (T,) and dissolved oxygen (DO, mg/l) at Upper Narrows (UN) 2009



LN Station

At LN DO was in non-attainment of the minimum DO criterion of 5 mg/l on the August 18 sampling date representing 6% of the summer (Appendix 3). The RMA DO, however, was not below the monthly average 6.5 mg/l criterion regardless of temperature (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 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.

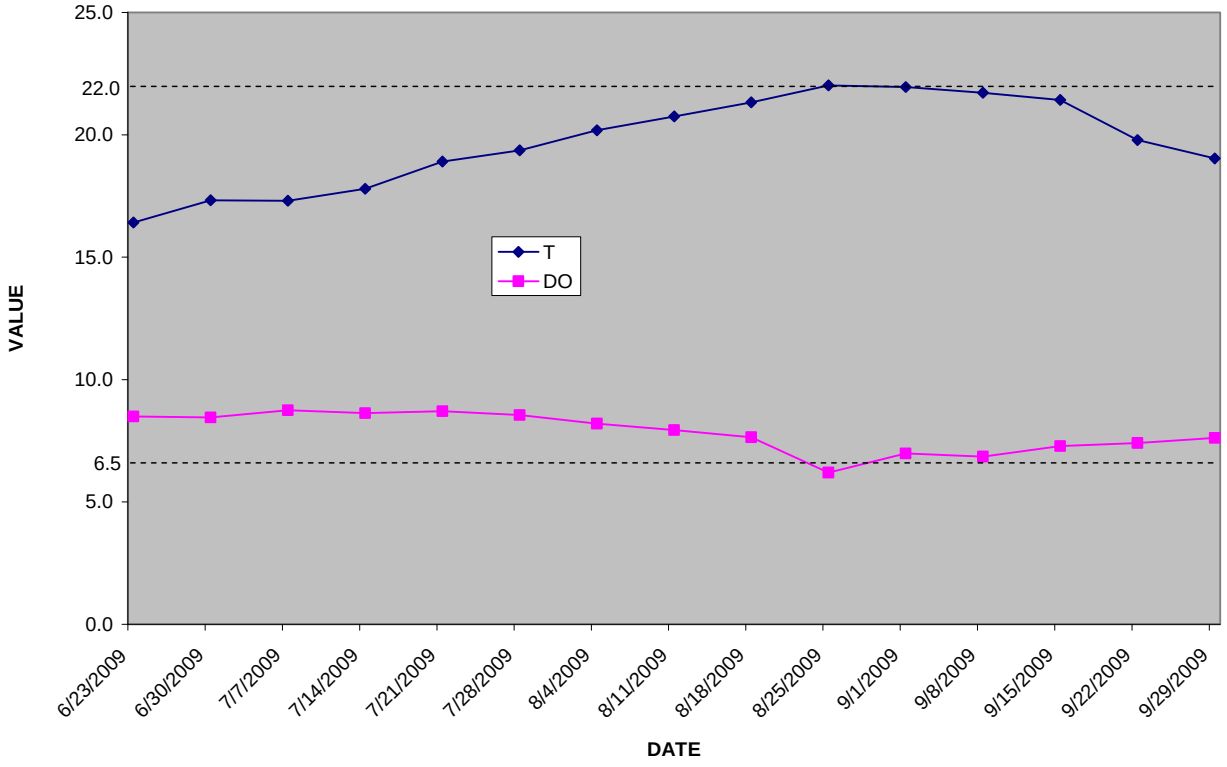
Figure 21. Rolling monthly average temperature (T,) and dissolved oxygen (DO, mg/l) at Lower Narrows (LN), 2009



GIP 4 Station

At GIP 4, DO was in non-attainment of the minimum DO criterion of 5 mg/l on the July 21 sampling date, representing about 6% of the summer. The RMA DO was below the monthly average 6.5 mg/l criterion at the August 25 sampling date, representing about 6% of the summer sampling period for which the RMA was calculated (Figure 22).

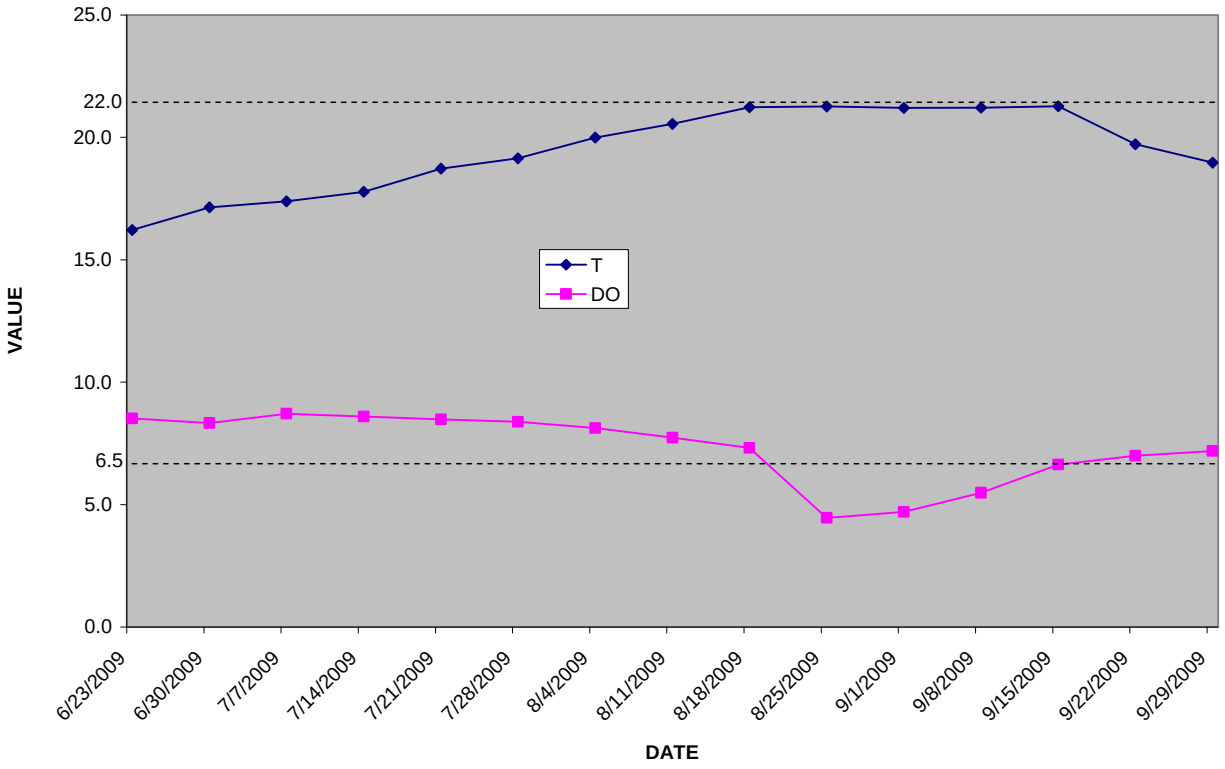
Figure 22. Rolling monthly average temperature (T,) and dissolved oxygen (DO, mg/l) at GIP4, 2009



DH Station

At the DH station, DO was in non-attainment of the minimum DO criterion of 5 mg/l on August 18 and 25, and September 8 and 15, representing about 21% of the summer (Appendix 3). The rolling monthly average DO appears to be below the monthly average 6.5 mg/l criterion for almost 4 weeks representing approximately 21% of the summer sampling period, based on the assumption that there is a linear transition in DO concentrations between weekly measurements (Figure 23). Examination of continuous monitoring data at the DH may help inform this assumption.

Figure 23. Rolling monthly average temperature (T,) and dissolved oxygen (DO, mg/l) at the Deep Hole, 2009



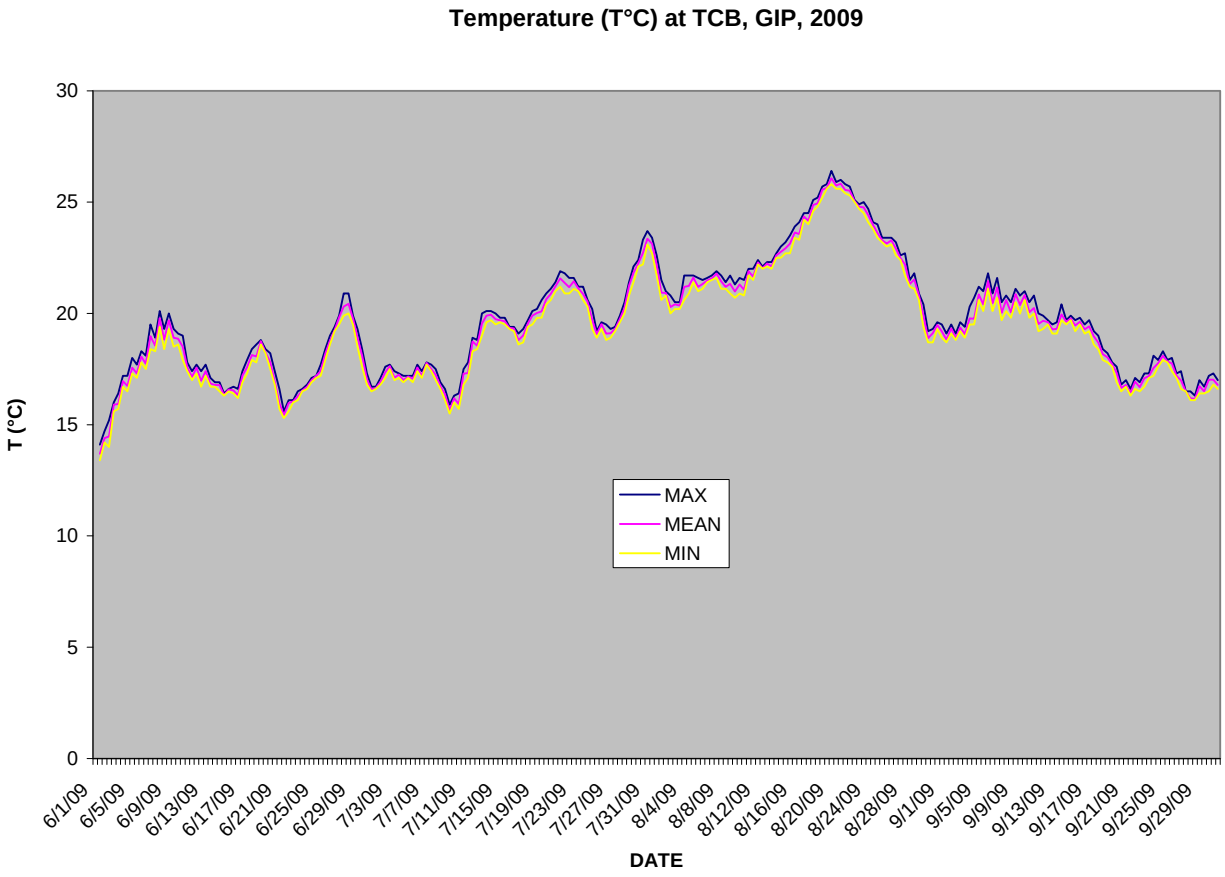
4. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN DATA

The continuous monitoring data, gathered and reported by Water Monitoring Services, Inc. on behalf of the GIPOP, provide additional information about temperature and DO. Beginning in 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 in a profile from top to bottom at one meter increments every two hours. 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 2009 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, Appendix 4). At DH there were fewer days than in previous years (estimated from limited data) of low DO at various depths, but still there were several days when either DO criterion was not met. For example, at 18 m there were several days in late August when DO was less than 5.0 mg/l (Figure 24b). Although temperature on some individual days was greater than 22° C when the monthly average criterion does not apply, the mean DO for the month of August (6.2 mg/l) was below the monthly average criterion of 6.5 mg/l. Although the figure shows daily fluctuations appearing to be at odds with the assumption of a linear transition between DO concentrations measured in DEP weekly samples, use of the rolling monthly average makes the results of the analysis of the two different data sets more congruent. 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 fewer days than in past years and mixing extended to the bottom on the others. There were several days where DO was below either criterion.

As demonstrated by the 2009 monitoring data, daytime air temperatures and exposure to summer sunlight can occasionally result in a large temperature gradient in the upper portion of the pond that is ephemeral and not considered significant thermal stratification. For example there were several readings throughout the summer where suddenly much warmer weather resulted in a sudden increase in temperature of the top 1-3 meters of the pond by more than 1^{o} C above the next deeper layer, 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 has been the DEP's long-time conclusion that during this phenomenon, mixing is not inhibited and compliance with numeric dissolved oxygen criteria is required.

Figure 24a. Continuous measurement of the temperature and DO at TCB, 2009 (data collected by Water Monitoring Services on behalf of GIPOP)



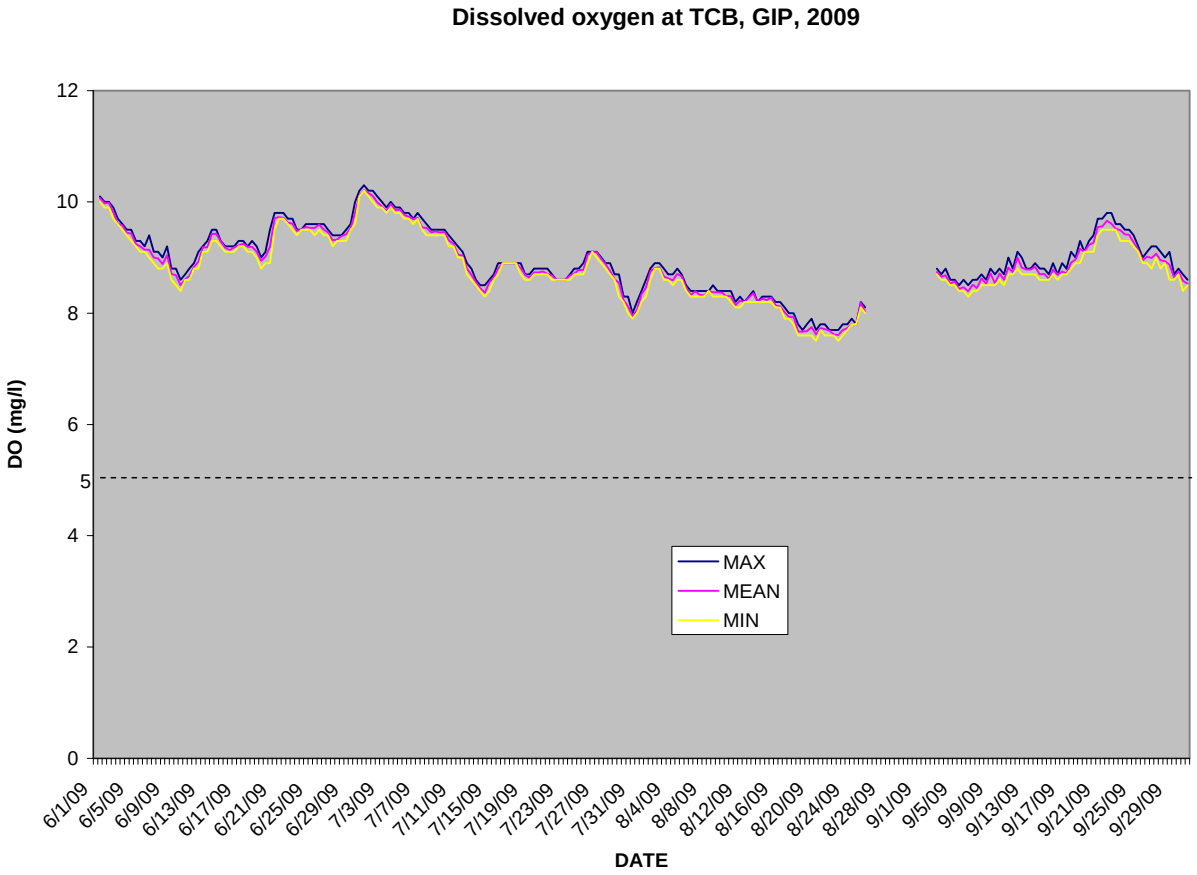
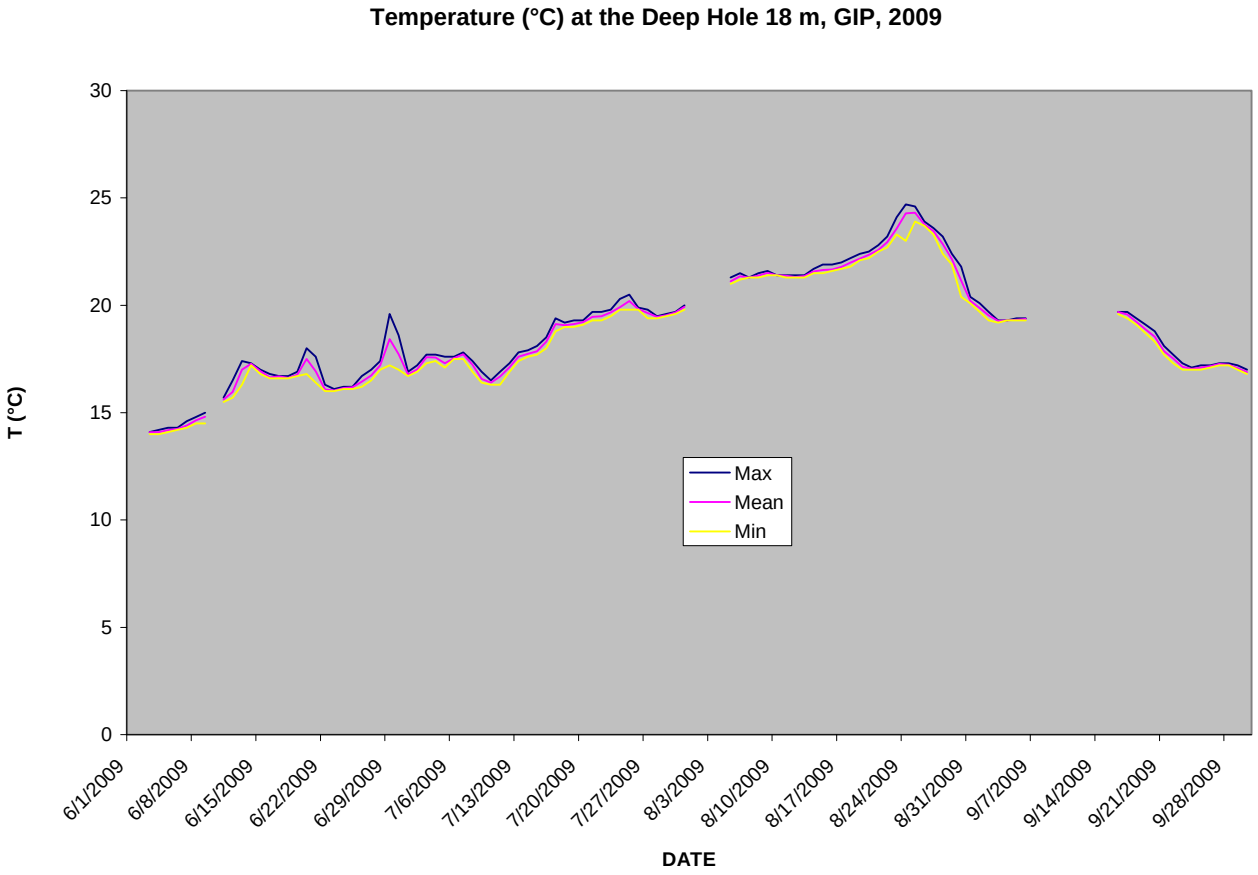

Dissolved oxygen at TCB, GIP, 2009
DO (mg/l)
12
10
8
6
5
4
2
0
MAX
MEAN
MIN
6/1/09
6/5/09
6/9/09
6/13/09
6/17/09
6/21/09
6/25/09
6/29/09
7/3/09
7/7/09
7/11/09
7/15/09
7/19/09
7/23/09
7/27/09
7/31/09
8/4/09
8/8/09
8/12/09
8/16/09
8/20/09
8/24/09
8/28/09
9/1/09
9/5/09
9/9/09
9/13/09
9/17/09
9/21/09
9/25/09
9/29/09
DATE

Figure 24b. Continuous measurement of the temperature and DO at 18 M at DH, 2009 (data collected by Water Monitoring Services on behalf of GIPOP)



Dissolved oxygen (DO) at the Deep Hole 18 m, GIP, 2009

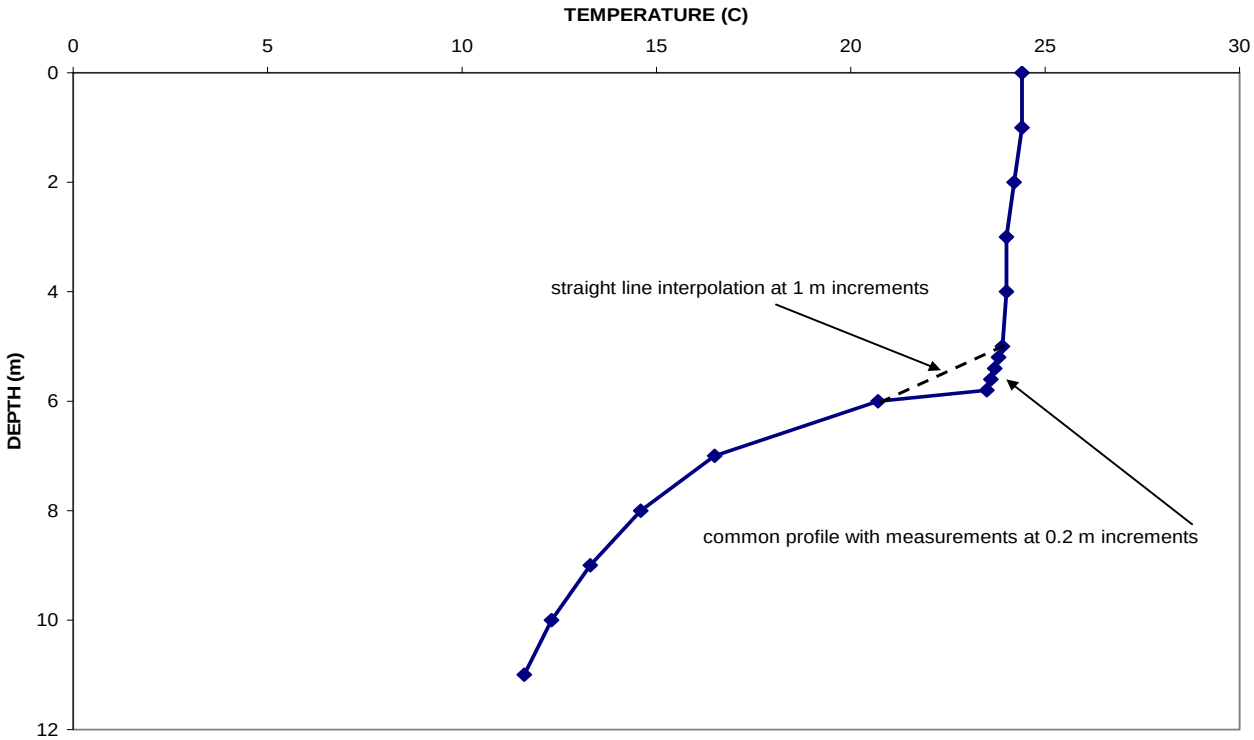
ANCILLARY DATA

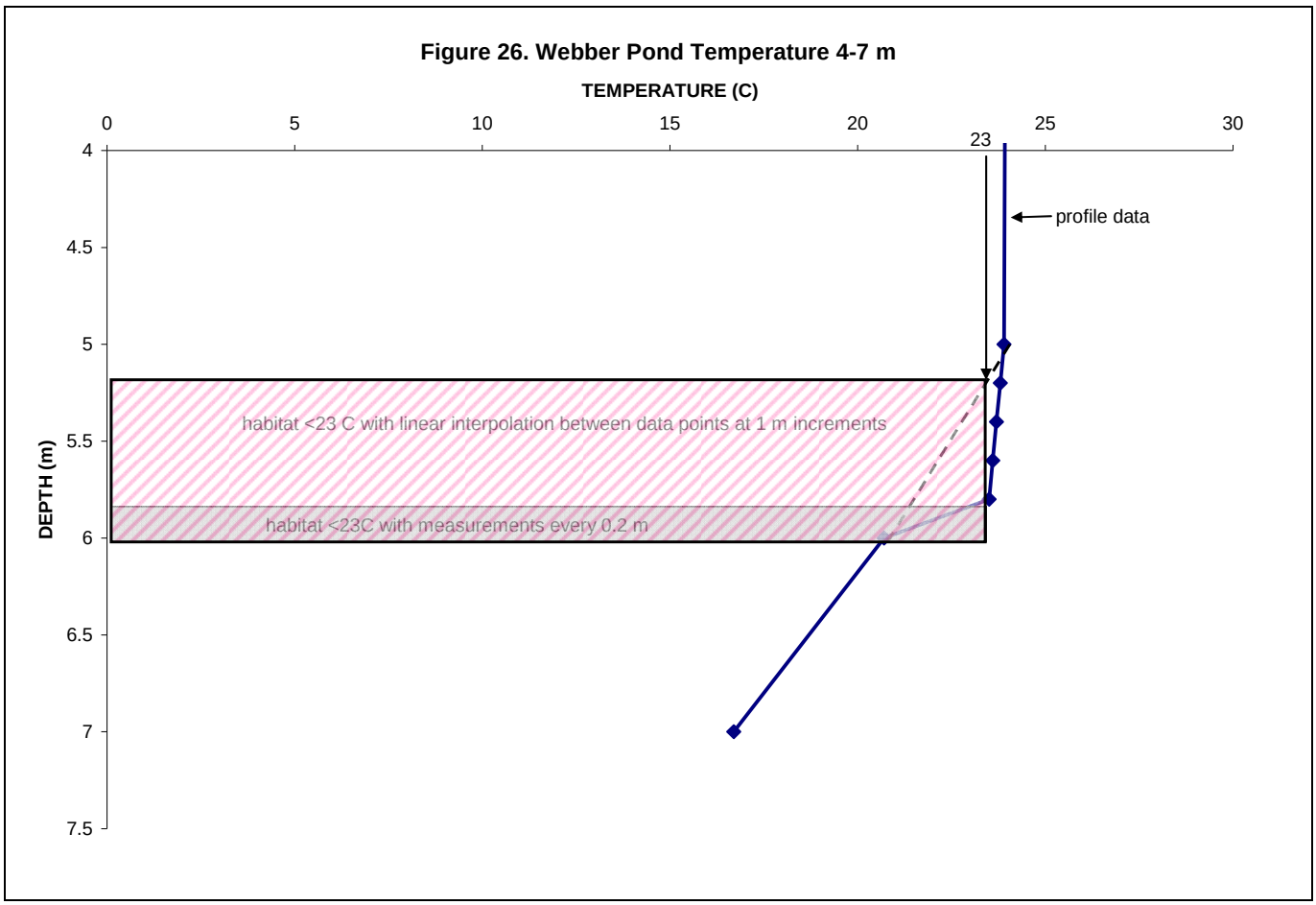
Point of Thermal Stratification (POTS)

As stated in Commissioner Littell's January 23, 2007 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 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 determined to be 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 was to collect data at more depths within the thermocline in order to determine a more accurate determination of the POTS, but high flows precluded strong stratification and the monitoring was not conducted. If flows and other conditions permit, the monitoring will be conducted in 2010.

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

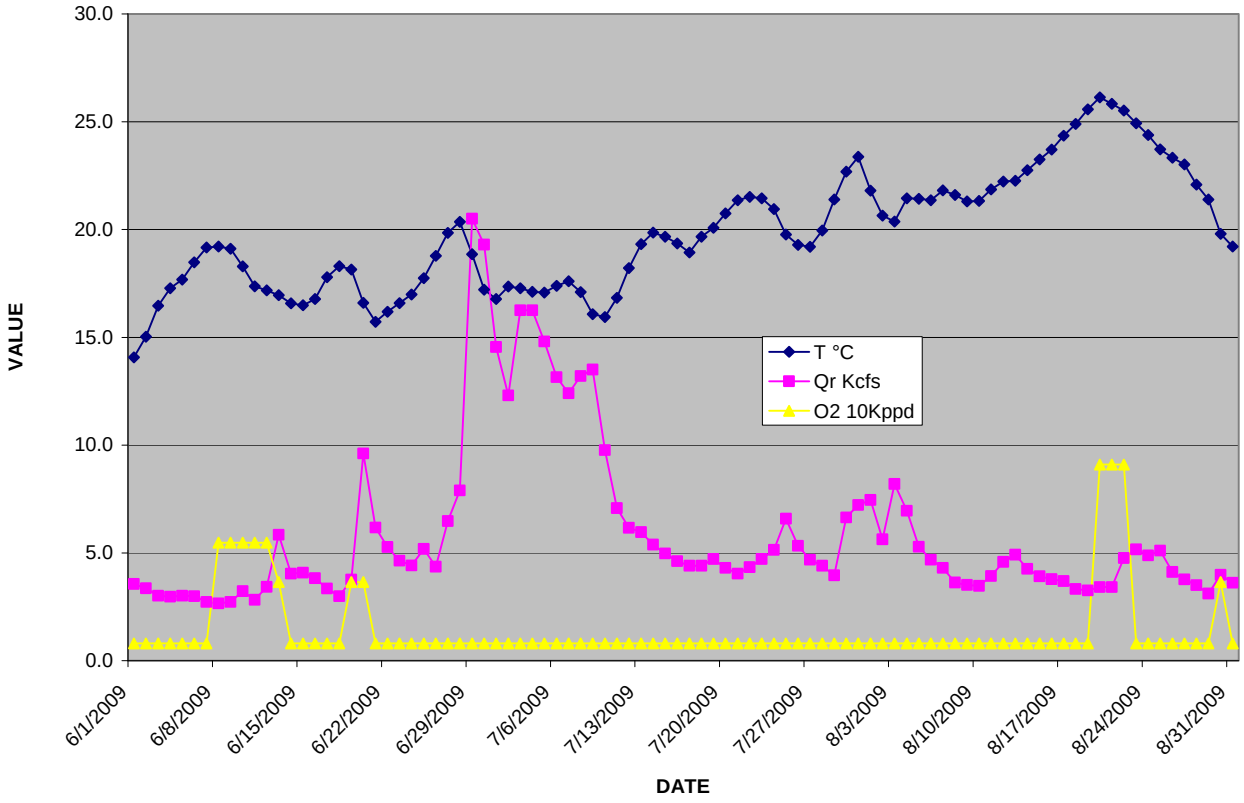
(1) All temperature (T°C) measurements shall be obtained from the continuous temperature monitor at Turner Bridge and shall be expressed as a 3-day rolling average. Because the monitor records maximum and minimum temperatures for a given day, the daily average temperature will be defined as the arithmetic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

An upgraded GIPOP system became operational in June 2009 to increase the transfer efficiency of oxygen from 33% to 54%. Because the upgraded system was operated to inject the same amount of oxygen into the pond (in lbs/day, as a function of river flow and water temperature) as the original system, the net effect was an increase in the amount of oxygen actually transferred to the water column in GIP, and thus an increase in DO levels in the pond during 2009 when compared to similar conditions in previous years.

Actual river temperatures and flows and oxygen injection rates (O2, Kppd=thousand pounds per day) are shown below (Figure 27). Because of relatively high river flows, the oxygen injection system was operated for many fewer days during the summer of 2009 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 at Lower Narrows.

Figure 27. Temperature (T), river flow (Qr), and oxygen injection rate (O2) AT GIP, 2009



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 approximately 50% since 2004 (Figures 28 and 29). Although the discharge OP increased in 2009, both OP and TP are still well within permit limits.

Figure 28. Mean summer orthophosphorous (OP) concentrations (ppd, pounds per day) discharged from Rumford Paper Co., 2004-2009

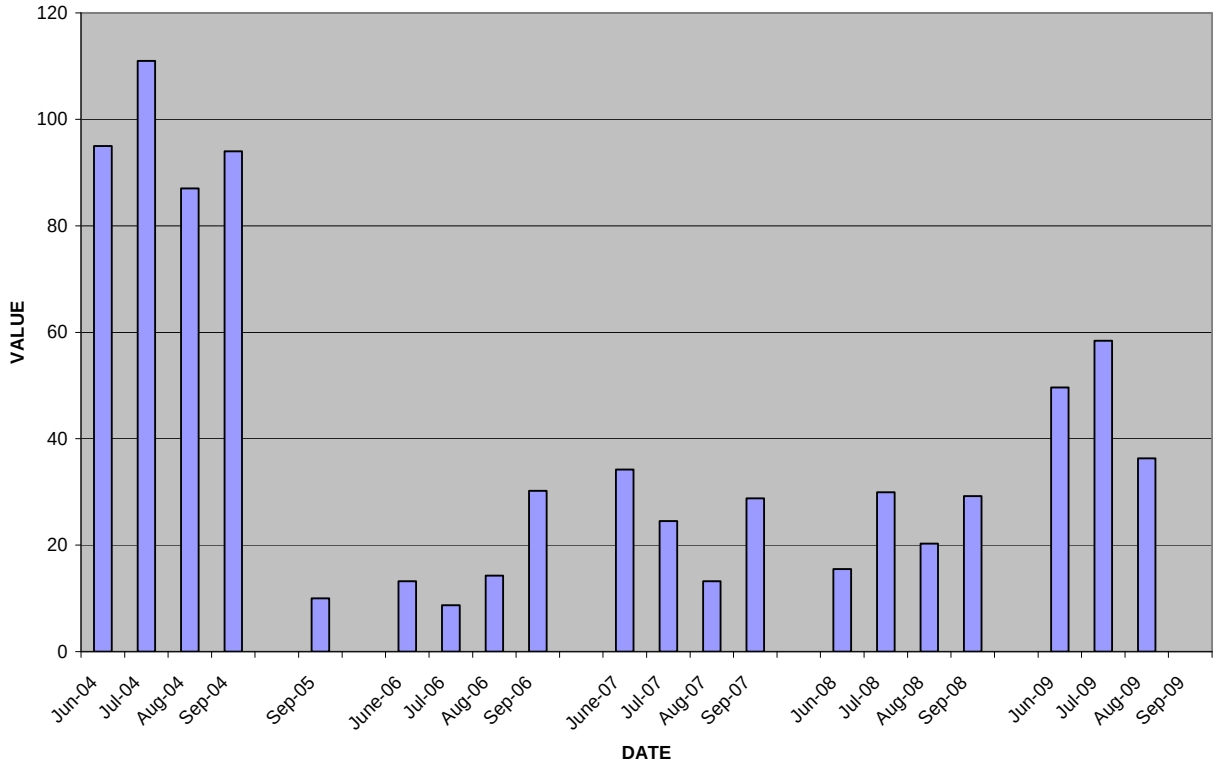
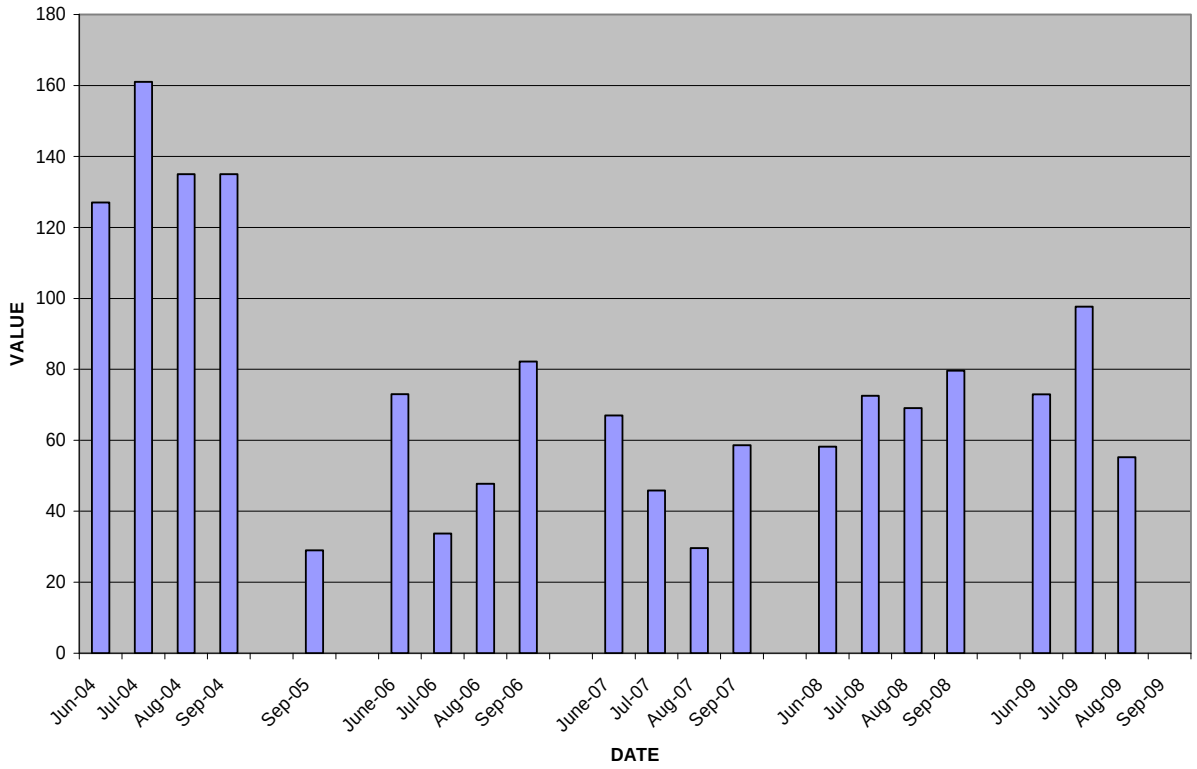


Figure 29. Mean summer total phosphorus (TP) concentrations (ppd, pounds per day) discharged from Rumford Paper Co., 2004-2009



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 limits since (Figures 30 and 31). The discharge of OP approached the permit limit in August 2009; the discharge of TP has increased in 2008 and 2009 but is still within permit limits for 2008 and 2010.

Figure 30. Mean summer orthophosphorus (OP) concentrations (ppd, pounds per day) discharged from Verso Paper Co., 2004-2009

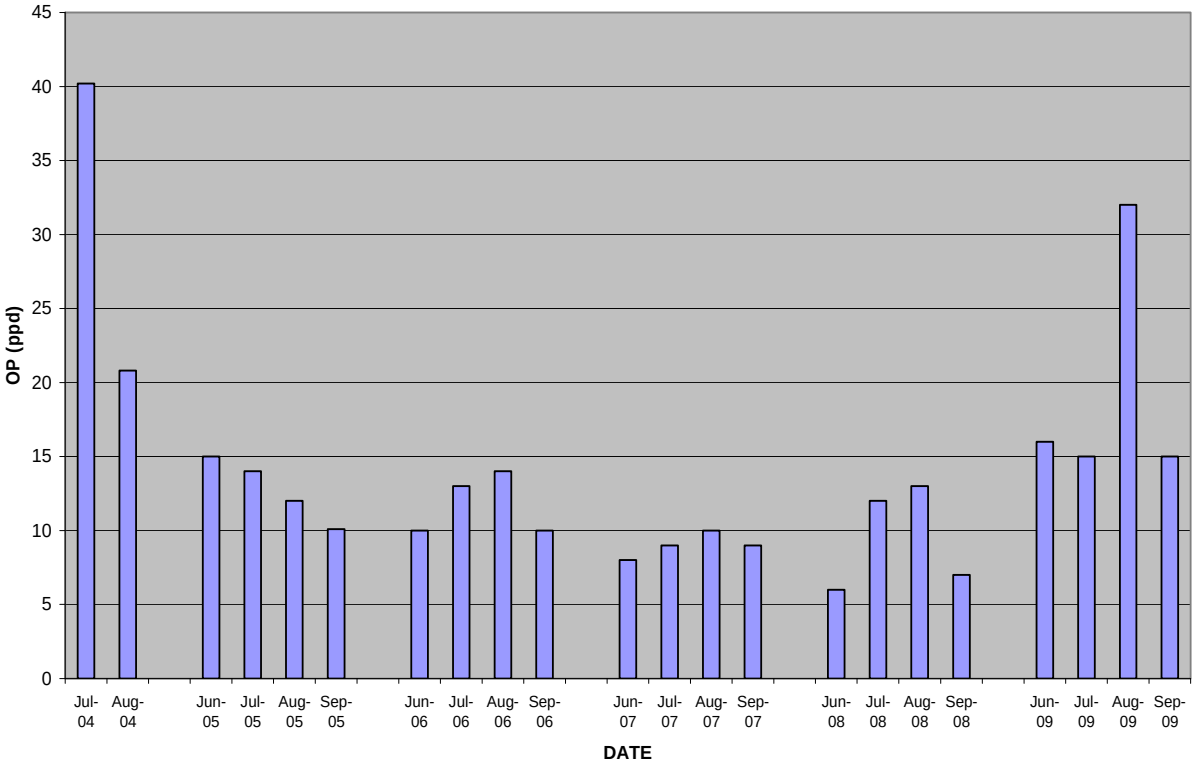
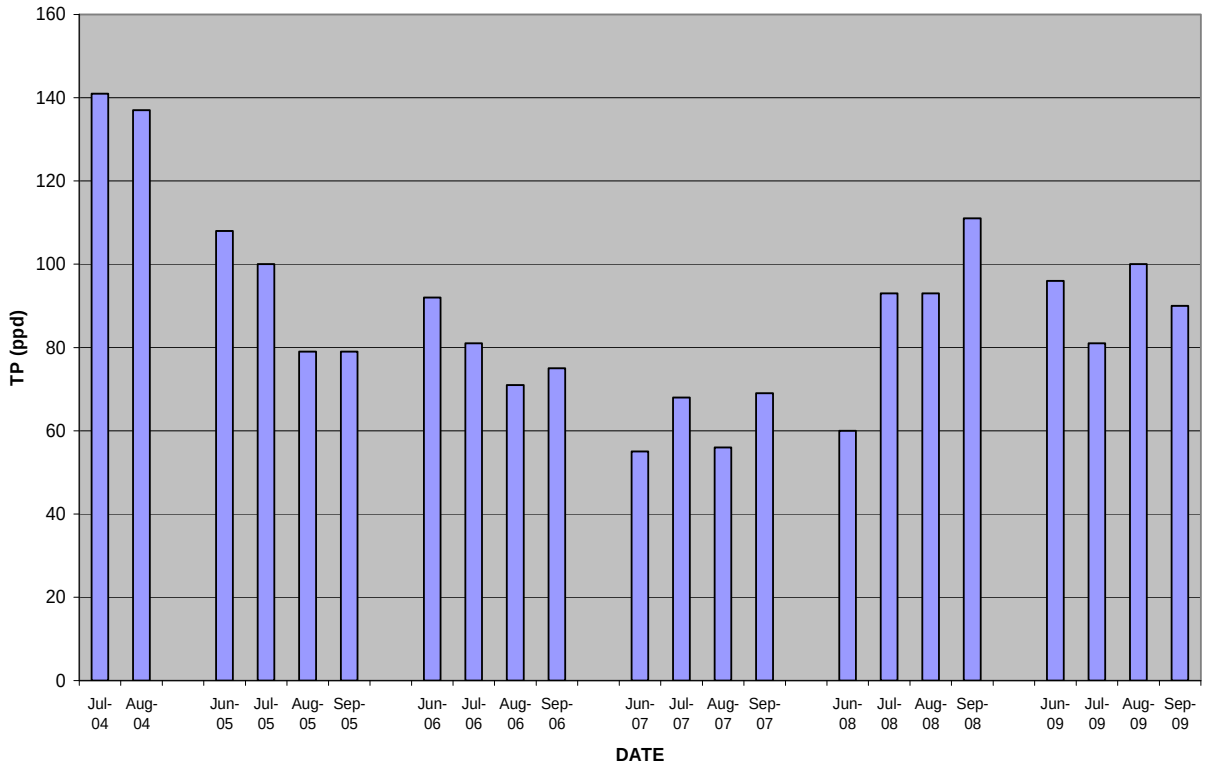


Figure 31. Mean summer total phosphorus (TP) concentrations (ppd, pounds per day) discharged from Verso Paper Co., 2004-2009



CONCLUSIONS

In 2009, 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 2009. Total phosphorus at Lower Narrows was similar to that of 2007 and 2008 and lower than in all previous years since the present monitoring strategy began in 2004. Chlorophyll-a concentrations were similar to those of 2008 and did not exceed the threshold for blooms in lakes (8 ug/l) nor the interim threshold for Gulf Island Pond (10 ug/l). There appeared to be a declining trend from 2004 to 2008.

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 2009 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 2009 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 2010.

References

Acheron, 2009. Androscoggin River and Gulf Island Pond Water Quality Monitoring Report, 20089. Submitted to the Maine Department of Environmental Protection, Augusta, Maine, November 30, 2009.

FPL, January 2010. Raw and summarized data from the continuous monitors in Gulf Island Pond submitted by CD and email.

Appendices

1. GIP 2009 WQ
2. GIP 2009 Acheron WQ
3. GIP 2009 Acheron TDO
4. GIP 2009 TDO continuous monitoring