2006 Gulf Island Pond Monitoring Program Report

Maine Department of Environmental Protection

August 2007

EXECUTIVE SUMMARY

This report is prepared in accordance with the requirements of Public Law 2005, chapter 409, An Act to Amend Water Quality Standards. Section 7 or that law 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 2006 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). Monitoring consisted of aerial observations by DEP, weekly water quality monitoring at several stations by DEP and by Gulf Island Pond Oxygenation Project (GIPOP) partnership, and continuous monitoring at three stations also by the GIPOP partnership.

Aerial observations documented an abundance of filamentous algae in the upper part of Gulf Island Pond from Twin Bridges to Turner Center Bridge in early August 2006. The algae then decayed and spread through the pond within a week. Filamentous algae get nutrients both from current discharges to the water column and from dissolution of total phosphorus from sediments into the water column. Therefore, it is difficult to determine the relative importance of current discharges versus sediments as sources of total phosphorus. Chlorophyll-a (corrected) concentrations approaching algal bloom thresholds were not coincident with this event, nor did aerial observations indicate a typical phytoplanktonic algae bloom during times of high corrected. Both total phosphorus and chlorophyll-a concentrations were significantly lower in 2006 than in 2004 and 2005 in order of reduction, likely reflecting reduced nutrient discharges from the bleached kraft pulp and paper mills and perhaps dilution from higher river flows in both years. There was no typical bloom of phytoplankton in 2006. Therefore, no conclusion can be reached regarding refinement of the interim chlorophyll-a threshold for blooms in Gulf Island Pond. Additional data are necessary.

Minimum dissolved oxygen criteria were not met for a number of days, but with the current monitoring strategy, it is difficult to assess the exact number. The weekly sampling is not continuous and the continuous monitoring is at fixed depths which do not provide necessary depth profile data. The monitoring strategy needs to be changed to collect temperature and dissolved oxygen profiles at one meter increments from top to bottom at the Deep Hole station in Gulf Island Pond.

GULF ISLAND POND WATER QUALITY MONITORING REPORT, 2006

Introduction

Water quality monitoring of Gulf Island Pond (GIP) on Maine's Androscoggin River was continued in the summer of 2006. The primary goal was to continue detailed monitoring initiated in 2004 and earlier to to assess attainment of Maine's Water Quality Standards, 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 (CHL) thresholds for algal blooms. And a third goal was to determine the degree of increased attainment of WQS resulted from recent reductions in point source discharges.

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 PCU,(platinum cobalt units) SD may be significantly influenced by color as well as the presence of algae. Therefore, for these waters, such as GIP, CHL is a better measure of blooms. In lakes, blooms have been associated with CHL concentrations greater than 8 ug/l (micrograms per liter). Given higher current velocities, rivers may have higher thresholds of CHL 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 CHL 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 by the Maine Department of Environmental Protection (DEP) for GIP (approved by federal Environmental Protection Agency, EPA, on July 18, 2005) targets a pond average value of 10 ug/l CHL as the interim goal for prevention of algal blooms. For calculation of the pond average, CHL will be included only at those stations where a bloom has been observed. The TMDL also specifies that annual monitoring should continue in order to further refine the CHL 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, 2005 and 2006. Aerial observations of bloom and scum layers were documented visually in conjunction with ambient monitoring of CHL.

There were four parts to the 2006 monitoring program, (see Figure 1 for stations)
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 six stations by the GIPOP partnership, and
4) continuous monitoring of temperature and dissolved oxygen at Turner (Center) Bridge, the deep hole station , and dam station) also by the GIPOP partnership. Each part will be discussed below.

1). Aerial Flight Observations

During the summer of 2006, 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 seat seaplane was utilized which 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. Observations were conducted weekly from May 30 through September 12, 2006, with the exception of September 5 when no flight was conducted due to weather conditions. The seaplane had a scheduled departure from Turner at 1p.m. and proceeded to the LN station in order to collect water chemistry data.

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

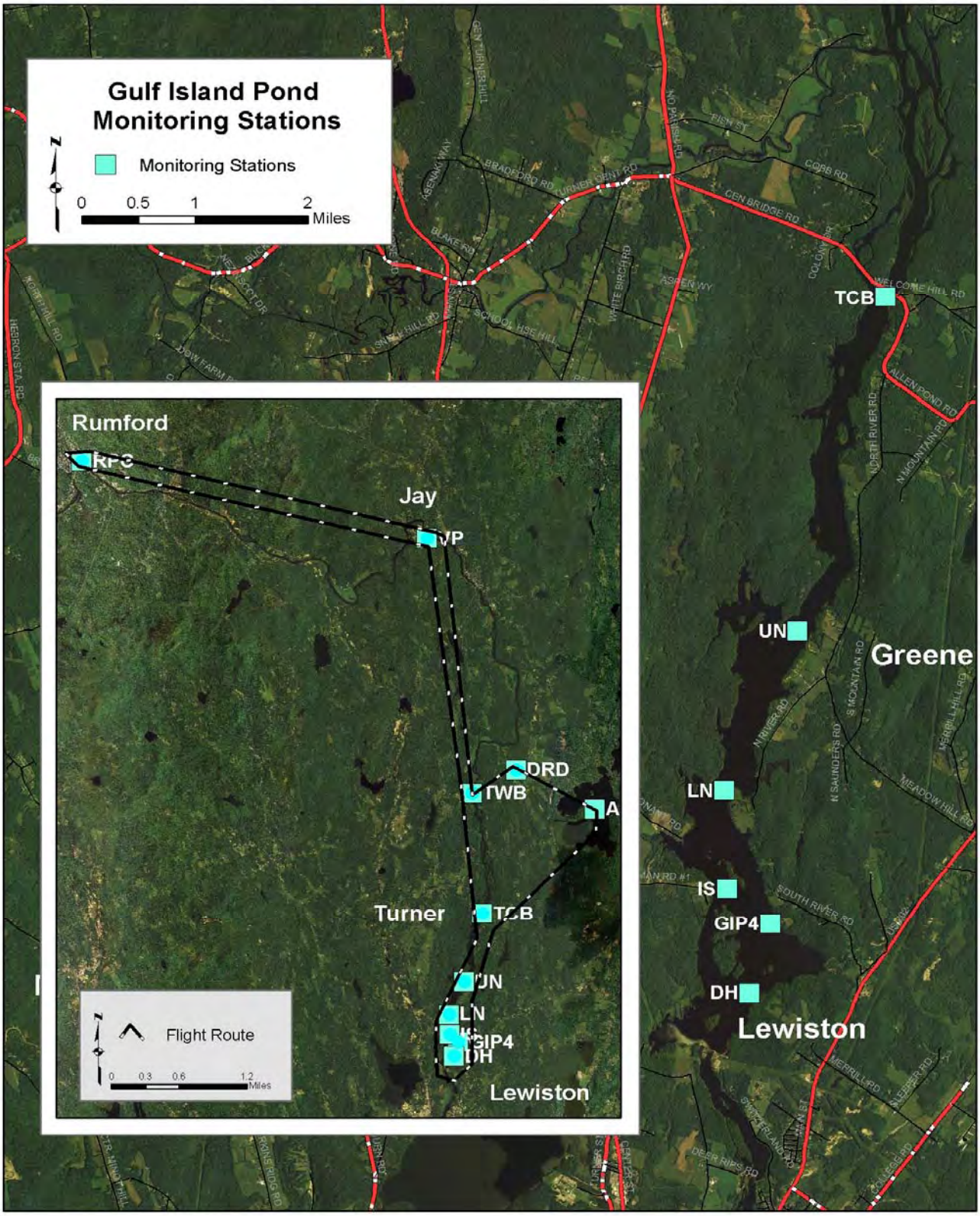
The route was northerly to the Upper Narrows monitoring station and then northerly along the river to Center Bridge, Androscoggin Lake, Twin Bridges, and then to the paper mills in Jay and Rumford. A southerly route was then taken to the most southerly monitoring stations (Gulf Island Pond monitoring 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) All data were recorded on a standard log sheet. 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).

During 2008 DEP will be conducting public meetings followed by a public hearing by the Board of Environmental Protection as part of the statutory triennial review of water quality standards (Reclassification). At that time the issue will be brought before the public to solicit input about the level

of public concern with the potential impact to recreational uses, and the possible need for revisions of water quality standards and water classifications to address that concern.

On August 1, 2006, there was what appeared from the air to be widespread growths of algae from Twin Bridges down to the Turner (Center) bridge. Collected samples confirmed that was not a typical phytoplanktonic bloom of blue-green algae, but rather clumps of filamentous green algae (Mougeotia spp. and Spirogyra spp.) and the diatom Synedra spp. with a small amount of the blue-green Oscillatoria spp.. Three days later there were patches of primarily decaying Spirogyra spp. throughout the pond from Turner Center Bridge to the dam. This observation followed a period of high rainfall and elevated river flow, which may have scoured these algae from their normal habitat in the shallows.

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



2. WATER QUALITY SAMPLING AT LOWER NARROWS BY DEP

During the weekly aerial flights, temperature and dissolved oxygen measurements were made in 1 m depth increments from top to bottom at LN. Secchi disk transparency was also measured and a sample taken for chlorophyll-a analysis. Results are discussed below for each variable measured along with similar measurements made on behalf of the GIPOP partnership.

and

3. WATER QUALITY SAMPLING AT OTHER GULF ISLAND POND STATIONS BY ACHERON ON BEHALF OF THE GIPOP PARTNERSHIP

In 2006, weekly profiling data were collected by Acheron Engineering under contract from NewPage and IP (now Verso Paper). This work was completed pursuant to the permit condition listed below.

> **"Between June 1 and September 30 of each year (beginning June 1 2006)**
> ***[PCS Code 90101]*** the permittee shall independently or in conjunction with other parties participate in ambient water quality monitoring of Gulf Island Pond and/or designated segments of the Androscoggin River at a frequency of 1/Week. There must be at least 72 hrs between sampling events. Samples for total phosphorus, ortho-phosphorus, chlorophyll *a*, secchi disc readings and dissolved oxygen/temperature profiles at one-meter increments and physical observations shall be taken at five (5) sampling stations. The sampling stations are designated as Twin Bridges, Upper Narrows, Lower Narrows, Gulf Island Pond 4 and Gulf Island Dam (deep hole). Sampling procedures must be consistent with the protocols established in a document entitled, Androscoggin River & Gulf Island Pond Water Quality Monitoring Plan 2004, Acheron, May 2004 or the most current revisions to said plan approved by the Department." IP Discharge Permit issued 9/25/2005.

TABLE 1.

Gulf Island Pond
2006 Water Quality Monitoring Plan
Sampling Sites, Parameters and Procedures

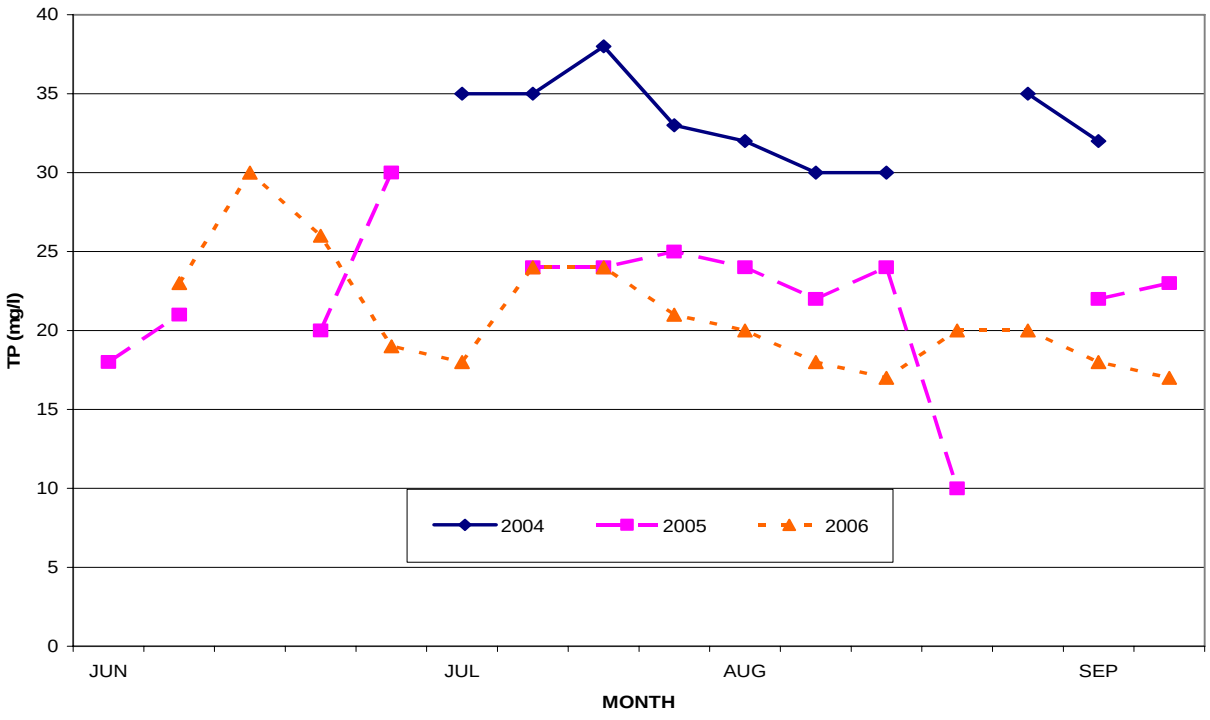
	Analytical Parameters and Sampling Procedure							
Sampling Location	*Total Phosphorus*	*Total Ortho-Phos*	*Dissolved Orhto-Phos*	*Chlorophyll-A Corrected*	*Secchi Disk*	*Dissolved Oxygen*	*Temperature*	*Physical Observations*
Gulf Island Pond Dam	*1 Core Composite from Surface to 2X Secchi Disk 9 AM to 3 PM*	*1 Core Composite from Surface to 2X Secchi Disk 9 AM to 3 PM*	*1 Core Composite from Surface to 2X Secchi Disk 9 AM to 3 PM*	*1 Core Composite from Surface to 2X Secchi Disk 9 AM to 3 PM*	*Secchi Disk Readings per DEP Protocol 9 AM to 3 PM*	*2 Profiles From Surface to 1M Above Bottom at 1 M Intervals AM & PM*	*2 Profiles From Surface to 1M Above Bottom at 1 M Intervals AM & PM*	*Visual Observations of Algae Density on or near the Surface 9 AM to 3 PM*
Gulf Island Pond 4								
Lower Narrows								
Upper Narrows								
Turner Bridge								
Twin Bridges	*1 Grab 9 AM to 3 PM*	*1 Grab 9 AM to 3 PM*	*1 Grab 9 AM to 3 PM*	*1 Grab 9 AM to 3 PM*	*Not Applicable*	*1 Grab 9 AM to 3 PM*	*1 Grab 9 AM to 3 PM*	*Not Applicable*

Samples were obtained prior to 8:00 am and during the afternoon, after 1:00 PM as long as weather conditions allowed. There were 34 discrete sampling events, which included morning and afternoon readings on 17 days. Of these events, there were 22 that showed dissolved oxygen less than 5 mg/l or 60% saturation at some point on the river and this occurred at all stations except Turner Center Bridge at some time during the summer.

Phosphorus

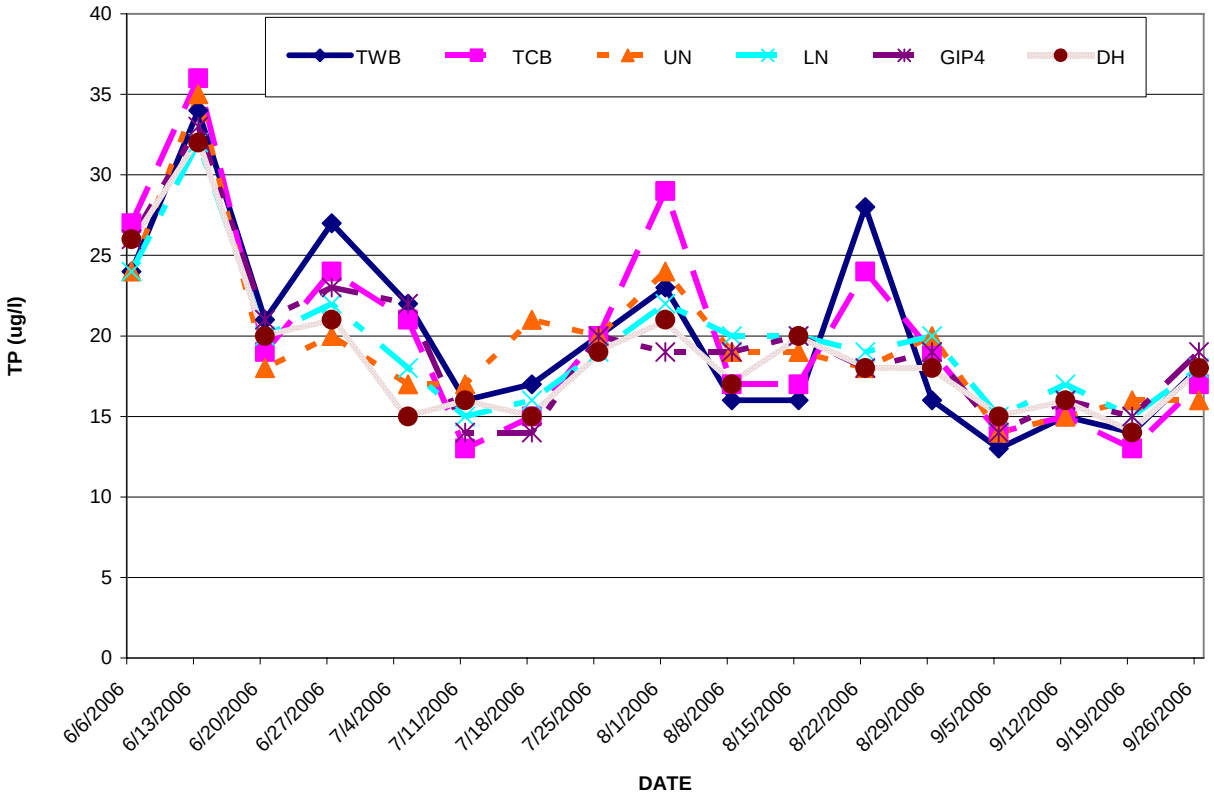
Samples for total phosphorus (TP) were collected by DEP weekly at Lower Narrows (LN) during the aerial flights. Additional samples were to be collected at any other locations where a bloom was observed, but no blooms occurred in 2006. The highest TP concentration occurred on June 15 and was well above the threshold (15 ug/l) normally associated with blooms in lakes with low color. (Figure 2). No bloom was observed at this time from the aerial flight perhaps due to the fact that it was early in the season and river temperature was still relatively low and/or due to high color. In colored lakes (>30, greater than 30 PCU), higher TP concentrations are usually required to cause a bloom due to chelation of TP by tannins and lignins responsible for the high color and also due to limited depth of sunlight penetration. Given that GIP usually has color >30 PCU at summer flows due to the mill discharges, the TP threshold for blooms is likely higher than in waters with low color. The TP concentration during early August, when the filamentous algae were abundant, was slightly lower than in June but still above the threshold for uncolored lakes. Mean TP for 2006 (21 ug/l) was similar to that of 2005 (22 ug/l) and both were statistically significantly (p=0.05) lower than that of 2004 (33 ug/l) due to improvements in effluent quality from the mills and perhaps dilution from higher river flows during these two years.

FIGURE 2. TOTAL PHOSPHORUS (TP) AT LOWER NARROWS (LN), GIP, 2004-2006



Weekly samples for ortho-phosphorus (OP), TP and chlorophyll-a were taken and analyzed by Acheron at six locations. TP numbers were elevated in the early summer (Figure 3), which was concurrent with a twelve day period in which flows is characterized by the U.S. Geological Survey (USGS) as high. A secondary peak occurred on August 1st at Turner Center Bridge, three days after another significant storm event raised river flows to 6,410 cfs (cubic feet per second). At the time of sampling Acheron reported river flow to be 3,410 cfs. This was the date of the observation of the abundant filamentous green algae from Twin Bridges to the Turner (Center) Bridge, where TP was the highest of all stations. While high TP might reflect luxury consumption and storage of excess TP by the algae, the observed cellular decay, might have subsequently caused a spike in OP concentrations. TP concentrations were much lower during the next two weeks and then peaked again later in the month in the same river reach, also after an increase in flow. While a simple explanation for the apparent coincidence of elevated TP might be non-point source (NPS) pollution inputs associated with an increased river flow, no such coincidence was seen with peaks in the 2004 and 2005 data. Furthermore, in 2004, the mean summer river flow was the lowest and the mean summer TP the highest of all three years (2004-2006), which tends to discount NPS as a significant source.

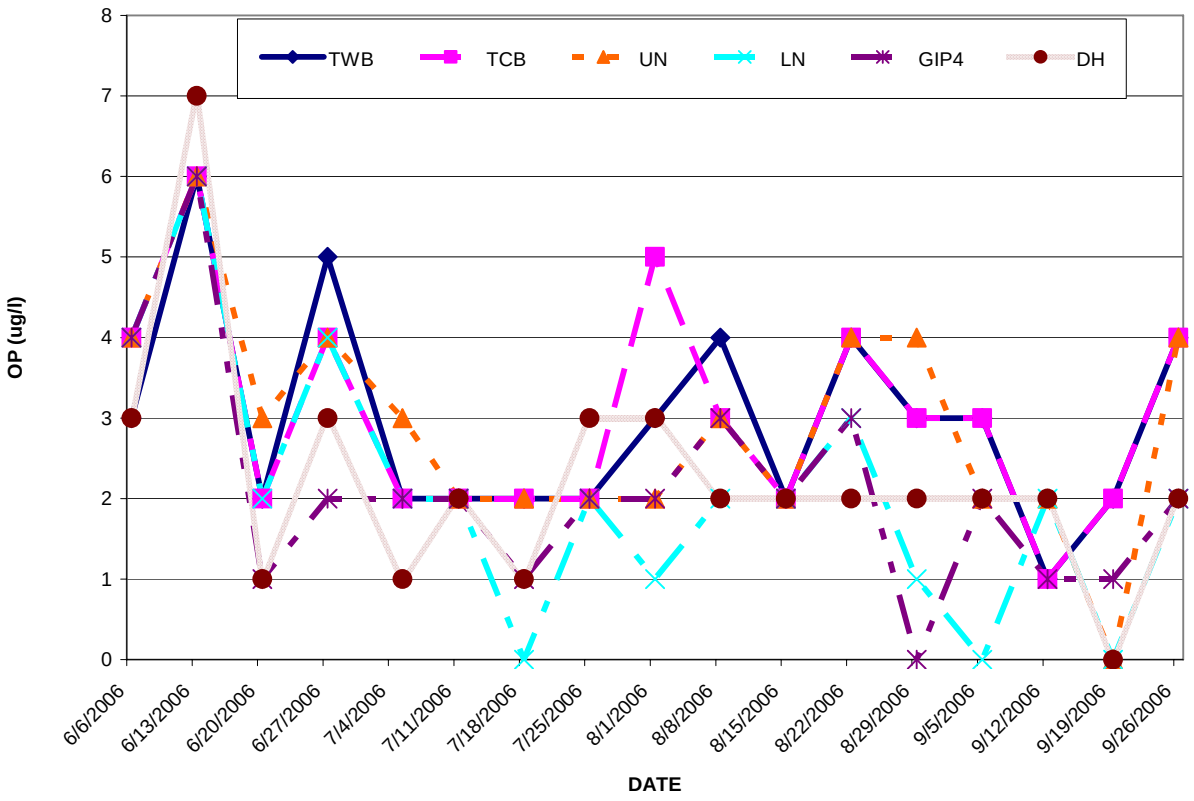
FIGURE 3. TOTAL PHOSPHORUS (TP) IN GULF ISLAND POND, 2006



Ortho-Phosphorus (OP)

OP values were for the most part lower in the first part of the summer (Figure 4). A peak occurred on August 1st from Twin Bridges to Upper Narrows, which corresponded with a secondary peak in TP. As noted above this sampling event occurred three days after a significant rain event. OP did not subsequently increase from the decay of the filamentous algae but rather declined over the next two weekly samples as did TP. Another peak in late August in the river reach from Twin Bridges to Turner Center Bridge may represent a new supply of OP/TP.

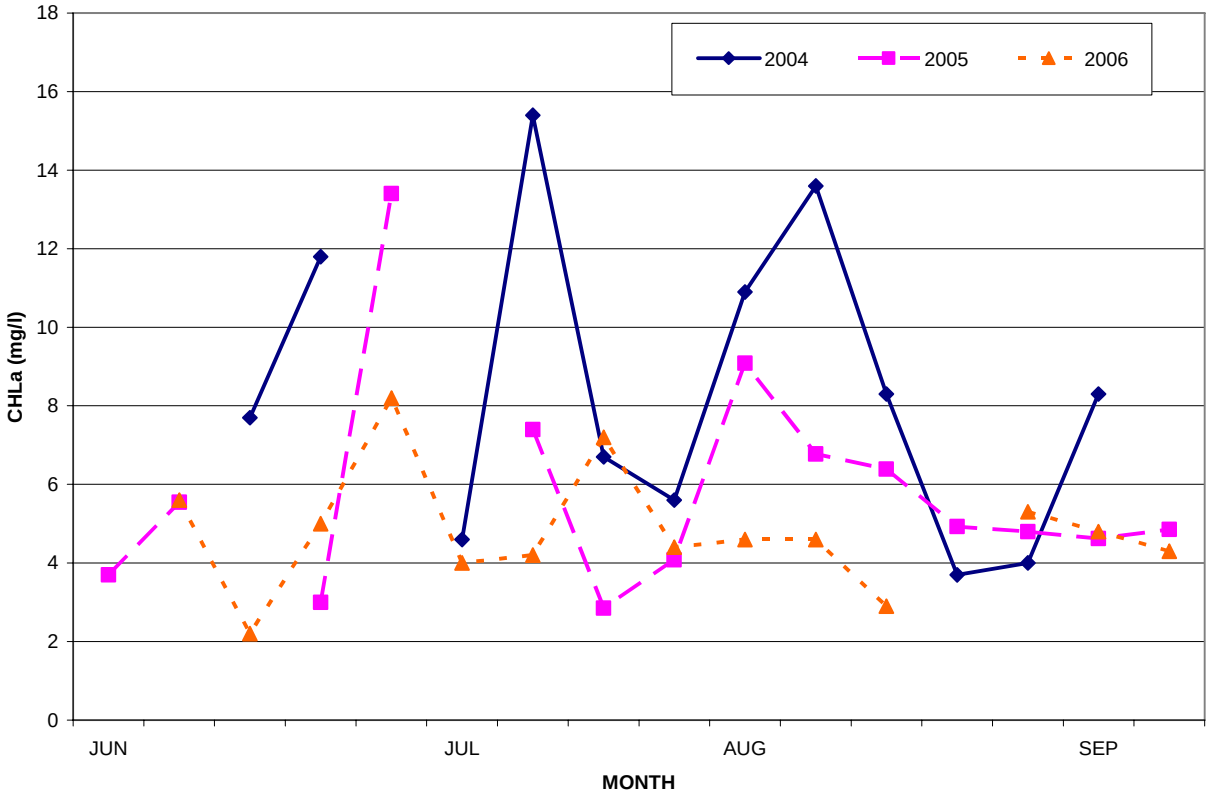
FIGURE 4. ORTHO-PHOSPHORUS (OP) IN GULF ISLAND POND, 2006



Chlorophyll –a

DEP sampling on June 29, 2006 and July 20, 2006 at LN documented CHL concentrations at (8.2 ug/l) or near (7.2 ug/l) the 8 ug/l threshold used for lakes for defining a phytoplanktonic algae bloom (Figure 5). On neither date did aerial observations note a bloom. On August 1 and in subsequent weekly samples, CHL concentration at LN did not approach the bloom threshold. Sampling for CHL may not measure washout of periphyton very well, although some of the peaks in CHL corresponded to peaks in river flow in 2004 and 2005 suggesting perhaps the same phenomenon as occurred in 2006 with filamentous algae, although no identification of the algae species was made in the the prior years. In 2006 the mean CHL concentration for the summer (4.8 ug/l) was significantly lower than that of 2004 (8.4 ug/l) but not that of 2005 (5.9 ug/l), which itself was marginally significantly lower than that of 2004 (p=0.087).

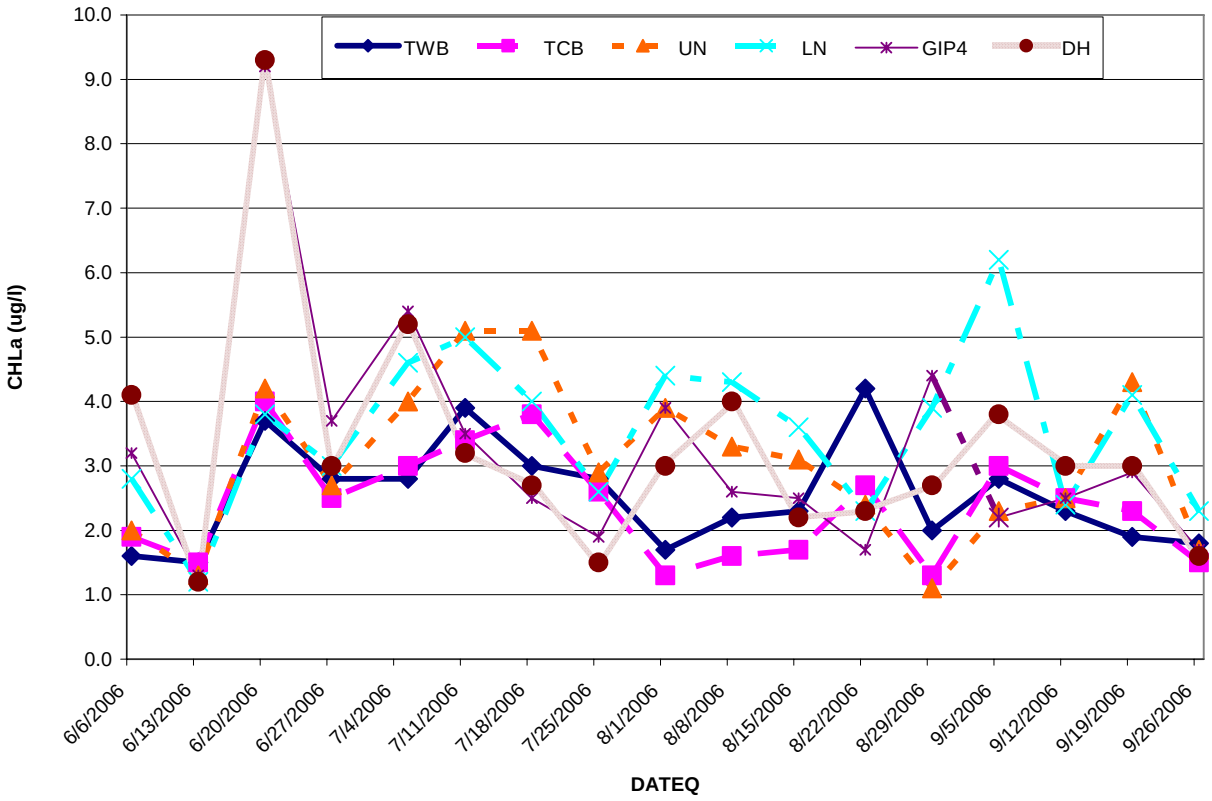
FIGURE 5. CHLOROPHYLL a (CHLa) IN LOWER NARROWS (LN), GIP, 2004-2006

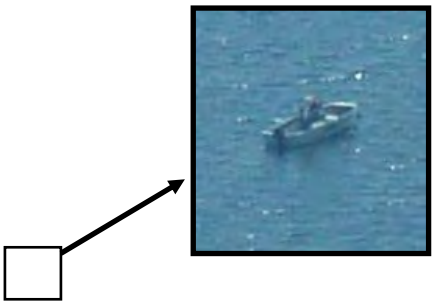


Weekly sampling at six stations by Acheron Inc for the GIPOP partnership showed only one event with CHL numbers approaching what DEP considers a bloom (Figure 6). This event occurred in mid-June at the lower stations GIP4 and the Deep Hole about a week after the high flow and high TP conditions on the river. Neither Acheron nor the DEP aerial flight noted any visible blooms in the area. The DEP actually photographed the Acheron boat, with no apparent bloom in the photograph (Figure 6A). Pond averaged values peaked on this day at 5.7 ug/L with a secondary peak of 4.2 ug/L two weeks later. CHL results for split samples were significantly lower from Acheron's Clearwater lab compared to those from

the Maine Health and Environmental Testing (HETL) lab, but the reason is not clear. Additional split samples should be taken in 2007.

FIGURE 6. CHLOROPHYLL A (CHLa) IN GULF ISLAND POND, 2006

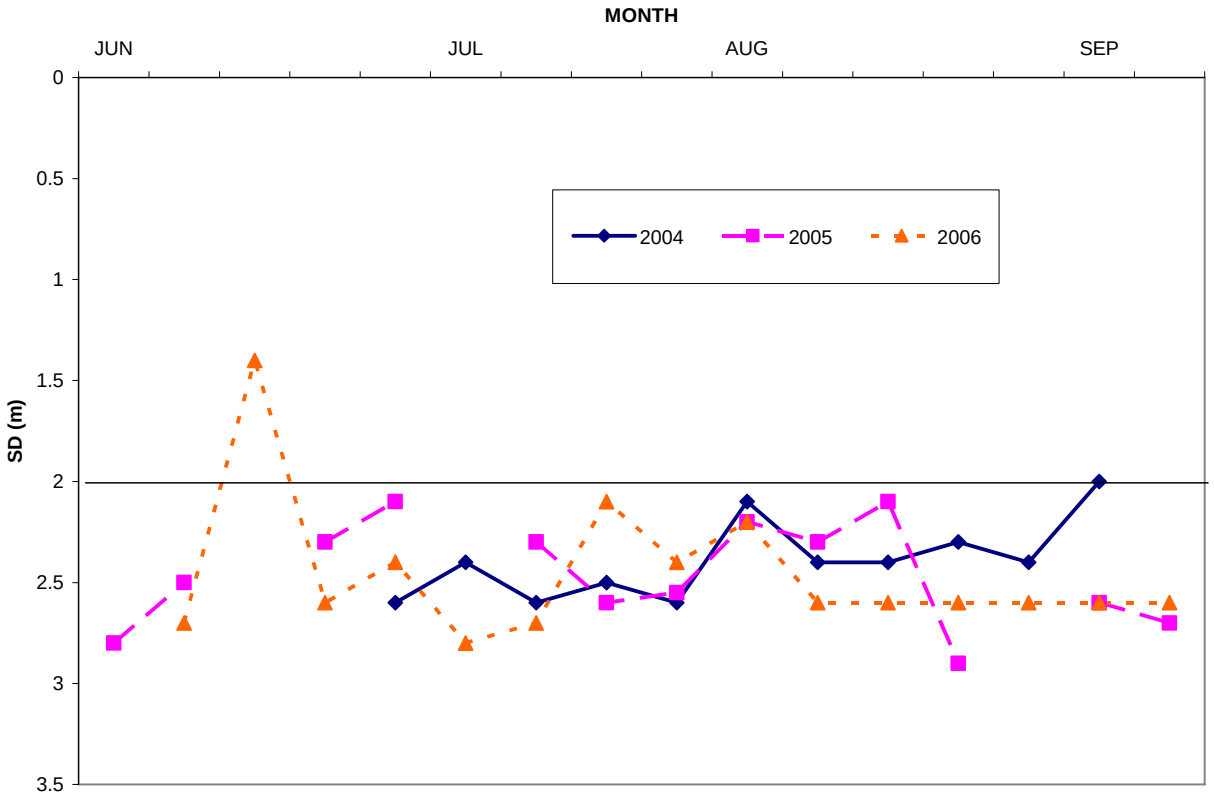




Secchi Disk Transparency (SD)

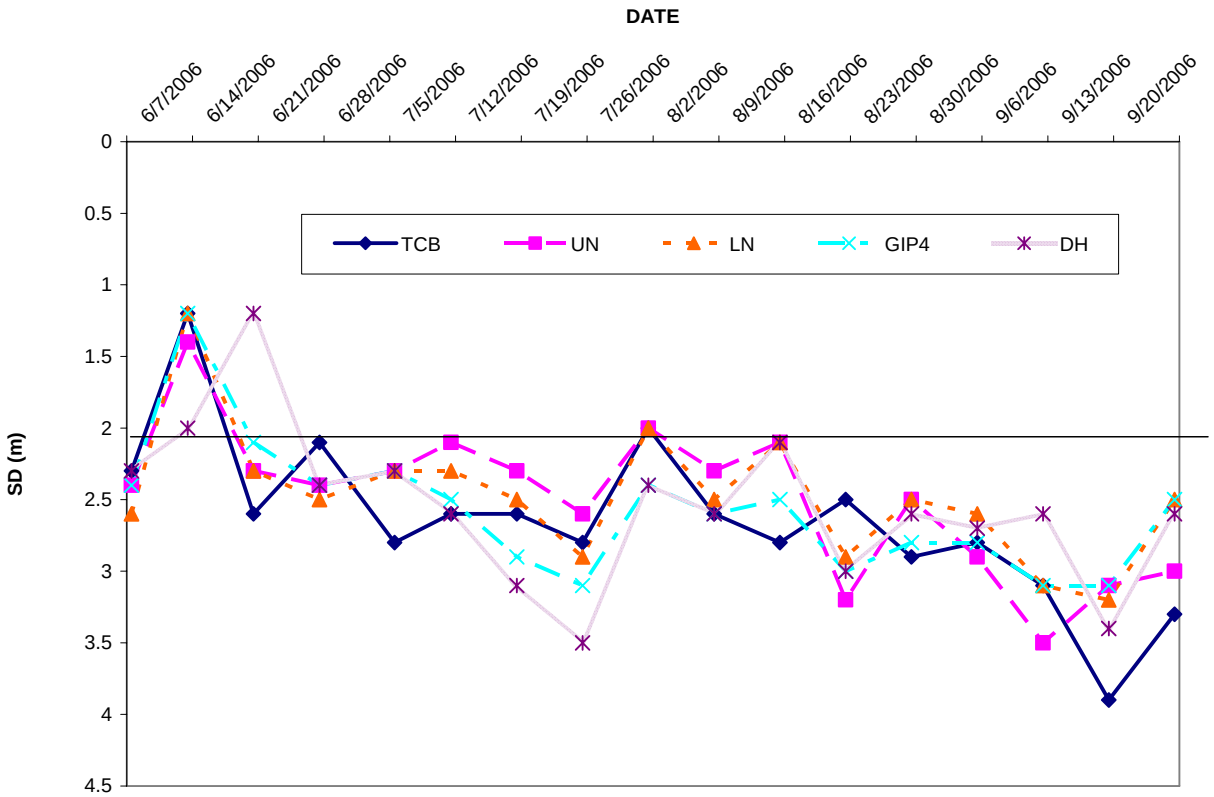
DEP sampling at LN documented a Secchi disk transparency (SD) less than 2 m (meters), the definition of a bloom in uncolored lakes, only on June 15, 2006 (Figure 7). Although this was also the date of the highest TP, CHL was well below bloom thresholds. Therefore, SD may reflect turbidity caused by recent rain or total suspended solids (TSS) from the mills. This is interesting given that CHL was at or near the threshold on 2 other dates when SD was higher and TP was lower. The fact that SD was not reduced and no bloom was observed on these 2 dates may reflect the influence of lower residence time in GIP (10-14 d at 7Q10 river flow) compared to most natural lakes or the influence of color. It takes about 10-14 days for blooms to develop even if all other conditions are conducive. Mean SD was not significantly different in 2006 from the previous two years.

FIGURE 7. SECCHI DISK TRANSPARENCY (SD) IN LOWER NARROWS, GIP, 2004-2006



Sampling by Acheron documented SD<2m for all stations during the same June period (Figure 8). This event occurred during the high flow week in June, and was most likely not caused by algae growth but by suspended solids (sediment and other debris) in the water. Another event occurred on August 1st, where SD was 2 meters. However, as stated before, this sampling event occurred a few days after high flows and SD was not reduced below 2 m.

FIGURE 8. SECCHI DISK TRANSPARENCY (SD) IN GULF ISLAND POND, 2006



CONCLUSIONS OF THE 2006 WATER QUALITY SAMPLING

Aerial observations documented an abundance of filamentous algae in the upper part of GIP from Twin Bridges to Turner Center Bridge in early August 2006. The algae then decayed and spread to the rest of the pond within a week. Filamentous algae get nutrients from both current discharges to the water column and from dissolution of TP from sediments into the water column. Therefore, it is difficult to correlate the occurrence of filamentous algae only to current discharges. CHL concentrations approaching bloom thresholds were not coincident with this event nor did aerial observations indicate a typical phytoplantonic algae bloom during times of high CHL. Both TP and CHL were significantly lower than in 2005 and 2004 respectively, likely reflecting reduced nutrient discharges from the mills and perhaps dilution from high river flows in both years. There was no typical phytoplanktonic bloom in 2006. Therefore, no conclusion can be reached regarding refinement of the interim CHL threshold for blooms in GIP. Additional data are necessary.

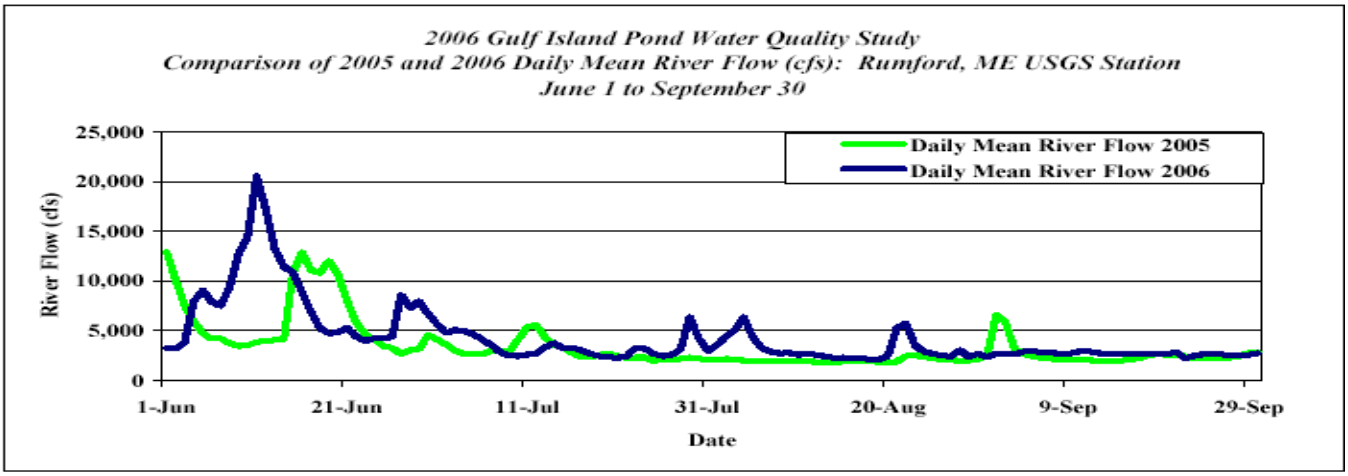
Temperature and Dissolved Oxygen Monitoring

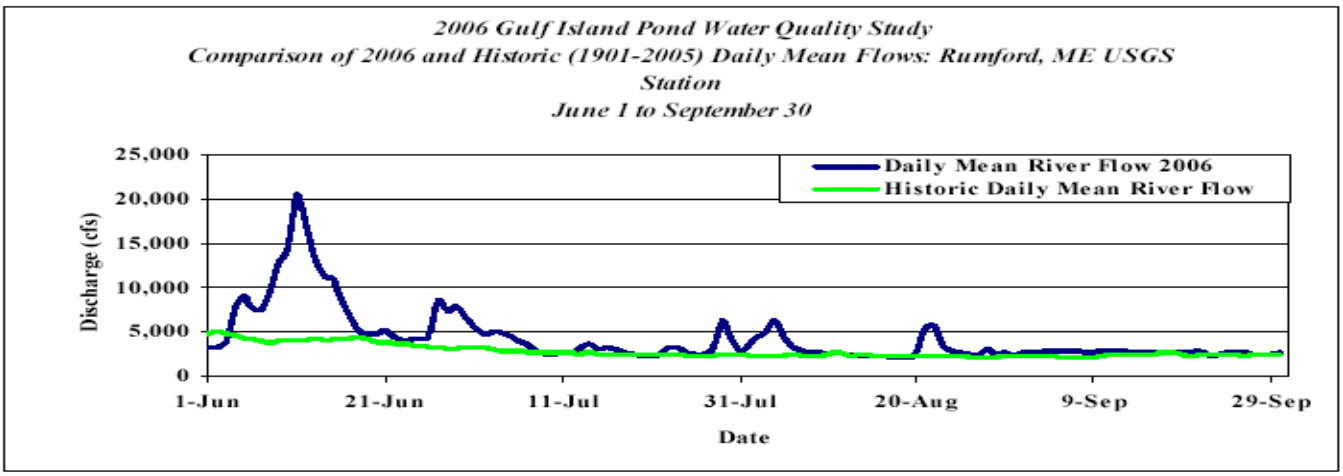
38 MRSA §465(4)(B) requires that, except as naturally occurs, the minimum dissolved oxygen (DO) concentration of the Androscoggin River below Rumford, including GIP, be not less than a minimum of 5 mg/l (milligrams per liter) or 60% saturation, whichever is less. The statute also requires that the monthly average be not less than 6.5 mg/l when the temperature is 22°C or less. Dissolved oxygen concentrations in rivers are greatly affected by point and non-point sources of organic pollutants as mediated by river flow and temperature.

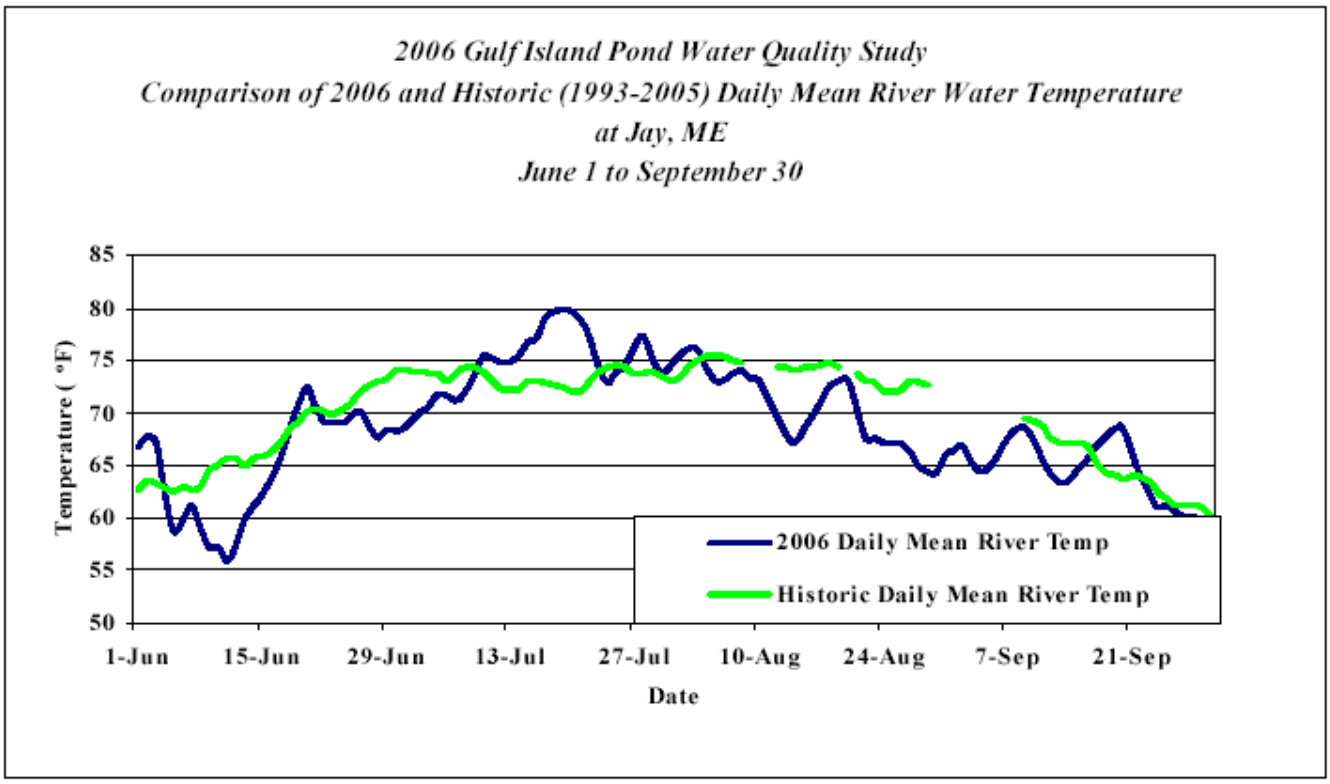
River Flow Characteristics

A review of the river flow shows that 2006 was a wetter year than average (Figure 10). Only 16 days were at or below mean flow for the river. River temperatures were below the mean for June and August and above the mean for July. September's temperature data shows it was an average month.

FIGURE 10. HISTORIC MEAN, 2005, and 2006 DAILY SUMMER ANDROSCOGGIN RIVER FLOWS AT RUMFORD (Charts from Acheron Report dated 11/30/2006, page 7)



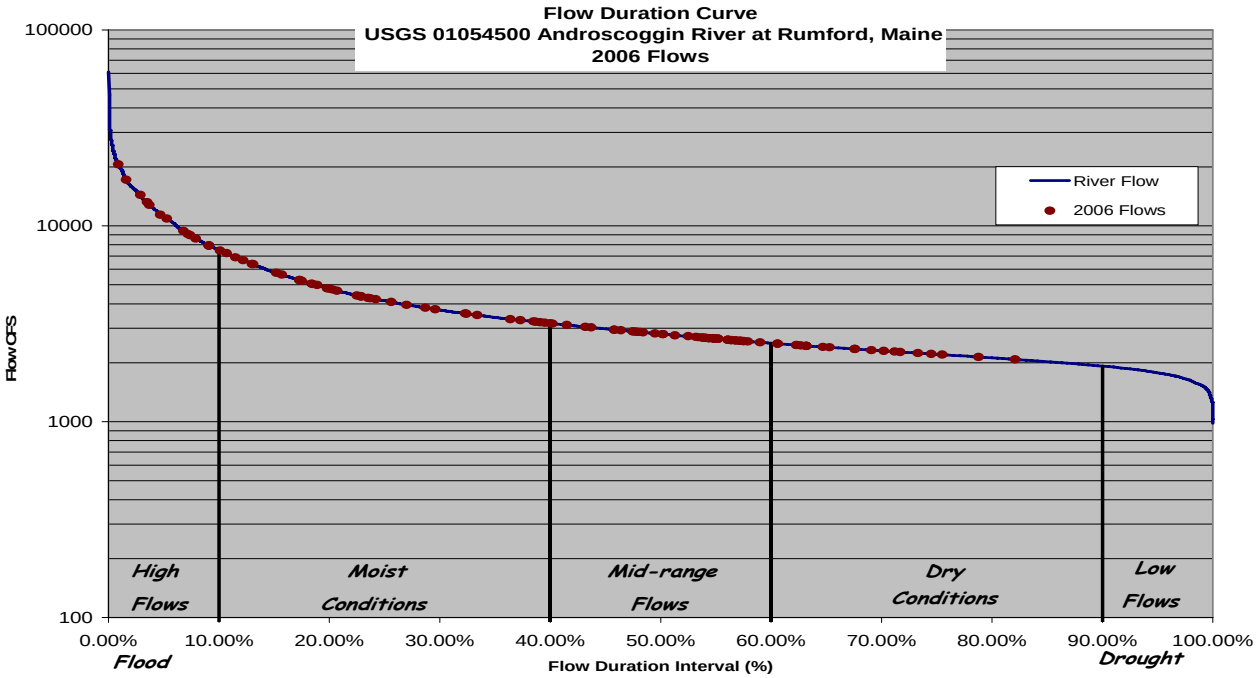




Charts from Acheron Report dated 11/30/2006, page 8

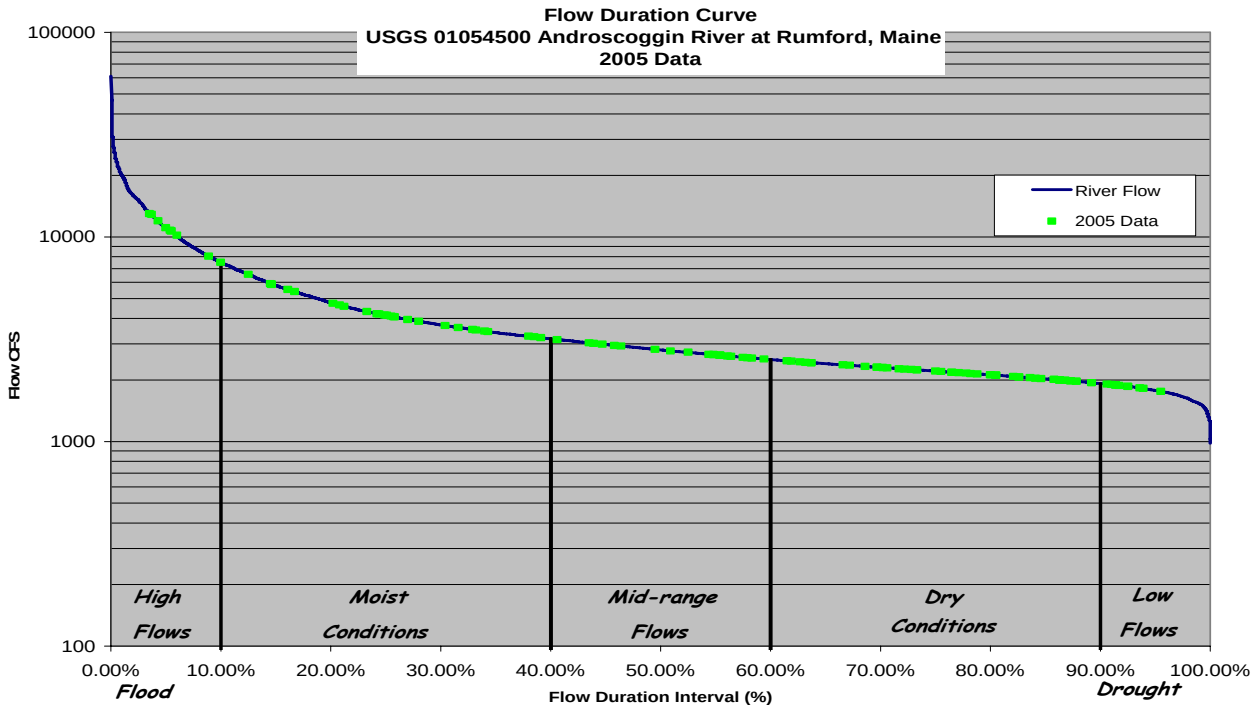
Plotted below (Figure 11) is a flow duration curve following USGS guidelines and their data from January 1, 1960 to the end of 2006. River flows from June 1 to September 30th of 2006 are plotted on this flow duration curve. As indicated on this curve, the majority of days are shifted to the left and are in the High, Moist and Midrange flow conditions, while there were no flows in what is characterized as the Low Flow condition, showing that this was a unusually wet year.

FIGURE 11. FLOW DURATION CURVE FOR THE ANDROSCOGGIN RIVER AT RUMFORD, 2006



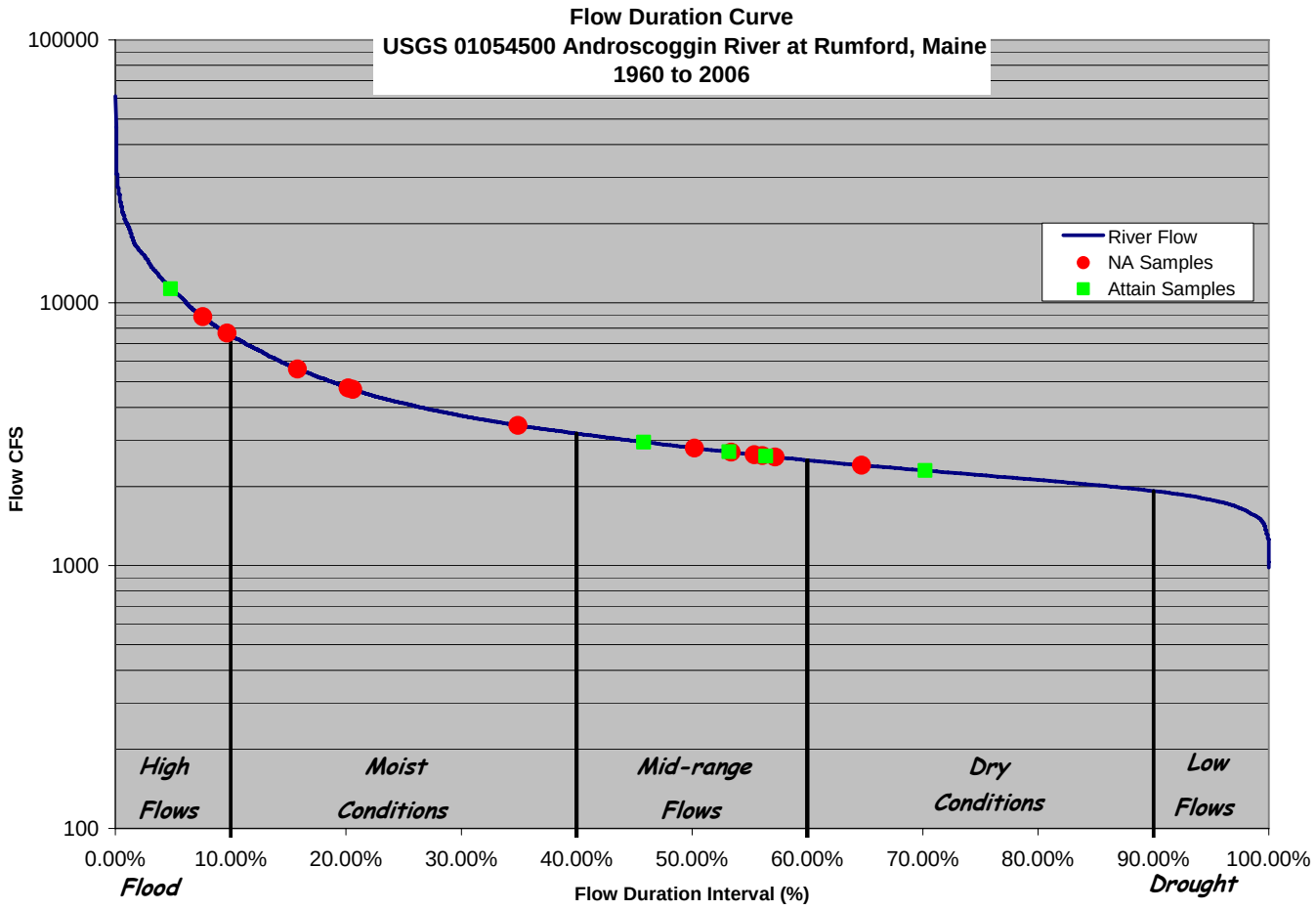
For comparison, the 2005 data (Figure 12) illustrates that year was more typical with flows more evenly distributed throughout the flow conditions.

FIGURE 12. FLOW DURATION CURVE FOR THE ANDROSCOGGIN RIVER AT RUMFORD, 2005



When sample dates were plotted along the long-term flow duration curve, they show some amount of non-attainment (NA) of DO in three (High flows, mid-range and dry) of the four flow conditions seen this year (Figure 13). Therefore, there appeared to be little correlation with river flow and low DO.

FIGURE 13. FLOW DURATION CURVE FOR THE ANDROSCOGGIN RIVER AT RUMFORD, 1960-2006.



Gulf Island Pond Oxygenation Project (GIPOP)

The system's operating parameters are outlined in discharge permits for NewPage's Rumford Paper Company and Verso Paper Company (formerly IP) (Table 2).

TABLE 2. OPERATING PARAMETERS FOR GIPOP

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

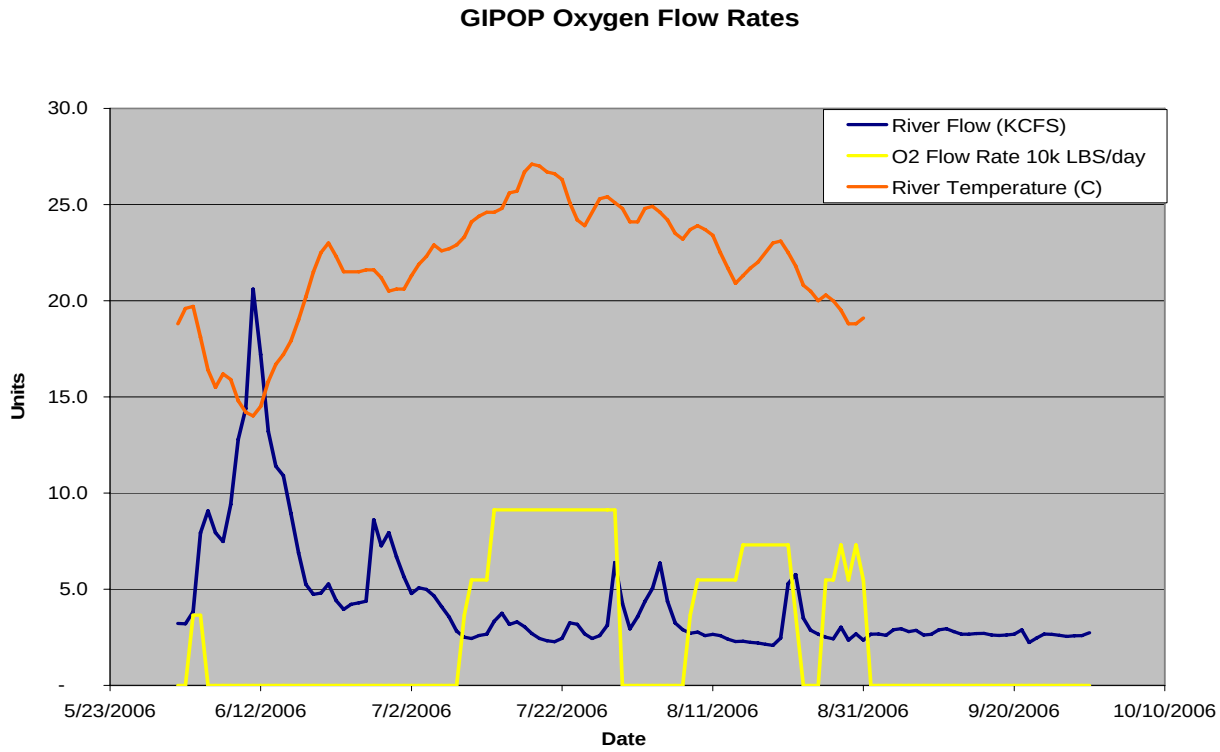
Oxygen Injection Thresholds	% Normal Capacity	Oxygen Injection* (lb/day)
Q(2) > 3500 cfs	Idle	8,000
T<24°C & 3,000 < Q ≤ 3,500	50%	36,500
T<24°C & 2,500 < Q ≤ 3,000	75%	54,750
T<24°C & Q < 2,500	100%	73,000
T≥24°C & Q ≤ 3,500	125%	91,000

(1)All temperature 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 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 oxygen injection amounts were within the prescribed operating parameters (Figure 14).

FIGURE 14.



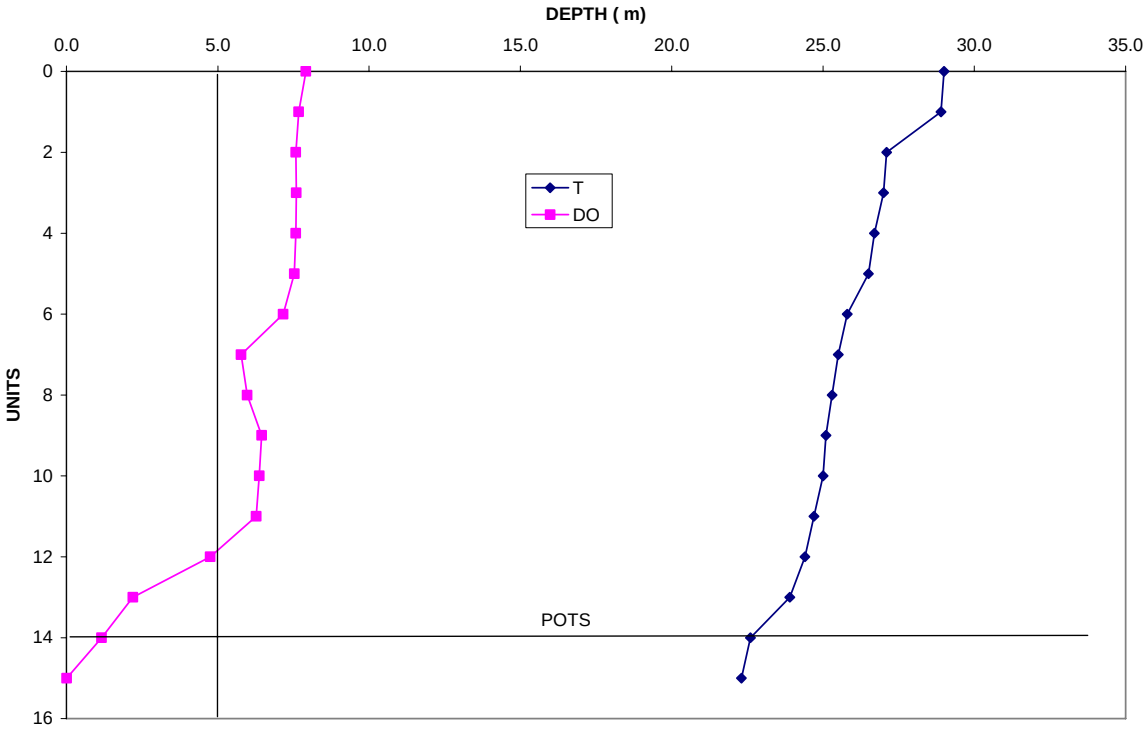
DISSOLVED OXYGEN CONCENTRATIONS IN GIP IN 2006

Even with the overall higher river flows in 2006, the data show that dissolved oxygen (DO) concentrations were below the instantaneous minimum dissolved oxygen criterion (<5 mg/l) specified in Maine's Water Quality Standards at all stations except TWB at some point during the season.

DEP Sampling at Lower Narrows

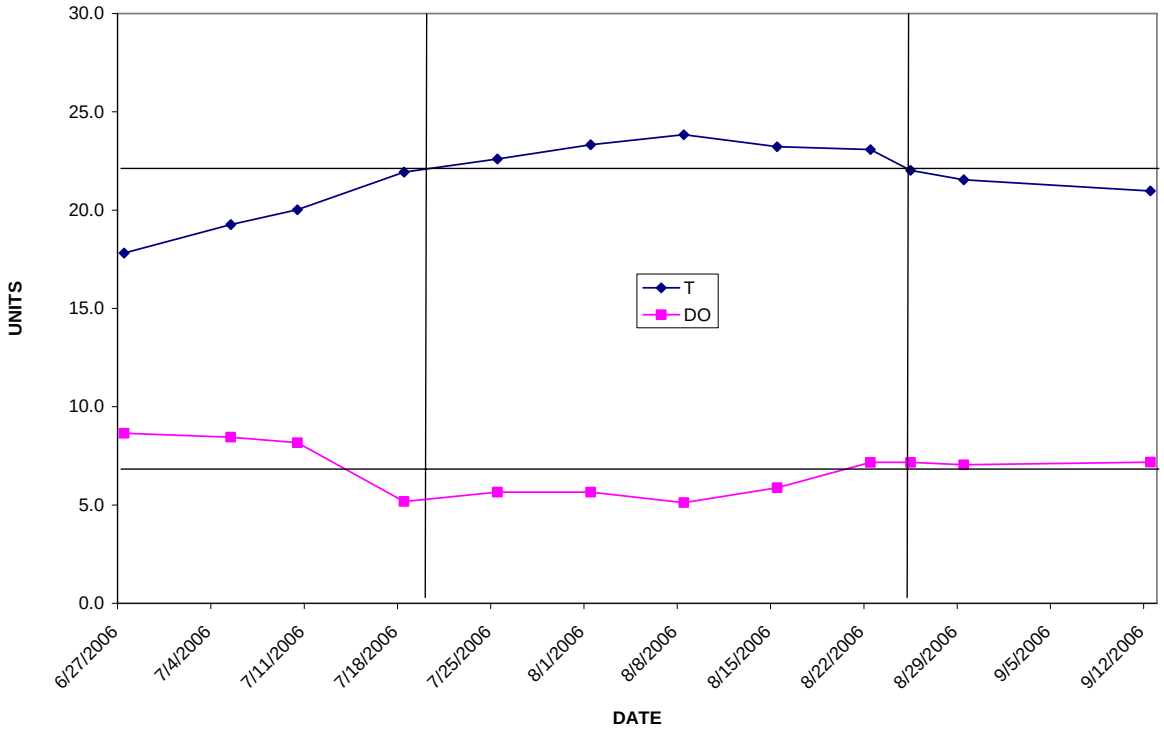
In 2006, DEP measured temperature (T°C) and DO at Lower Narrows (LN) weekly in vertical profiles at 1 meter (m) increments. Maximum depth at LN is approximately 15 m, and varies weekly by 1-2 m due to drawdown for hydropower generation at the Gulf Island Dam. Although not the deepest part of GIP, LN exhibited thermal stratification on 1 of the 16 sampling days, July 18 (Appendix 2). For that sample date DO concentrations were below the minimum DO criterion of 5 mg/l above the point of thermal stratification (POTS), which is indicated on the chart below and is measured at a depth of 1 meter below the top of the thermocline (the first indication of thermal stratification) (Figure 15). Given that sampling 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 this excursion below the criterion represents about 1 week of 15 sampling weeks, or about 7% of the summer period.

FIGURE 15. TEMPERATURE (T°C) AND DISSOLVED OXYGEN (DO, mg/l) AT LN JULY 18, 2006



The 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. In 2006 at LN there was non-attainment of the monthly average criterion for one 30 day sampling period, actually representing a shorter period of time (2-3 weeks) assuming a linear transition of DO and interpolating between sampling dates (Figure 16). There were other 30 day means with DO<6.5 mg/l, but T>22°C, so the 6.5 mg/l monthly average criterion did not apply. That the non-attainment of the minimum and monthly average DO criteria occurred when oxygen injection was at it highest, is likely due to the relatively high water temperatures during that time.

FIGURE 16. ROLLING MONTHLY AVERAGE T (°C) AND DO (mg/l) AT LN, 2006



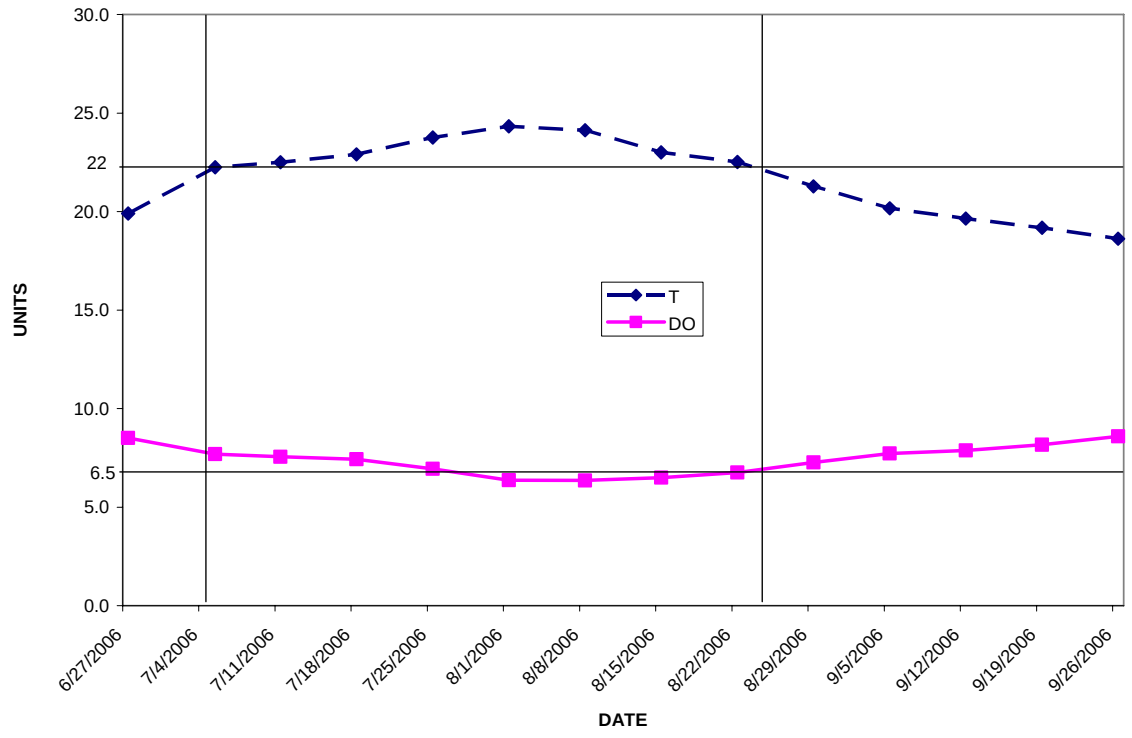
Sampling by GIPOP

Detailed results of weekly temperature and DO profile measurement made at 5 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/ .

TCB Station

At TCB there were no sampling days when DO was in non-attainment of the minimum DO criterion of 5 mg/l during either morning or afternoon. The rolling monthly average (RMA) DO was slightly below the 6.5 mg/l monthly average criterion from the end of July to the middle of August (Figure 17). However, during this period water temperature was greater than 22°C, when the monthly average criterion does not apply (between the 2 vertical lines).

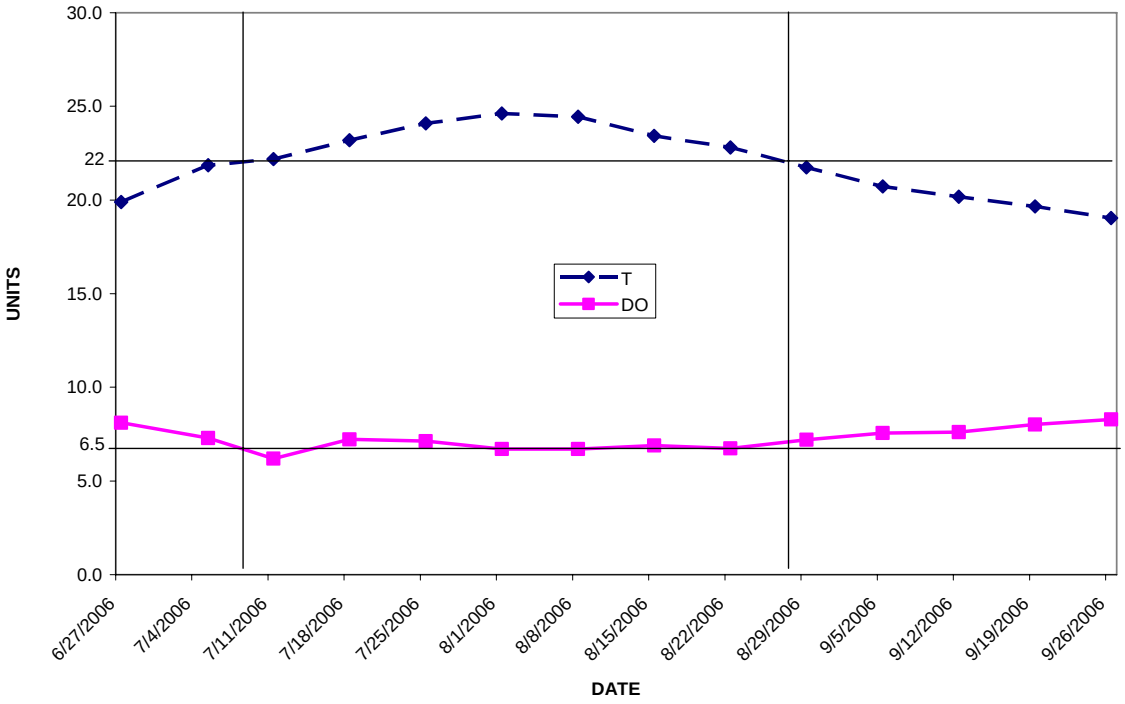
Figure 17. Rolling monthly average temperature (T) and dissolved oxygen (mg/l) at TCB, 2006



UN Station

At UN there were two of seventeen sampling dates, representing about 12% of the summer, when DO was in non-attainment of the minimum DO criterion of 5 mg/l at some depth (not counting the bottom most reading, which may be more representative of the sediment than the water column) in the morning or afternoon. There was only one of the fourteen calculated RMAs that was below the 6.5 mg/l monthly average criterion, representing about 7% of the summer sampling period for which the RMA was calculated (Figure 18). On July 11 the RMA was 6.2 mg/l but this was during the period when the temperature was greater than 22°C (between the two vertical lines) and therefore the monthly average DO criterion does not apply. That most of the measurements showed attainment of the instantaneous minimum and monthly average DO criteria was expected since UN is immediately below the point of oxygen injection into the river. Nevertheless, the few excursions show the importance of proper design and operation of the oxygenation system.

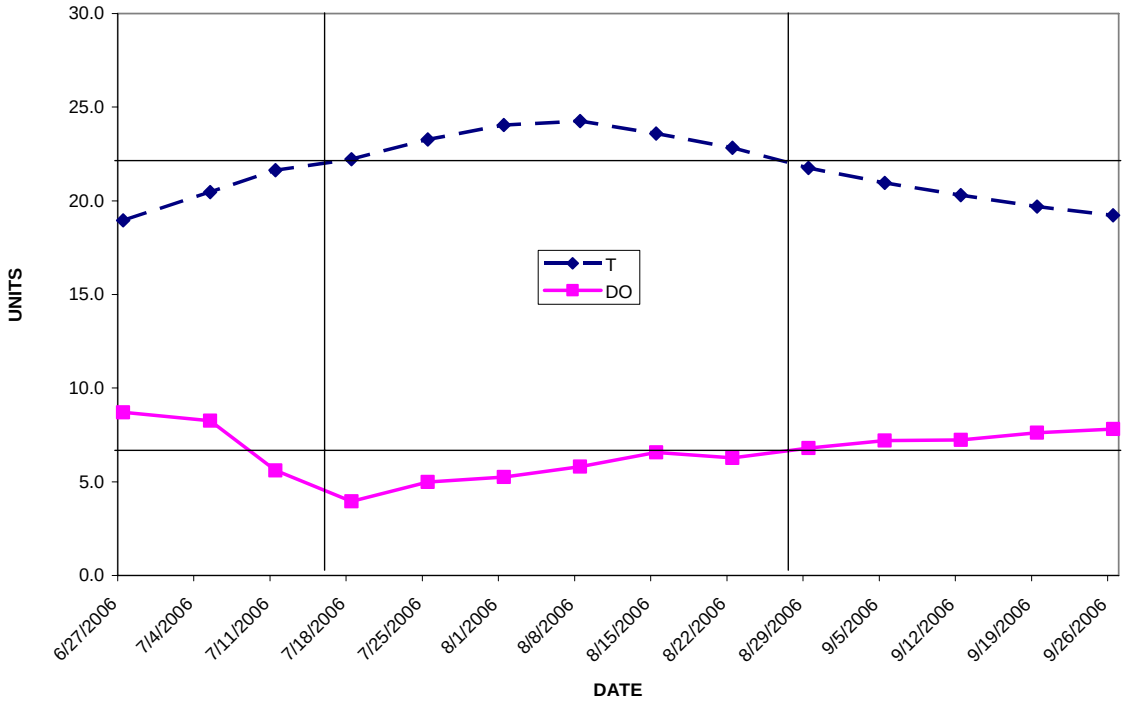
Figure 18. Rolling monthly average temperature (T) and dissolved oxygen (DO, mg/l) at UN, 2006



LN Station

At LN there were seven of seventeen sampling dates, representing 41% of the summer, when 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 9 to August 13 and August 18 to August 25, or about 45% of the summer sampling period for which the RMA was calculated (Figure 19). However, the temperature was greater than 22°C, when the monthly average criterion does not apply, from about July 16 to August 18 (between the two vertical lines), leaving about 14% of the period when the monthly average criterion was not attained. These data are relatively similar to those collected by DEP (Figure 16). The reason that there is any difference from DEP data from the same location at all is due to a couple of 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. 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.

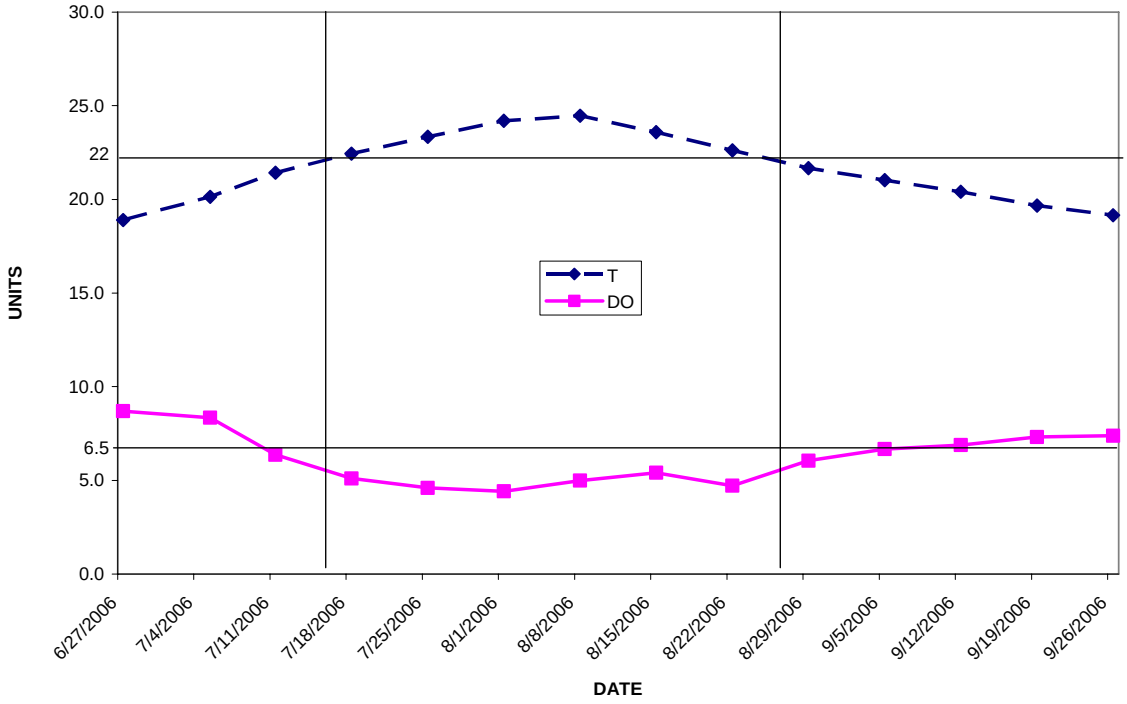
FIGURE 19. MONTHLY AVERAGE TEMPERATURE (T) AND DISSOLVED OXYGEN (MG/L) AT LN, 2006



GIP 4 Station

At GIP 4 there were five of seventeen sampling dates, or about 29% of the summer, when 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 10 to September 10, or about 57% of the summer sampling period for which the RMA was calculated (Figure 20). But the temperature was greater than 22°C, when the monthly average criterion does not apply (between the two vertical lines) from about July 16 to August 18, leaving about 14% of the period when the monthly average criterion was not attained. GIP 4 showed much more thermal stratification at lower depths than either the Upper or Lower Narrows.

FIGURE 20. ROLLING MONTHLY AVERAGE TEMPERATURE (T) AND DISSOLVED OXYGEN (DO) AT GIP4, 2006

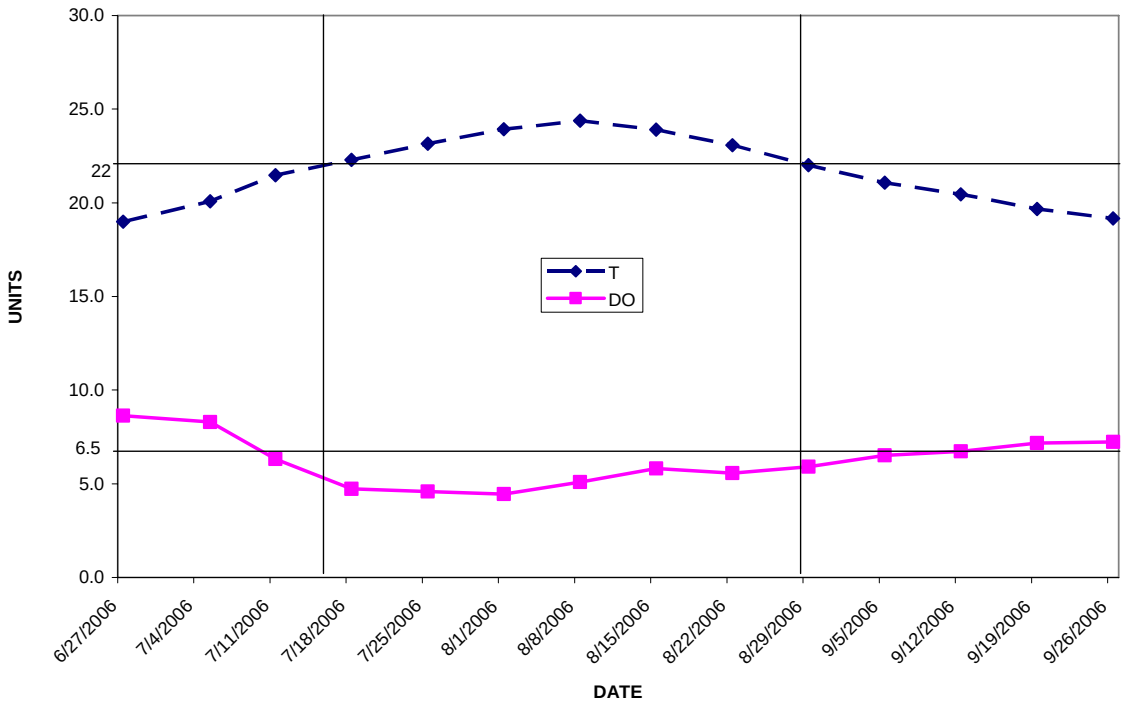


DH Station

The DH sampling location is the furthest downstream from GIPOP and is the deepest station sampled in GIP. The DH thermally stratified over several weeks during the summer. The longest stretch was a three week stretch from mid July to the first week in August, essentially ending during the first week in August. After which, the DH temperature remained relatively uniform. The thermal stratification or lack thereof, was a function of both river flow rate (June) and surface water temperature (August & September). Higher flow rates in June kept the DH relatively well mixed thermally, while, despite the lower flow rates, lower surface water temperatures encouraged better mixing after the first week in August.

At the DH there were ten of seventeen sampling dates, representing about 59% of the summer, where DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both. The rolling monthly average DO was below the monthly average 6.5 mg/l criterion from about July 10 to September 5, representing about 61% of the summer sampling period for which the RMA was calculated (Figure 21). However, the temperature was greater than 22°C, when the monthly average criterion does not apply (between the two vertical lines), from about July 15 to August 29, leaving 16% of the summer where the monthly average DO criterion was not attained. DO appeared to be independent of river flow rates.

FIGURE 21. MONTHLY AVERAGE TEMPERATURE (T) AND DISSOLVED OXYGEN (DO, MG/L) AT DH, 2006



4. CONTINUOUS MONITORING

The current temperature (T) and dissolved oxygen (DO) continuous monitoring plan was approved as an attachment to the consent agreements with Boise Cascade (now NewPage's Rumford Paper Co.) and International Paper (now Verso Paper Co.) in 1990 in order to verify the water quality model for GIP. Continuous (hourly) monitoring was required at the bottom of the river at TCB upstream of the diffuser, and at the 5, 20, 35, and 50 foot depths 0.2 miles upstream of the dam. Later at the DEP's request, continuous monitoring at DH was initiated 0.6 miles upstream of the dam, but only at a single depth somewhere near the bottom. This monitoring strategy never was sufficient to determine compliance with Maine's water quality criteria for dissolved oxygen. Consequently, DEP conducted its own monitoring after the diffuser began operation in 1992, measuring DO profiles from the surface to the bottom at the deep hole and other stations and found that DO concentrations were improved but still not attaining the minimum DO criterion. With the enactment of 38 MRSA 464 (13) the continuous monitoring at the 5, 20, 35, and 50 foot depths is even less useful for monitoring compliance with the water quality criteria as it is insufficient to determine the location of the point of stratification and thermocline.

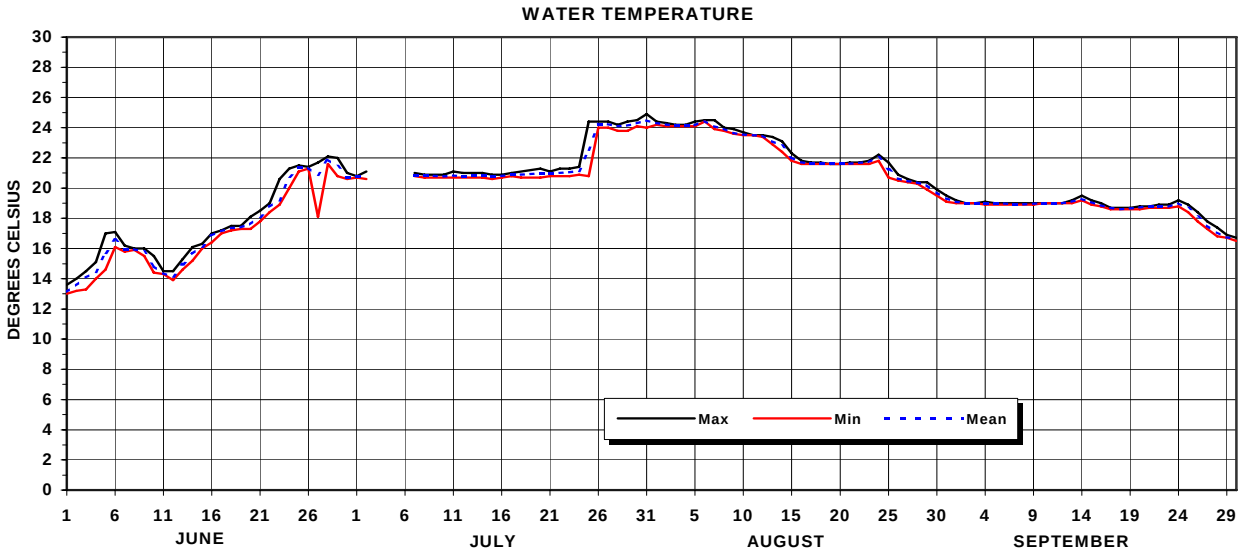
Nevertheless, the continuous monitoring data from 2006, gathered and reported by Water Monitoring Services, Inc. on behalf of the GIPOP, can provide some information about compliance. Data from the 50 foot depth at the dam station show that the minimum DO<5.0 ppm for about 9% of the summer sampling period. The mean monthly DO for July was 6.0 mg/l,, below the monthly average criterion of 6.5 mg/l. The DH data also can be used. Data from Water Monitoring Services show T and DO recorded at a depth of 20-25 feet above the bottom during 2006 (Figure 22). The data show that when T is less than or equal to 22 C, DO is less than 5 mg/l about 27% of the summer sampling period. The mean monthly DO for July was 1.5 mg/l, well below the monthly average criterion. If 1 meter profiles had been measured to provide better data, actual amount of time of non-compliance would likely have been more. Raw data are available for viewing in paper copy at DEP or on the web at http://www.maine.gov/dep/blwq/topic/gip/ .

FIGURE 22. TEMPERATURE (T) AND DISSOLVED OXYGEN (DO) CONCENTRATIONS IN GIP MEASURED CONTINOUSLY (HOURLY) IN GIP.

GULF ISLAND POND DEEPHOLE 0.6 MI
ABOVE GULF ISLAND DAM NEAR LEWISTON, ME

WATER TEMPERATURE, DEGREES CELSIUS, 2006

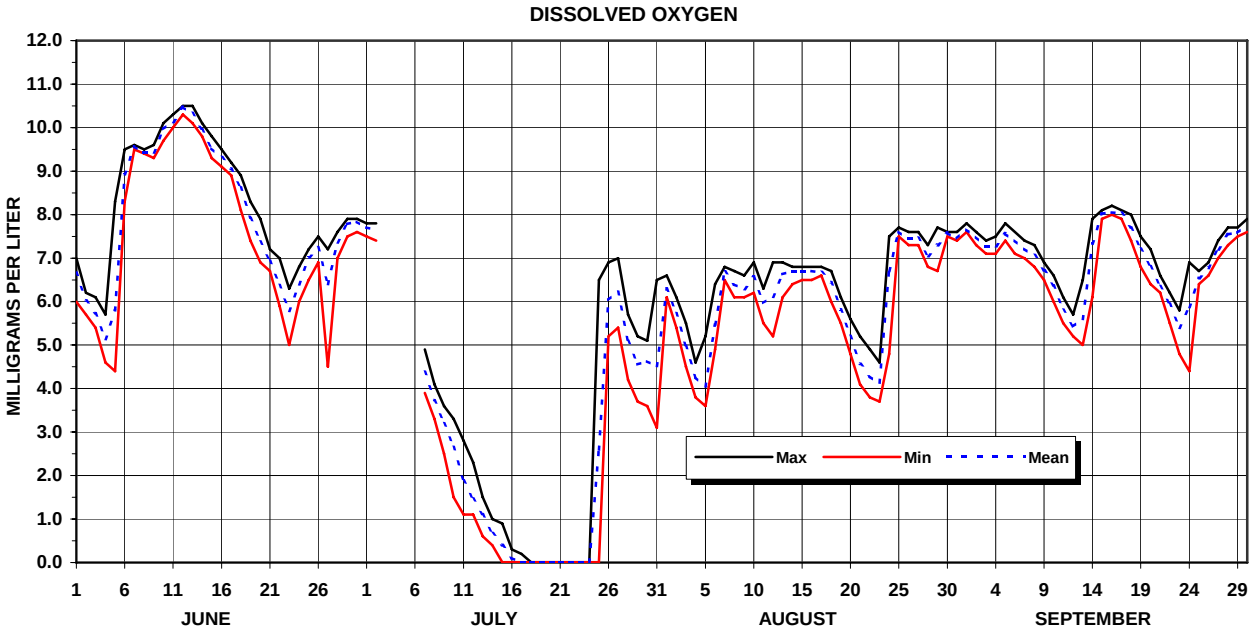
	JUNE			JULY			AUGUST			SEPTEMBER		
DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
1	13.6	13.0	13.1	20.8	20.7	20.7	24.4	24.2	24.3	19.2	19.0	19.1
2	14.0	13.2	13.6	21.1	20.6	20.8	24.3	24.1	24.2	19.0	19.0	19.0
3	14.5	13.3	14.1	----	----	----	24.2	24.1	24.1	19.0	19.0	19.0
4	15.1	14.0	14.4	----	----	----	24.2	24.1	24.1	19.1	18.9	19.0
5	17.0	14.6	15.7	----	----	----	24.4	24.1	24.2	19.0	18.9	19.0
6	17.1	16.1	16.6	----	----	----	24.5	24.4	24.4	19.0	18.9	19.0
7	16.2	15.8	15.9	21.0	20.8	20.8	24.5	23.9	24.1	19.0	18.9	18.9
8	16.0	15.9	16.0	20.9	20.7	20.8	24.0	23.8	23.9	19.0	18.9	18.9
9	16.0	15.5	15.8	20.9	20.7	20.8	23.9	23.6	23.7	19.0	18.9	19.0
10	15.5	14.4	14.8	20.9	20.7	20.8	23.7	23.5	23.5	19.0	19.0	19.0
11	14.5	14.3	14.4	21.1	20.7	20.8	23.5	23.5	23.5	19.0	19.0	19.0
12	14.5	13.9	14.2	21.0	20.7	20.8	23.5	23.4	23.5	19.0	19.0	19.0
13	15.3	14.6	14.9	21.0	20.7	20.8	23.4	22.9	23.1	19.2	19.0	19.1
14	16.1	15.2	15.7	21.0	20.7	20.8	23.1	22.4	22.8	19.5	19.2	19.3
15	16.3	16.0	16.1	20.9	20.6	20.8	22.3	21.8	22.0	19.2	18.9	19.1
16	17.0	16.4	16.9	20.9	20.7	20.8	21.8	21.6	21.7	19.0	18.8	18.9
17	17.2	17.0	17.1	21.0	20.8	20.9	21.7	21.6	21.6	18.7	18.6	18.7
18	17.5	17.2	17.4	21.1	20.7	20.9	21.7	21.6	21.6	18.7	18.6	18.6
19	17.5	17.3	17.4	21.2	20.7	20.9	21.6	21.6	21.6	18.7	18.6	18.7
20	18.1	17.3	17.6	21.3	20.7	21.0	21.6	21.6	21.6	18.8	18.6	18.7
21	18.5	17.8	18.1	21.1	20.8	21.0	21.7	21.6	21.6	18.8	18.7	18.8
22	19.0	18.4	18.8	21.3	20.8	21.0	21.7	21.6	21.7	18.9	18.7	18.8
23	20.6	18.9	19.2	21.3	20.8	21.0	21.8	21.6	21.7	18.9	18.7	18.8
24	21.3	20.0	20.8	21.4	20.9	21.1	22.2	21.8	22.0	19.2	18.8	19.0
25	21.5	21.1	21.4	24.4	20.8	22.5	21.7	20.7	21.2	18.9	18.4	18.7
26	21.4	21.3	21.4	24.4	24.0	24.2	20.9	20.5	20.6	18.4	17.8	18.1
27	21.7	18.1	20.9	24.4	24.0	24.2	20.6	20.4	20.5	17.8	17.3	17.5
28	22.1	21.6	21.9	24.2	23.8	24.1	20.4	20.3	20.4	17.4	16.8	17.1
29	22.0	20.8	21.4	24.4	23.8	24.1	20.4	19.9	20.2	16.9	16.7	16.7
30	21.0	20.6	20.7	24.5	24.1	24.3	19.9	19.5	19.7	16.7	16.5	16.7
31	---	---	---	24.9	24.0	24.5	19.5	19.1	19.3	---	---	---
MONTH	22.1	13.0	17.0	24.9	20.6	21.0	24.5	19.1	21.8	19.5	16.5	18.9
PERIOD	24.9	13.0	20.6									



GULF ISLAND POND DEEPHOLE 0.6 MI
ABOVE GULF ISLAND DAM NEAR LEWISTON, ME

DISSOLVED OXYGEN MILLIGRAMS PER LITER, 2006

	JUNE			JULY			AUGUST			SEPTEMBER		
DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
1	7.0	6.0	6.7	7.8	7.5	7.7	6.6	6.1	6.3	7.8	7.6	7.7
2	6.2	5.7	6.0	7.8	7.4	7.7	6.1	5.4	5.7	7.6	7.3	7.5
3	6.1	5.4	5.7	----	----	----	5.5	4.5	5.0	7.4	7.1	7.3
4	5.7	4.6	5.1	----	----	----	4.6	3.8	4.3	7.5	7.1	7.3
5	8.3	4.4	5.8	----	----	----	5.2	3.6	4.1	7.8	7.4	7.6
6	9.5	8.3	8.9	----	----	----	6.4	4.9	5.5	7.6	7.1	7.4
7	9.6	9.5	9.6	4.9	3.9	4.4	6.8	6.5	6.7	7.4	7.0	7.2
8	9.5	9.4	9.4	4.1	3.3	3.7	6.7	6.1	6.4	7.3	6.8	7.1
9	9.6	9.3	9.4	3.6	2.5	3.2	6.6	6.1	6.3	6.9	6.5	6.7
10	10.1	9.7	10.0	3.3	1.5	2.7	6.9	6.2	6.6	6.6	6.0	6.4
11	10.3	10.0	10.1	2.8	1.1	1.9	6.3	5.5	6.0	6.1	5.5	5.8
12	10.5	10.3	10.5	2.3	1.1	1.5	6.9	5.2	6.1	5.7	5.2	5.4
13	10.5	10.1	10.3	1.5	0.6	1.1	6.9	6.1	6.6	6.5	5.0	5.6
14	10.1	9.8	10.0	1.0	0.4	0.7	6.8	6.4	6.7	7.9	6.1	7.3
15	9.8	9.3	9.5	0.9	0.0	0.4	6.8	6.5	6.7	8.1	7.9	8.0
16	9.5	9.1	9.3	0.3	0.0	0.1	6.8	6.5	6.7	8.2	8.0	8.0
17	9.2	8.9	9.1	0.2	0.0	0.0	6.8	6.6	6.7	8.1	7.9	8.0
18	8.9	8.1	8.6	0.0	0.0	0.0	6.7	6.0	6.4	8.0	7.4	7.7
19	8.3	7.4	7.9	0.0	0.0	0.0	6.1	5.5	5.8	7.5	6.8	7.2
20	7.9	6.9	7.4	0.0	0.0	0.0	5.6	4.8	5.2	7.2	6.4	6.8
21	7.2	6.7	6.9	0.0	0.0	0.0	5.2	4.1	4.6	6.6	6.2	6.3
22	7.0	5.9	6.4	0.0	0.0	0.0	4.9	3.8	4.3	6.2	5.5	6.0
23	6.3	5.0	5.8	0.0	0.0	0.0	4.6	3.7	4.1	5.8	4.8	5.4
24	6.8	6.0	6.4	0.0	0.0	0.0	7.5	4.8	6.7	6.9	4.4	5.9
25	7.2	6.5	7.0	6.5	0.0	2.6	7.7	7.5	7.6	6.7	6.4	6.5
26	7.5	6.9	7.2	6.9	5.2	6.0	7.6	7.3	7.5	6.9	6.6	6.8
27	7.2	4.5	6.4	7.0	5.4	6.2	7.6	7.3	7.5	7.4	7.0	7.2
28	7.6	7.0	7.4	5.7	4.2	5.1	7.3	6.8	7.0	7.7	7.3	7.5
29	7.9	7.5	7.8	5.2	3.7	4.6	7.7	6.7	7.3	7.7	7.5	7.6
30	7.9	7.6	7.8	5.1	3.6	4.6	7.6	7.5	7.6	7.9	7.6	7.7
31	---	---	---	6.5	3.1	4.5	7.6	7.4	7.5	---	---	---
MONTH	10.5	4.4	7.9	7.8	0.0	1.5	7.7	3.6	6.5	8.2	4.4	7.1
PERIOD	10.5	0.0	6.6									



5. EPA SOD Analysis (Report Issued January 9, 2007)

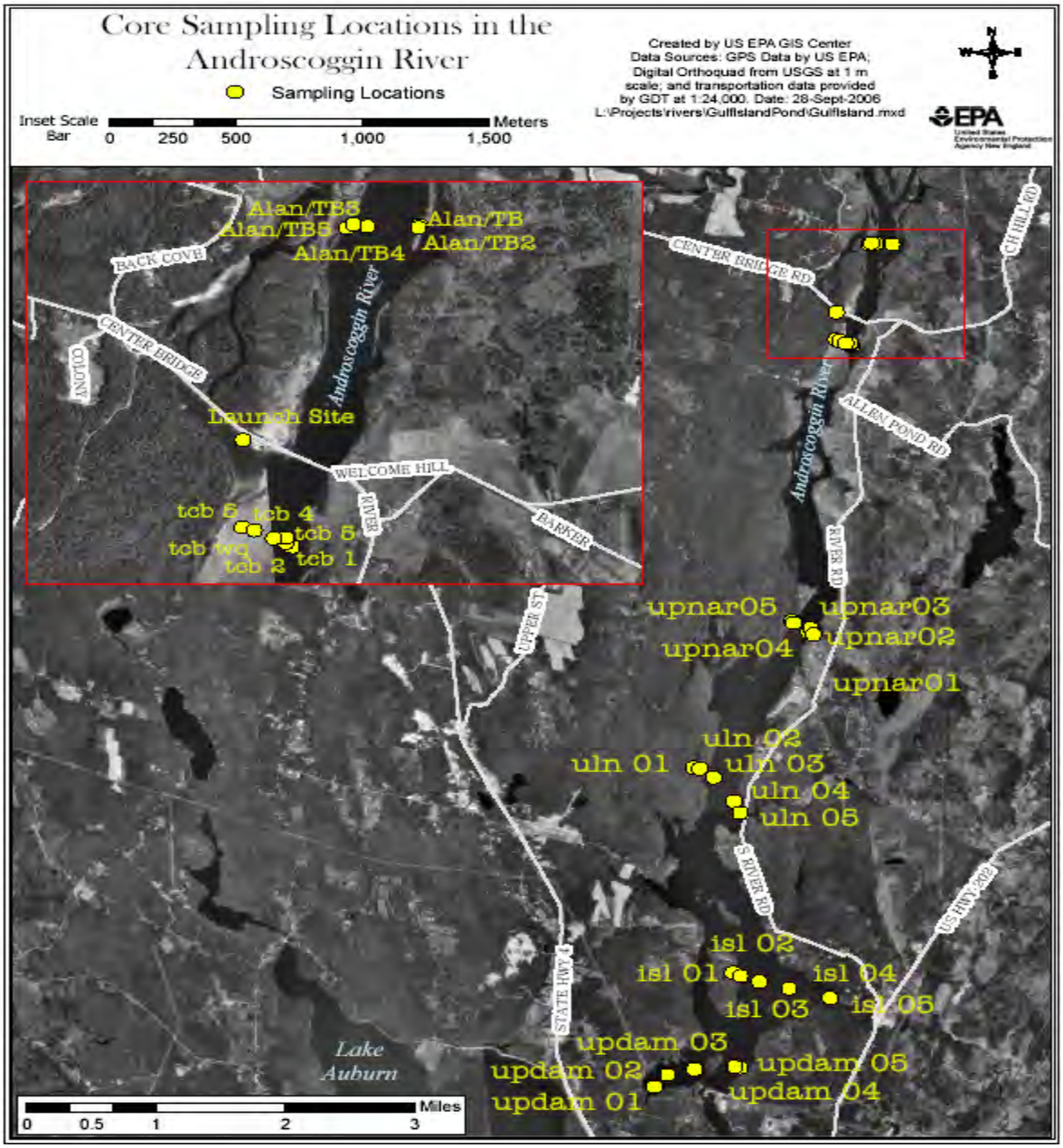
SOD or sediment oxygen demand is the total of biological and chemical processes in sediment that utilize oxygen. SOD studies are useful in the development of predictive mathematical models that will determine waste load allocations. They are also useful in measuring the depletion of oxygen in stratified waters when there are concerns about nutrient regeneration and the loss of aquatic life.

This project included monitoring six sites on the Androscoggin River, beginning upstream of Gulf Island Pond near Turner Center Bridge and Twin Bridge, and ending upstream of the Gulf Island Pond dam in Auburn. The sites chosen were in low-gradient areas where possibility existed for fine sediments tend to accumulate. Site descriptions and locations are shown below. Stations were also based on Androscoggin/Gulf Island Pond MEDEP sampling locations. Sediments were analyzed for SOD, total organic carbon (TOC) and grain size.

TABLE 3. SAMPLE STATIONS FOR SOD STUDY

Station #	Description
Allen/TB	*Twin Bridge*
TCB	*Turner Center Bridge*
UPNAR	*Upper Narrows*
ULN	*Upper Lower Narrows*
ISL	*Island station*
UPDAM	*Upstream of Gulf Island Pond dam*

FIGURE 23.



SOD results ranged from a low of 0.59 g/(m2day)upstream of the dam at station UPDAM to a high of 1.30 g/(m2day) at the Upper Lower Narrows, station ULN. Station Upper Lower Narrows, ULN, and Upper Narrows, UPNAR, were in the medium range of 1.0 to 2.0 g/(m2day). No stations were in the high SOD range of greater than 2.0 g/(m2day). Standard deviations were less than 1.0 or not applicable (N/A) at all six sites. No rates were observed in the Island section. Results may be due to high spring flows in the Androscoggin River. The river is impounded at Gulf Island Pond. Grain size analyses indicate a high sand content with lack of silt and clay in these samples.

TABLE 4. SOD AT GIP STATIONS

Station #	Station Description	SOD Mean (g/m^2day)	Standard Deviation
Allen/TB	*Twin Bridge*	0.78	0.39
TCB	*Turner Center Bridge*	0.99	0.23
UPNAR	*Upper Narrows*	1.17	0.39
ULN	*Upper Lower Narrows*	1.30	0.50
ISL	*Island station*	N/A	N/A
UPDAM	*Upstream of Gulf Island Pond dam*	0.59	0.24

Grain size analysis was performed to categorize sediment particle size at each of the sample locations. In general the grain size is dominated by sand at most stations. This could be due to the high flows in the spring of 2006. Only the deepest station, UPDAM, had more silt and clay fines than sand. Finer sediments were sought for the sediment cores because the small particle size and proportionately greater surface area have a higher affinity for binding contaminants. Flooding occurred in the area during the spring which may have scoured the river bed in the majority of the study area.

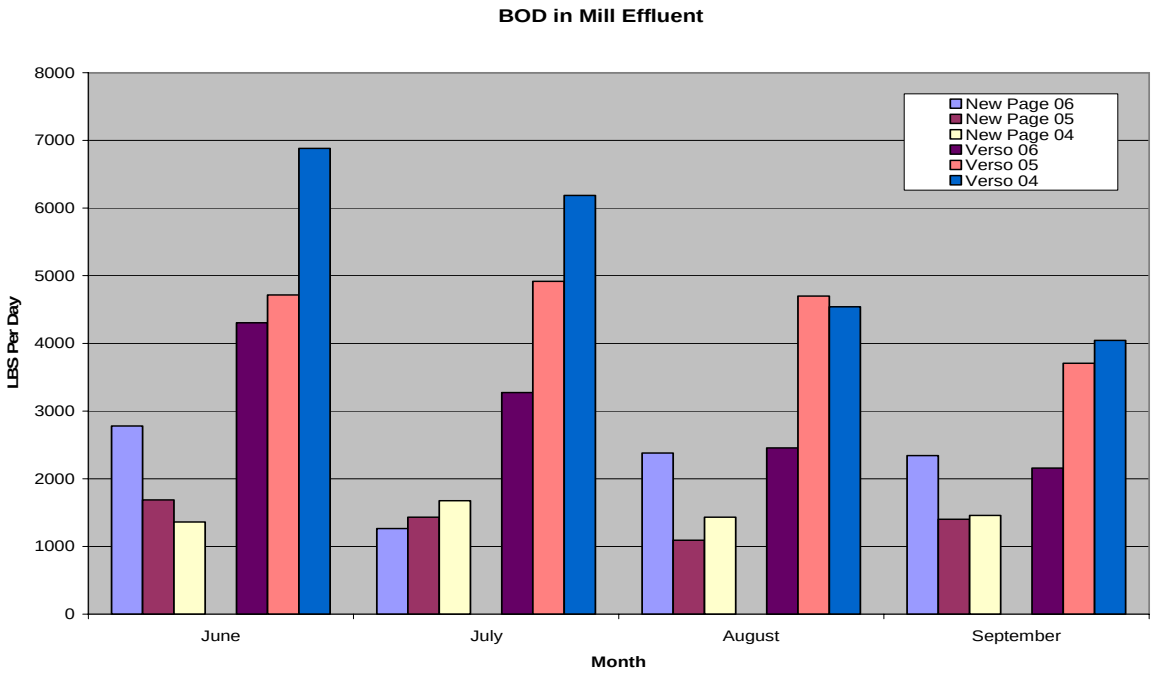
TABLE 5. GRAIN SIZE ANALYSIS AT GIP SAMPLE STATIONS

Station #	% Sand >0.075mm	% Silt/Clay <0.075mm
Allen/TB	91.3	8.7
TCB	75.8	24.2
UPNAR	72.2	27.8
ULN	66.3	33.7
ISL	63.3	36.7
UPDAM	26.9	73.1

6. Mill Effluent Data

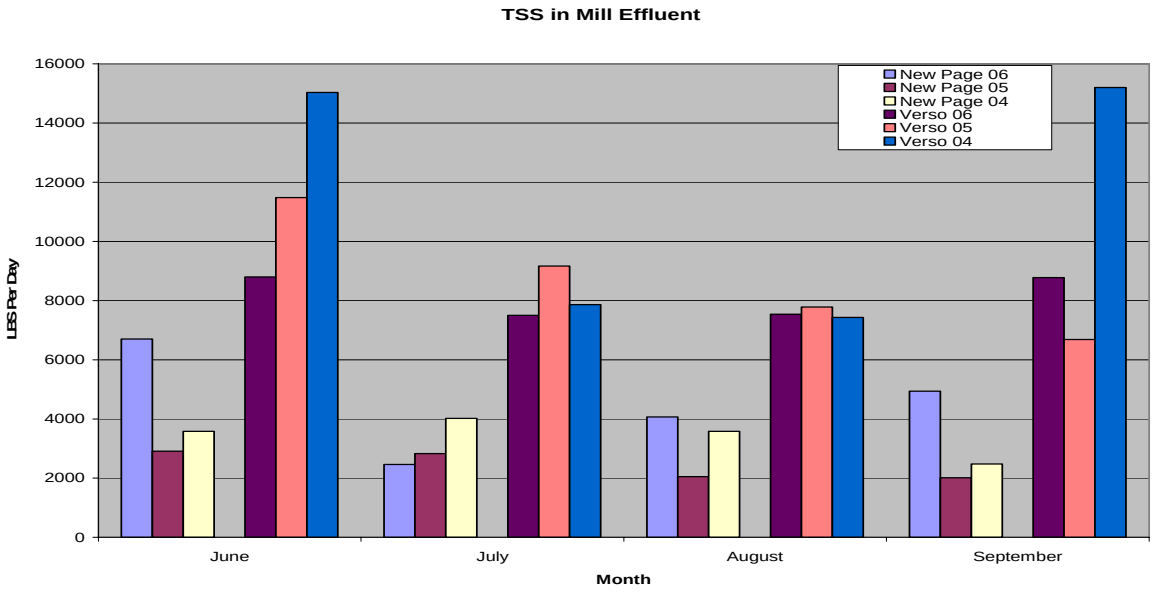
Mill effluent data indicates that the Rumford Mill has remained below 3,000 lbs per day BOD for the past three years. The Verso (formerly IP) Mill has reduced their BOD discharge to the river in 2006 when compared to either 2005 or 2004.

FIGURE 24.



The same can be said for total suspended solids (TSS). The New Page Mill in Rumford essentially has similar loadings over the past three years. The Verso Mill in Jay has reduced the loadings when compared to the 2004 year.

FIGURE 25.


TSS in Mill Effluent
New Page 06
New Page 05
New Page 04
Verso 06
Verso 05
Verso 04
16000
14000
12000
10000
8000
6000
4000
2000
0
June
July
August
September
Month

7. RECOMMENDATIONS

The continuous monitoring program of Gulf Island Pond is a part of the Gulf Island Pond Oxygenation Project of GIPOP and needs to be changed to provide more useful information. Temperature and DO profiles at 1 meter intervals are needed at the Deep Hole station. In addition, the MEDEP should continue the flyover program collecting other beneficial field data including photographic evidence of water quality, the collection of Secchi transparency and water samples for total phosphorus and Chlorophyll-A analysis and algae identification. Current procedure is to schedule weekly flyovers on Wednesday of each week, it is recommended in order to remove any potential, however slight, bias to randomize the flyovers to include other days of the week. Also, vertical temperature and DO profiles should be conducted as part of the flyover program.

As a requirement of their discharge permits additional information will be available increasing the amount of pertinent data. Starting in 2006, from the waste discharge permits of International Paper and Rumford Paper Company, "Between June 1 and September 30 of each year (beginning June 1 2006) the permittee shall independently or in conjunction with other parties participate in ambient water quality monitoring of Gulf Island Pond and/or designated segments of the Androscoggin River at a frequency of 1/Week. There must be at least 72 hrs between sampling events." These data will help further determine the next steps if necessary to fully meet attainment on the Androscoggin River.