Union River Estuary Modeling Report

June 2008

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Executive Summary

1. The City of Ellsworth is planning to build a new treatment plant to replace its existing plant. The new plant and outfall will be located approximately 1.1 miles further down the estuary. The primary goal of this water quality modeling effort is to assess the effects of the current discharge vs. the proposed new discharge on attainment of Maine's Water Quality Standards. The model will be used to make recommendations regarding NPDES permit parameters. These in turn will affect treatment process design.

2. Intensive survey data were used in developing and calibrating a one-dimensional hydrodynamic water quality model (WASP7.2) for the Union River Estuary, including the Ellsworth WWTP discharge.

3. The intensive water quality survey was conducted on a 5.6 mile stretch of the Union River Estuary between head of tide (at the base of Ellsworth Dam) and Tuppers Ledge (in Union River Bay) during the summer of 2007. The survey was coordinated by Maine DEP and Woodard & Curran. This survey effort involved the following facets;

- Six days of water quality monitoring and sampling at nine locations along the defined stretch of estuary. Monitoring/sampling was conducted July 24-26 and August 21-23, which were periods of approximate neap tide (critical) conditions.
- Water quality monitoring included morning and afternoon water column profile measurements for dissolved oxygen (DO), temperature and salinity. Secchi disc readings were also conducted during afternoon monitoring rounds. Profile data was recorded at one-meter intervals
- Water quality samples were collected at all nine locations during the morning monitoring run, and at one location (UR-05) during the afternoon monitoring run. Bottom water quality samples were collected at two locations (UR-05 and UR-07) during the morning monitoring run as conditions permitted. Sampling was conducted for nutrients, chl-a and BOD.
- Daily effluent flow measurements and daily composite samples from the Ellsworth WWTP during each of the six survey days. Sampling was conducted for nutrients and BOD.
- Staff from USEPA collected numerous sediment samples from the estuary for sediment oxygen demand (SOD) evaluation.
- Fresh water inflow measurements at the Ellsworth Dam and Card Brook (Card Brook is the only significant tributary along the pertinent section of the estuary) during all six sampling days.

4. The survey data indicates attainment of dissolved oxygen standards (class SB) along most portions of the Union River Estuary. A few isolated non-attainment readings were recorded in the uppermost portion of the estuary, below the WWTP.

5. Relatively low chlorophyll-a concentrations indicate that eutrophication and related nutrient interactions are not a significant issue with the Union River Estuary.

6. The water quality model predicts a measurable improvement associated with relocating the discharge to the new downstream location, and attainment of dissolved oxygen standards for all potential discharge scenarios and. SOD has the biggest impact on dissolved oxygen (DO) at approximately 0.31 mg/l during critical (neap) tide conditions. The existing discharge creates a DO impact of approximately 0.1 mg/l (at license limits), with 75% of this impact resulting from NBOD and 25% from CBOD.

7. The existing discharge has a relatively small impact on DO in the Estuary at just less than 0.1 mg/l as modeled. The proposed new discharge location lessens the DO impact by approximately 40% (0.04 mg/l), primarily through improved hydraulic conditions (dilution and mixing).

8. Based on the improved hydraulic conditions at the new outfall location, it is reasonable to expect a far lesser point source impact to the Union River Estuary. The existing outfall is located at almost the worst possible location with respect to dilution and mixing. It is suspected that the poor mixing/dilution are a significant contributing factor associated with the variability of observed DO readings during the 2007 survey.

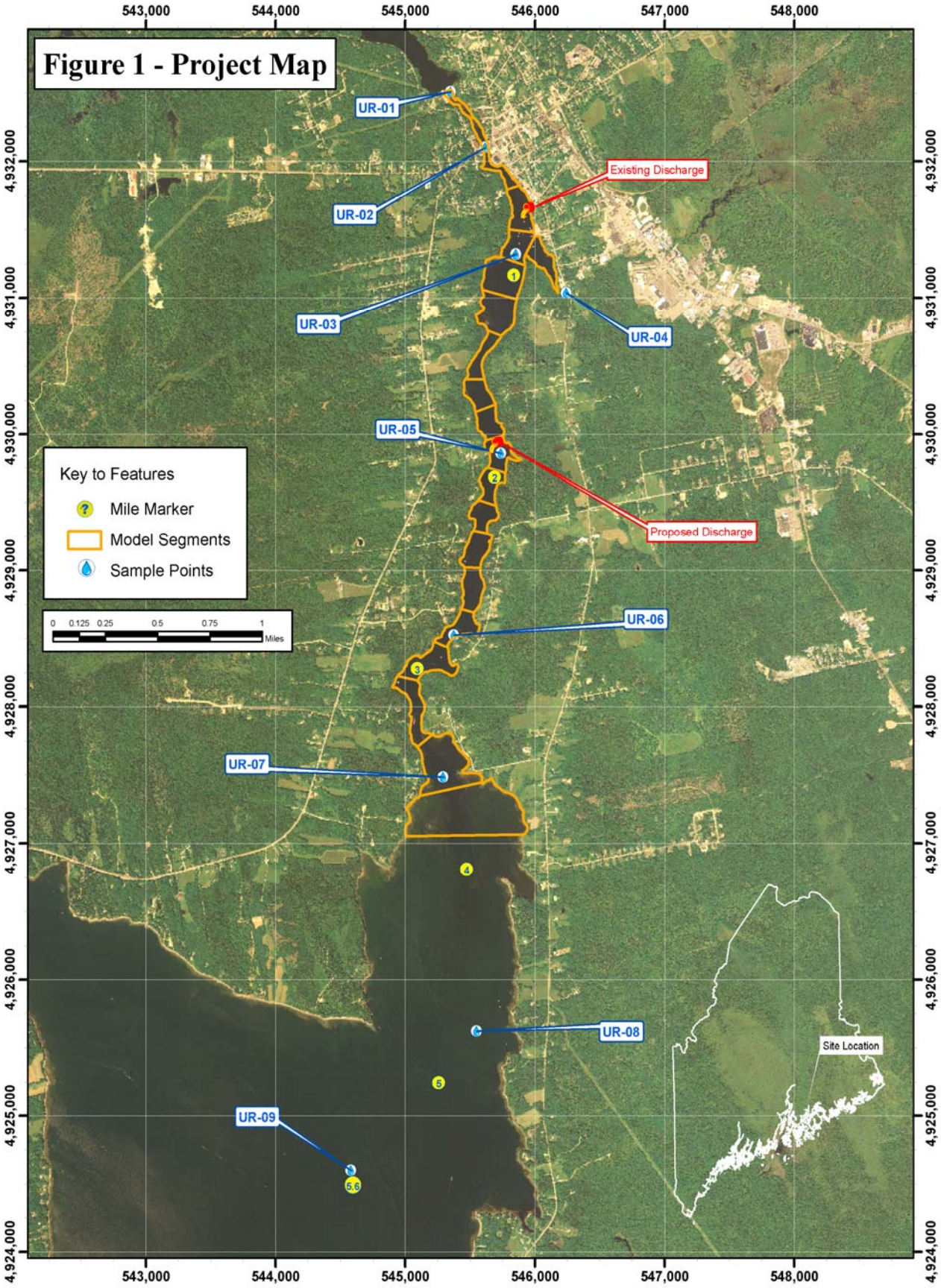
Figure 1 - Project Map
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Existing Discharge
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Site Location
Key to Features
Mile Marker
Model Segments
Sample Points
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Introduction

The Union River is located in Hancock and Penobscot counties and drains a mid-coastal watershed directly to Union River Bay in Ellsworth. The drainage area at Ellsworth is approximately 520 square miles. The Union River Estuary extends approximately 5 miles from head of tide at Ellsworth Dam to Union River Bay at Weymouth Point.

The Union River is categorized as Class B above head of tide and Class SB below head of tide. The only point source is the City of Ellsworth's waste water treatment plant (WWTP). The City is licensed to discharge 0.85 MGD of secondary treated wastewater to the estuary at a point approximately 0.7 miles below head of tide.

The existing treatment plant has experienced a variety of operational problems, which have resulted in a consent agreement between the City of Ellsworth and the Maine DEP. This consent agreement is the driving force toward building a new treatment plant with improved treatment capacity and a better outfall location. Ellsworth is expecting to design/build the new plant at a more downstream location, approximately 1.8 miles from head of tide. The new plant is expected to have an increase in licensed flow from 0.85 to 1.0 MGD along with proportionate increases in mass loadings of BOD5[1] and TSS[2]. The Union River estuary is presently considered to be in attainment of class SB DO standards. SB standards include the following:

A. Class SB waters shall be of such quality that they are suitable for the designated uses of recreation in and on the water, fishing, aquaculture, propagation and harvesting of shellfish, industrial process and cooling water supply, hydroelectric power generation and navigation and as habitat for fish and other estuarine and marine life. The habitat shall be characterized as unimpaired.

B. The dissolved oxygen content of Class SB waters must be not less than 85% of saturation. Between May 15th and September 30th, the numbers of enterococcus bacteria of human and domestic animal origin in these waters may not exceed a geometric mean of 8 per 100 milliliters or an instantaneous level of 54 per 100 milliliters. In determining human and domestic animal origin, the department shall assess licensed and unlicensed sources using available diagnostic procedures. The numbers of total coliform bacteria or other specified indicator organisms in samples representative of the waters in shellfish harvesting areas may not exceed the criteria recommended under the National Shellfish Sanitation Program, United States Food and Drug Administration.

C. Discharges to Class SB waters shall not cause adverse impact to estuarine and marine life in that the receiving waters shall be of sufficient quality to support all estuarine and marine species indigenous to the receiving water without detrimental changes in the resident biological community. There shall be no new discharge to Class SB waters which would cause closure of open shellfish areas by the Department of Marine Resources.

The summer of 2007 survey was the first intensive water quality survey conducted on the Union River Estuary. The Union has been assumed to be in attainment of class SB standards, and the survey confirmed this presumption, but also highlighted some cause for concern based on a few isolated non-attainment readings (isolated non-attainment appears to be driven more by natural conditions/limitations than by point source loadings). The potential area of concern is the approximate 1 mile reach below Ellsworth's existing outfall. The data from this survey provide sufficient information to develop/calibrate a reliable water quality model.

Hydraulic Data Collection

A 3-dimensional georeferenced bathymetric model (TIN – Triangulated Irregular Network) was developed utilizing GIS, to aid in the development of appropriate hydrodynamic properties for the Union River Estuary. Data collection for the bathymetric model was conducted in the Fall of 2007. Hydraulic data collection efforts included GPS coordinated depth soundings, interpretation from recent dredging plans, aerial photo interpretation, and tidal stage observation. It was determined that tidal stage between the upper and lower portion of the estuary equalizes at a uniform elevation throughout each tidal cycle. The

[1] Biochemical oxygen demand, five day
[2] Total suspended solids

bathymetric model helped in developing model segmentation and allows for ready interpretation of hydrodynamic properties for any reference tidal range.

The primary freshwater inflow to the estuary is regulated at the Ellsworth Dam (owned/operated by Pennsylvania Power & Light) on Leonard Lake, which is located at the head of tide (River Mile 0). The Ellsworth Dam is required to pass a minimum of 105 cfs through the dam at all times. Typical flows during the course of the 2007 sampling were expected to be maintained at approximately 160 cfs, but a storm just prior to the July sampling caused flows to jump to near 240 cfs during the July sampling. Card Brook is the only other significant freshwater inflow to the Union River Estuary. Card Brook is located at river mile -0.9 at the Elsworth Marina. Flows were measured at Card Brook during each day that samples were collected. Flows at Card Brook averaged approximately 10 cfs at all times during the survey. Salinity data indicated that the influence of the freshwater inflow was generally restricted to the top meter of the estuary before mixing.

Tide charts were referenced to determine the frequency and range of tidal activity in the estuary.

The hydraulic data were used to develop a realtime hydrodynamic model of the Union River Estuary. The hydrodynamic model was developed using EPA's DYNHYD software, which is directly ported into WASP. The hydrodynamic model was calibrated to ensure that uniform tide elevations were maintained throughout the model reach of the estuary.

Chemical Data Collection

Chemical data collection during the intensive survey involved profile measurement of temperature, salinity, and DO, and collection of composite water samples for laboratory testing at nine stations along the estuary. Laboratory parameters included TKN[1], ammonia (NH_3-N), nitrite+nitrate (NO_2+NO_3), total phosphorous (TP), dissolved phosphorous (PO_4), chlorophyll (chl-a)[2], BOD5 and BODu. Also during the surveys, daily composite samples of treatment plant effluent were collected and analyzed for BOD5 and all of the above parameters except chl-a. These data are summarized in the Appendix, page 17.

Profile readings were taken at both low and high tides. The survey was scheduled to coincide with critical/neap tide conditions. Water samples were collected during the morning monitoring run with an additional afternoon sample taken each day at sample location UR-05 (proposed location of new treatment plant). Bottom samples (water) were also collected during the morning run at stations UR-05 and UR-07. Freshwater boundary samples were collected at Ellsworth Dam (UR-01) and Card Brook (UR-04) each day above head of tide.

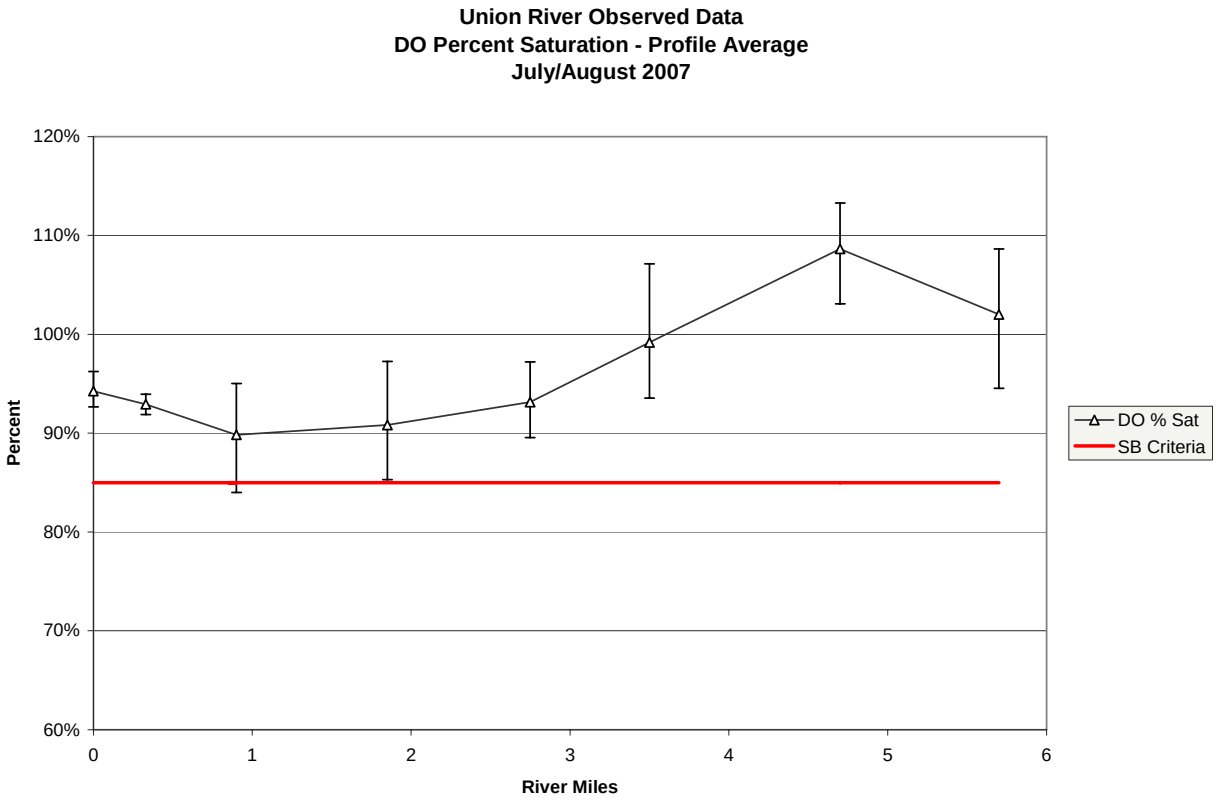
Sediment samples were also collected by an EPA crew headed by Tim Bridges during the Summer of 2007. These samples were analyzed for SOD.

Data Results

The low tide, early morning data collected during the survey can be used to assess compliance with minimum DO standards. Class SB DO standards call for a minimum DO concentration of 85% saturation. DO saturation is dependent upon both water temperature and salinity concentration. By law assimilative capacity is determined at 7Q10 river flows. Freshwater flow in the Union River Estuary is regulated by dams; minimum flow dam releases were targeted for critical condition water quality data collection. Figure 2 shows the DO data from the 2007 intensive survey plotted in terms of percent saturation. The data are included in the appendix of this report (pages 18-23). The Ellsworth treatment plant was operating at approximately 30% of its licensed loading during the period when observed data were collected.

[1] Total Kjeldahl nitrogen (organic + ammonia)
[2] Chlorophyll-a, a measure of water column algae

Figure 2: Intensive Survey DO Data



Water Quality Model

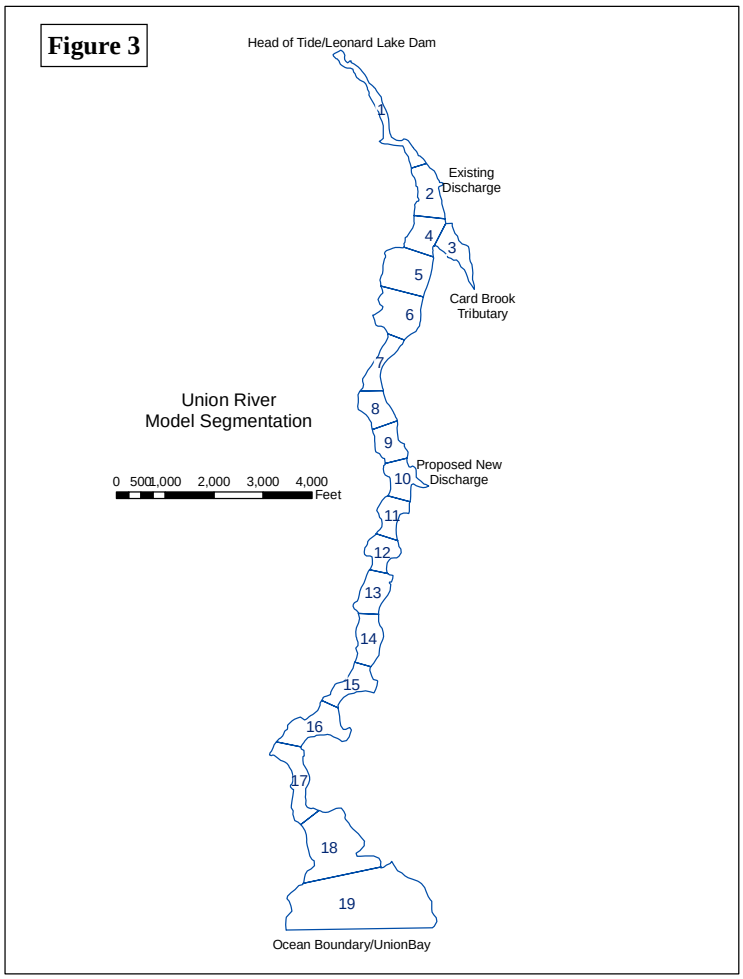
Water quality models are used to investigate various environmental scenarios which would be difficult to control and/or monitor in the field. In the case of the Union River Estuary, modeling is required to investigate potential impacts associated with a different outfall location, and potential loading changes associated with a new treatment plant. The modeling framework selected for the Union River Estuary utilizes WASP (version 7.2) to simulate water quality kinetics and DYNHYD to simulate hydrodynamic transport. WASP has traditionally been used by Maine DEP for estuarine modeling. WASP also supports integration with DYNHYD.

DO is the primary parameter of interest with regard to the Union River Estuary. Class SB standards require that DO percent saturation (DO%Sat) be maintained at or above 85% saturation. The Union River model is a hydrodynamic model, which enables the tracking of DO%Sat as it fluctuates during tidal cycles. The critical (minimum) DO%Sat condition occurs shortly after the low/slack tide.

Water quality modeling analyses typically involve two independent components; that of transport and that of kinetics or chemistry. Transport is a mathematical representation of how the water moves and involves the components of advection and dispersion. The kinetic representation of the model is quite complex and mathematically relates all the relevant factors associated with dissolved oxygen production and depletion. A flow chart representation of the general kinetic model framework is provided in the Appendix (page 24), which details the potential processes involved. The modeling framework selected for the Union River does not simulate algal growth kinetics, based on the limited degree of algal growth in the observed data.

The first step in the development of a water quality model is to divide the system into segments. For the Union River Estuary the reach breakup from head of tide (upstream, rivermile 0) to the mouth (downstream, rivermile 3.75) resulted in 19 segments as depicted in Figure 3. Segmentation was not

extended further into Blue Hill Bay due to the distinct change in physical characteristics at this point. The model demonstrates that this segmentation is sufficient to fully characterize the condition and location of the critical condition because the model indicated no discernible effects of the Ellsworth discharge at the chosen ocean boundary. This particular section of the Union River Estuary is quite confined, in a lateral sense, by bedrock topography. Based on the confined nature of the estuary we expected the system to be fairly well mixed with limited stratification (vertical or lateral). The observed data from the 2007 survey bear this out, hence the model was setup as one-dimensional system (no vertical segmentation/stratification and/or lateral segmentation was deemed necessary). The implication of a one- dimensional system is that observed profile data is depth averaged for purposes of model inputs and comparison of model outputs. The fresh water portion of the Union River enters the estuary at the landward boundary (Leonard Lake Dam) and the tidal flow enters at the ocean boundary (Blue Hill Bay).



A model must be calibrated and verified before it can be used as a predictive tool. In this particular case the 2007 survey was the only data set available for this purpose.

Transport

The Union River model is set up as a hydrodynamic model utilizing DYNHYD. The hydrodynamic model incorporates geometric segment data that was extracted from a three-dimensional Triangulated Irregular Network (TIN) model. The TIN model was developed in coordination with GIS based depth readings,

Unites States Army Corps of Engineers (USACE) dredging maps, GIS based aerial photo interpolation, and tidal stage observations. There was no

observed tidal stage differentiation between the upland boundary and the ocean boundary, therefore the timing of tidal stages throughout the model reach was uniform. The hydrodynamic model incorporates actual tidal stages for a period from June 30 – September 4, 2007 and freshwater inflows at the Ellsworth Dam and Card Brook tributary. Relevant hydrodynamic transport data is ported to the WASP model.

The customary method of calibrating estuary hydraulics is by matching the model output of salinity to measured/observed values. Ocean and freshwater boundary conditions for salinity are established based on actual observed data input into the model. Longitudinal dispersion rates are adjusted until a match with observed salinity data is achieved. The longitudinal dispersion rate for the Union River estuary was calibrated at 100 m^2/sec. The resulting salinity calibration plots are shown in Figure 4 and Figure 5.

Figure 4

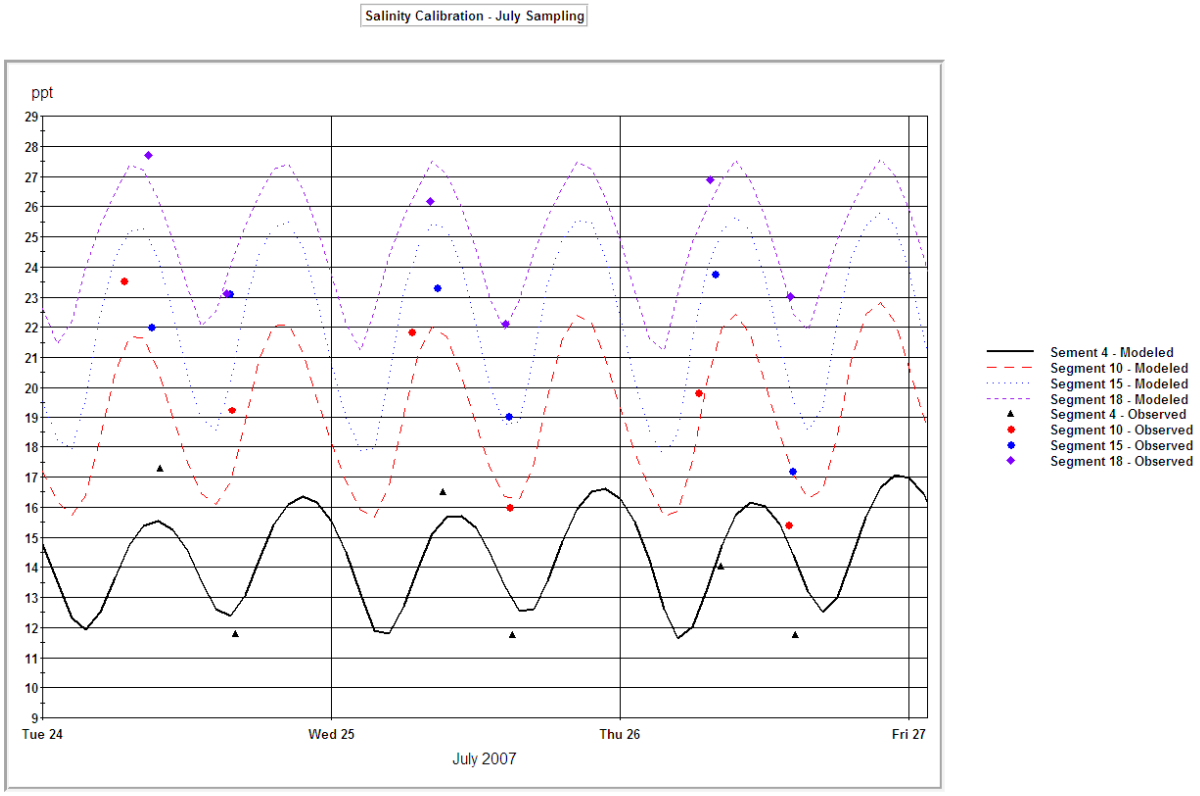
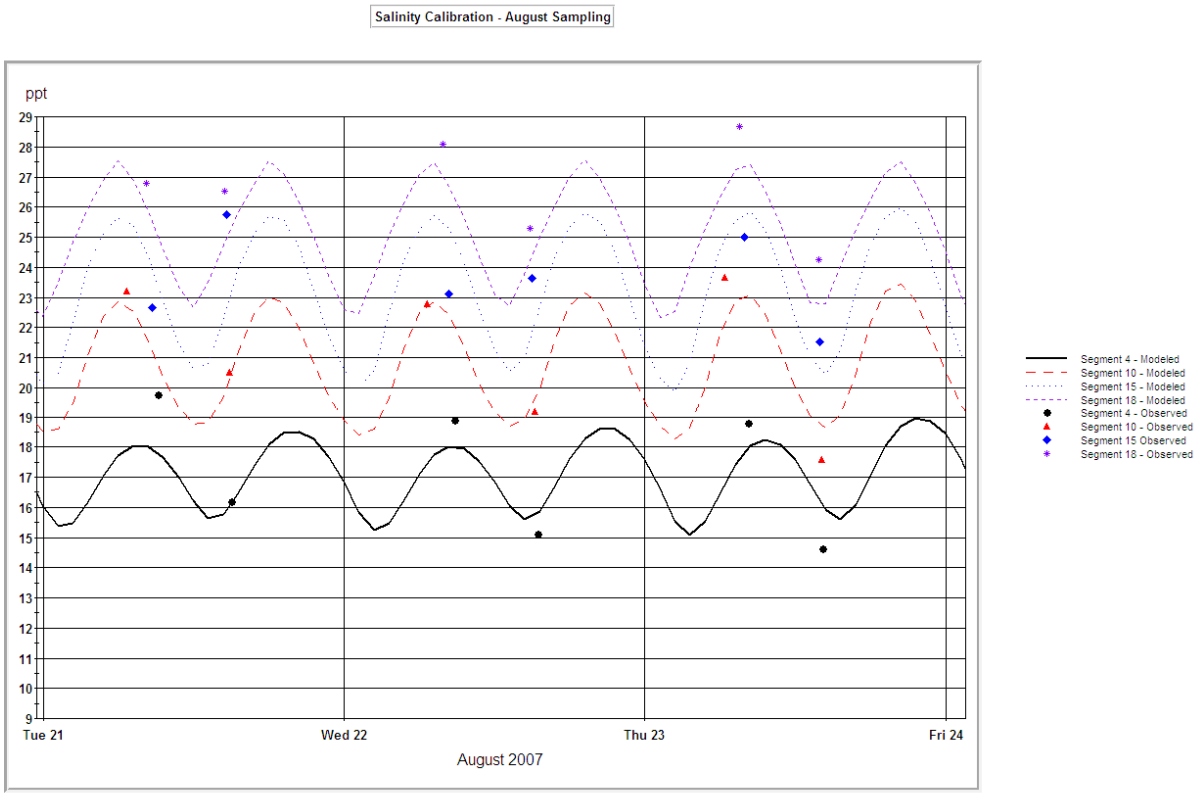


Figure 5



Load Inputs

Many of the model inputs were directly measured/observed during the intensive survey as observed flows and concentrations. The measured inputs include the Union River flow through the dam at head of tide, the flow at the Card Brook tributary sampling location, and the Ellsworth treatment plant discharge. Tidal flows were modeled by DYNHYD. The Union River estuary is predominated by tidal flow, but the existing treatment plant discharge is located in the uppermost portion of the estuary where nearfield dilution/mixing is not optimal.

Boundary conditions and loadings for the model were determined based on average survey results for sample points; UR-02 (Upstream Boundary), UR-04 (Card Brook Tributary), and UR-07/UR-08 (Ocean Boundary). All boundary conditions were assumed to be constant, with the exception of salinity at the ocean boundary. The observed salinity data at the ocean boundary demonstrated a consistent difference between high and low tides (28 and 23 ppt respectively), and this variation was built into the model to aid with calibration. Boundary conditions and loadings are summarized in Table 1.

Table 1: Calibration Model Boundary Conditions/Loadings

	Upstream	Card Brook	Ocean	Ellsworth Discharge
Flow (cfs)	240 July 160 August	9	Variable (DYNHYD)	N/A – Mass Loading
Salinity (ppt)	0	0	28 High Tide 23 Low Tide	0
CBODu (mg/l)	3.4	6.4	2.4	180 kg/day
Ammonia-N (mg/l)	0.01	0.02	0.018	41 kg/day
Organic-N (mg/l)	0.34	0.6	0.52	8.21 kg/day
Nitrate-N (mg/l)	0.005	0.05	0	1.3 kg/day
DO (mg/l)	8.1	8.9	8.1	N/A

*Discharge loadings are modeled as mass loadings in kg/day

Chemical Calibration

The chemical calibration of the water quality model involves adjusting various parameter rates until the model output for various chemical constituents (DO, CBODu, Nutrients) match the observed values from the water quality survey. The following is a brief summary for each constituent and its pertinent rate. A summary table is provided in the Appendix (page 12A) that compares calibrated rates to suggested literature values. In general, good matches were made with all modeled chemical parameters.

CBODu

The final model calibration plots for CBODu are shown in the Appendix (page A14). High and low error bars depict the range of values for the observed data. The final calibration rate for CBOD decay was determined to be 0.1 day^{-1}, which is the lower end of the suggested literature range for estuaries. Laboratory BOD decay rates for ambient samples averaged between 0.04 – 0.05, but natural systems generally exhibit higher decay rates than found in laboratory bottles.

Phytoplankton and Nutrients

The data collected during the surveys showed relatively low chl-a concentrations (maximum of 5.3 ppb with an average of 2.8 ppb) and no evidence of significant supersaturation of DO (chl-a concentrations of approximately 8 ppb or higher are generally indicative of algal blooms in lakes) and/or significant diurnal DO swings. There was also very little indication of significant aquatic plants and/or marsh grasses within the tidal water column area. Consequently, nutrient/plant interactions are not represented in the Union River model.

Nitrogenous interactions were modeled, as they have a direct impact on DO (particularly ammonia nitrification). Ammonia and Organic-Nitrogen were the only constituents with potentially significant impacts on DO concentrations. The calibrated rate for ammonia nitrification was determined to be 0.45 day-1, with a nitrification temperature coefficient of 1.08 (see Appendix page 28). The dissolved organic nitrogen mineralization rate constant calibrated to 0.25, with a dissolved organic nitrogen mineralization temperature coefficient of 1.08 (see Appendix page 28). Both parameter rates are within the range of accepted literature values. The organic nitrogen mineralization rate is higher than might normally be expected, but necessitated by calibration.

Reaeration Rate

Oxygen exchange between the water surface and the atmosphere is represented by the reaeration rate, Ka. Model reaeration rate was calculated internally by WASP using hydrodynamic data from the DYNHYD model. The Union River WASP model utilizes the O'Connor Dobbins formula

$Ka = 3.93 * V^{.5} / D^{1.5}$

where Ka = reaeration rate at $20^{o}C$ (1/day)

V = average tidal velocity in mps

D = average tidal depth, m.

SOD

Sediment oxygen demand rates were measured by USEPA in the summer of 2007 at four locations along the estuary. Unfortunately, two of the four locations were outside the scope of the model segmentation scheme. Additionally, one of the two sampling locations within the model segmentation did not produce statistically relevant data. A uniform SOD rate of 1.5 g/m^2day was used throughout the model segmentation, based the on the single relevant data set that derived a 1.48 g/m^2day rate. The WASP model assigns this rate to each model segment, with segment bottom areas determined hydrodynamically through DYNHYD. The following table demonstrates how the Union River SOD rate compares with other similar studies.

Table 2: SOD Rates

Source	SOD, gm/m2/day		Reference
	ave	range	
Sphaerolitus(10 g-dry wt/m^2)	7	-	Thomann 1972 and Rast and Lee 1978
Municipal Sewage Sludge:			"
Outfall vicinity	4	2-10	"
Downstream of outfall, aged	1.5	1-2	"
Estuarine mud	1.5	1-2	"
Sandy bottom	0.5	0.2-1	"
Mineral soils	0.07	0.05-1	"
Kennebec Estuary	1.2*	0.04-2.5	Maine DEP
Kennebec River	1.4*	0.1-5.6	"
Piscataquis River	1.6*	1.1-2.6	"
Royal Estuary, 2005	1.9*	0.07-10.2	"
Royal Estuary, 1994	2.4*	1.1-3.2	"
Penobscot River	2.5*	1.4-3.4	"
Penobscot Estuary	2.6*	1.7-3.8	"
Mousam Estuary	2.7*	1.9-4.0	"

*average of individual samples, not weighted to bottom area

Temperature

Ambient temperature conditions are incorporated into the Union River Model. Temperatures averaged approximately 2 ^{o}C warmer in July vs. August. There was also a significant temperature gradient of approximately 6 ^{o}C between Segment 1 (warmer) to Segment 19 (cooler), which is also incorporarted into the model.

DO Calibration

The aforementioned calibration efforts produced a very good modeled DO match with observed ambient DO data (see Appendix page 25). The model reproduces the average observed data quite well, but does not predict the full range of observed data values. This is fairly typical when comparing idealized models

with non-ideal natural systems. The model can only assume complete/instantaneous mixing within each model segment as water moves throughout the system. Natural systems are expected to demonstrate a greater degree of spatial variability in this regard.

Sensitivity Analyses

Sensitivity analyses were run on the calibrated model. The sensitivity analyses consisted of varying parameter rates for CBOD decay, SOD, Ammonia Nitrification, and Organic Nitrogen Mineralization. Rates were changed 50% and 150% of the final calibration rates to determine how sensitive the model is to any particular rate constant. The difference in resulting DO concentrations for this particular analysis are as follows:

SOD	0.5	mg/l
CBOD	0.125	mg/l
NH3 Nitrification	0.1	mg/l
Org. Nitrogen Mineralization	0.075	mg/l

Not surprisingly, the model is most sensitive to the SOD rate. The model is not nearly as sensitive to the CBOD and Nitrogen rate constants.

Low Flow Predictive Model[1]

Model Inputs

The calibrated model provides a viable platform for predictive model runs that investigate different scenarios. The calibrated model is a fair representation of critical conditions associated with neap tide, mid-summer temperatures, and low river flow (minimum release).

In order to model potential maximum licensed loading conditions from the treatment plant, BOD5 license limits must be converted to CBODu loads. The ratio of CBODu to BOD5 from the survey (representing existing plant discharge conditions) was used to convert the BOD5 limit. The resulting ratio is 3.8. This was applied to the daily maximum limit of 354 lb/day BOD5, which translates to 590 kg/day CBODu.

There are no nitrogen limitations in Ellsworth's current discharge license. Based on BOD5 data from the survey, it was determined that the plant was operating at approximately 30% of potential daily maximum loading during the survey. This percentage was used to convert observed nitrogenous loadings to potential maximum nitrogenous loadings of 134 kg/day Ammonia, 27 kg/day Organic Nitrogen, and 4.25 kg/day Nitrate.

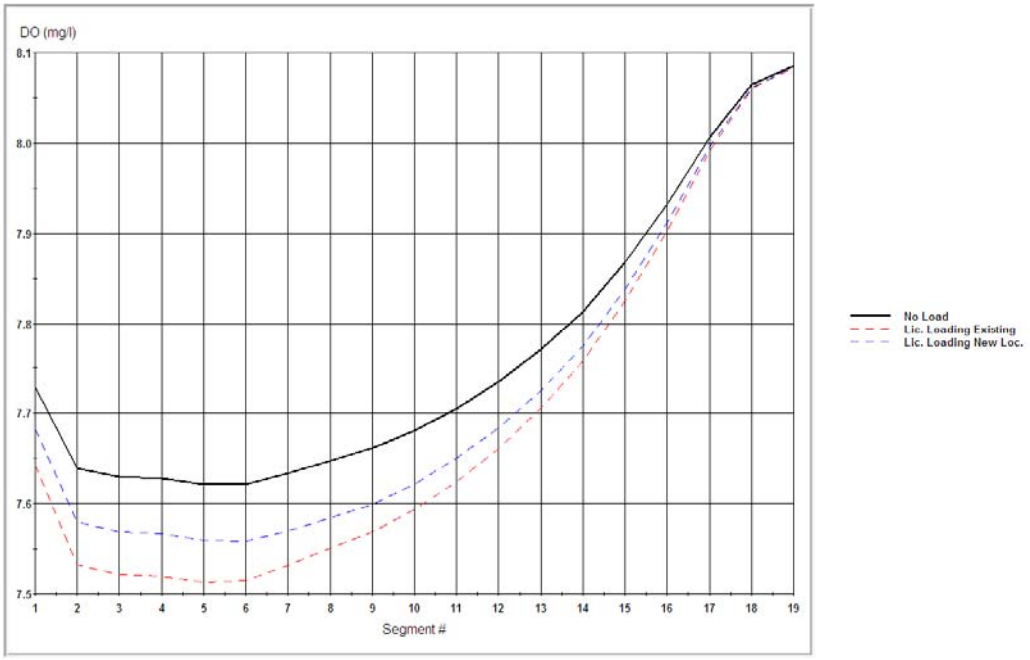
No other predictive adjustments were made to the calibrated model.

Model Run – Current Discharge Permit

Figure 6 shows the results of the predictive model critical DO condition for no loading, licensed loading at existing outfall location (segment 2), and licensed loading at proposed outfall location (segment 10). The critical DO saturations for these respective scenarios are 88.8% (no-loading), 87.5% (existing outfall location), and 88.1% (proposed outfall location). The model predicts an overall DO impact of approximately 0.11 mg/l for the existing outfall at maximum licensed loading conditions. This impact drops to approximately 0.06 mg/l at the proposed outfall location. Neither impact is dramatic, but improvements are predicted at the new location (based primarily on improved hydrodynamic conditions).

[1] The term predictive is used to refer to the model as set up for low flow, near neap tide, high temperature conditions with the discharge at current permit load

Figure 6: Minimum DO, Predictive Model Run Comparison
Critical Conditions



Component Analysis – Permit Load

In order to investigate the relative impact of various factors upon estuary DO a component analysis was conducted. The analysis focused on segment 6, which represents the "sag" point of the predictive model. This component analysis reflects factors relative to maximum licensed loading. Impacts associated with specifc components are reflected in the following table:

Table 3: DO Deficit Component Analysis, Segment 6

Parameter	DO Deficit, mg/l (%)
Boundary: DO	0.40 (38.7)
SOD	0.31 (30.0)
Boundary: CBOD	0.15 (14.5)
Boundary: NBOD	0.075 (7.2)
Discharge: NBOD	0.075 (7.2)
Discharge: CBOD	0.025 (2.4)

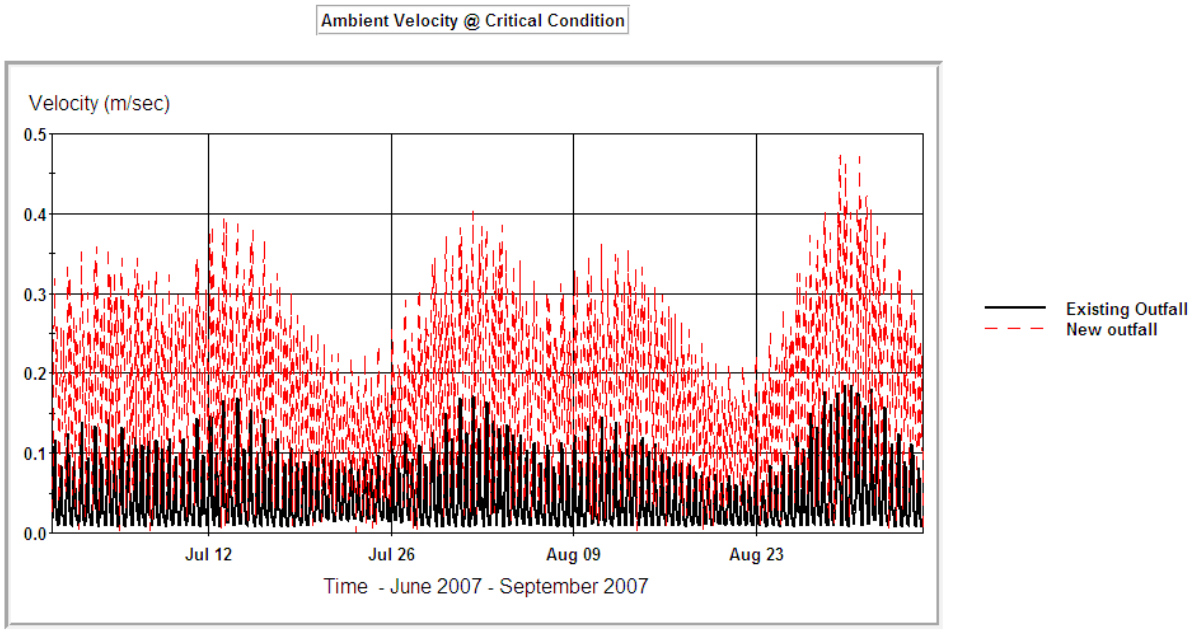
This analysis represents the relative DO impact of Ellsworth's discharge (9.6%) in comparison with other influences. The proposed new discharge location reduces the relative impact of the discharge to approximately 5%.

Discussion

Attainment of DO Standards

The predictive model runs indicate that the class SB DO standard of 85% saturation is attained during critical conditions under maximum permitted discharge loading. Further, measurable improvements are predicted at the proposed new outfall location versus the existing location. Isolated non-attainment readings were observed during the intensive survey (summer 2007). These non-attainment readings are believed to be mostly attributable to the poor hydrodynamic properties at the existing discharge location. The existing discharge is located at probably the singular worst place in the estuary with regard to hydrodynamic conditions. It is located at the point where upstream fresh water first meets seaward saline water. There is very little ambient current at this location during ebb and incoming tides, which greatly reduces the potential for thorough mixing to occur. Poor mixing greatly increases the potential spatial variability with regard to water chemistry. The predictive model assumes complete/instantaneous mixing within each model segment. Based on the observed data results, this is probably not entirely true in the upper part of the estuary. The proposed new discharge location provides significantly improved hydrodynamic properties as compared to the current situation (Figure 6). Much less spatial variability would be expected with the new discharge.

Figure 6:



Discharge Implications

Component analyses indicate that the licensed discharge accounts for about 10% of the DO deficit (at the existing outfall location, and approximately 5% of the DO deficit when the outfall is moved to the new discharge location. The majority of the deficit is due to Boundary Conditions (90%). Ellsworth's discharge is not expected to be a significant obstacle to continued attainment of water quality standards, particularly when considering the improved hydrodynamic conditions associated with the new outfall location.

Recommendations

1. The proposed new outfall location provides significant hydrodynamic improvements to the existing outfall location. Relocating the discharge is recommended.
2. The proposed increase in licensed flow from 0.85 MGD to 1 MGD is not predicted to impact water quality to any degree of significance. Hydrodynamic improvements associated with the new outfall location, and process improvement associated with a new treatment plant are expected to have a far greater positive impact on water quality.
3. NBOD is the greatest DO deficit impact associated with the existing discharge. The new treatment plant design should incorporate a degree of improved treatment in this regard.

Appendix

Laboratory Related Data

Station	Date	River Mile	Qualifier	Time	Chl a © mg/l	BOD60 mg/l	BODu mg/l	NOx-N mg/l	NOx (60) mg/l	NH3-N mg/l	TKN mg/l	Org-N mg/l	TP mg/l	orthoP ug/l	TBOD mg/l	NBOD mg/l	CBODu mg/l	BOD5 mg/l	NOx(60)-NOx mg/l
UR-01	07/24/2007	0.00	AM	6:30		3.2	3.54	0.02	0.07	0.01	0.4	0.39	0.016	4	3.54	0.22	3.32	-	0.05
	07/25/2007	0.00	AM	6:52	0.0037	2.9	3.38	<0.01	0.06	0.01	0.2	0.19	0.013	2	3.38	0.22	3.16	-	0.05
	07/26/2007	0.00	AM	6:35	0.0043	3	3.35	0.01	0.07	0.01	0.3	0.29	0.012	1	3.35	0.26	3.09	-	0.06
	08/21/2007	0.00	AM	6:30	0.0048	3	3.75	0.01	0.08	0.01	0.6	0.59	0.014	1	3.75	0.30	3.45	-	0.07
	08/22/2007	0.00	AM	6:27	0.0045	2.8	3.91	0.01	0.05	U	0.4	0.4	0.014	1	3.91	0.17	3.74	-	0.04
	08/23/2007	0.00	AM	6:22	0.0043	2.4	2.77	0.01	0.07	0.01	0.4	0.39	0.013	1	2.77	0.26	2.51	-	0.06
UR-02	07/24/2007	0.33	AM	7:12	0.0048	3.3	3.46	0.01	0.09	0.01	0.3	0.29	0.019	2	3.46	0.35	3.11	-	0.08
	07/25/2007	0.33	AM	7:18	0.0053	3.2	3.47	<0.01	0.07	0.01	0.3	0.29	0.014	2	3.47	0.26	3.21	-	0.06
	07/26/2007	0.33	AM	7:15	0.0043	3.2	3.62	0.01	0.07	0.01	0.2	0.19	0.013	2	3.62	0.26	3.36	-	0.06
	08/21/2007	0.33	AM	7:05	0.0045	3	3.90	0.01	0.08	0.01	0.4	0.39	0.015	1	3.90	0.30	3.60	-	0.07
	08/22/2007	0.33	AM	6:46	0.004	3.5	4.41	<0.01	0.08	0.01	0.5	0.49	0.015	1	4.41	0.30	4.11	-	0.07
	08/23/2007	0.33	AM	6:43	0.0037	2.3	2.94	<0.01	0.08	0.01	0.4	0.39	0.014	1	2.94	0.30	2.64	-	0.07
UR-03	07/24/2007	0.90	AM	9:45	0.0037	3.5	3.73	<0.01	0.09	0.09	0.3	0.21	0.036	21	3.73	0.35	3.38	-	0.08
	07/25/2007	0.90	AM	9:14	0.0037	3.4	3.63	<0.01	0.11	0.1	0.4	0.3	0.033	18	3.63	0.43	3.20	-	0.1
	07/26/2007	0.90	AM	8:22	0.0024	2.9	3.64	<0.01	<0.01	0.09	0.3	0.21	0.036	18	3.64	ND	3.64	-	ND
	08/21/2007	0.90	AM	9:08	0.0029	2.7	3.28	<0.01	<0.01	0.09	0.4	0.31	0.042	28	3.28	ND	3.28	-	ND
	08/22/2007	0.90	AM	8:47	0.0023	2.7	3.83	<0.01	<0.01	0.09	0.5	0.41	0.036	24	3.83	ND	3.83	-	ND
	08/23/2007	0.90	AM	8:15	0.0019	<2.0	2.36	<0.01	<0.01	0.09	0.6	0.51	0.039	27	2.36	ND	2.36	-	ND
UR-04	07/24/2007	0.85	AM	8:00	0.0027	6	6.63	0.04	0.14	0.02	0.6	0.58	0.018	5	6.63	0.43	6.20	-	0.1
	07/25/2007	0.85	AM	8:15	0.0028	5.1	7.00	0.04	0.1	0.02	0.7	0.68	0.015	4	7.00	0.26	6.74	-	0.06
	07/26/2007	0.85	AM	7:45	0.002	5.3	6.64	0.06	0.16	0.03	0.6	0.57	0.018	5	6.64	0.43	6.20	-	0.1
	08/21/2007	0.85	AM	7:20	0.0019	3.7	6.90	0.04	0.08	0.02	0.6	0.58	0.011	4	6.90	0.17	6.73	-	0.04
	08/22/2007	0.85	AM	7:18	0.0016	3.6	5.59	0.06	0.12	0.02	0.8	0.78	0.011	4	5.59	0.26	5.33	-	0.06
	08/23/2007	0.85	AM	7:01	0.0019	3.1	4.78	0.05	1	0.02	0.6	0.58	0.011	3	4.78	4.11	0.67	-	0.95
UR-05	07/25/2007	1.85	Bottom	7:02	0.0027	3.2	3.68	<0.01	<0.01	0.06	0.2	0.14	0.029	15	3.68	ND	3.68	-	ND
	07/26/2007	1.85	Bottom	6:37	0.0021	3.1	3.69	<0.01	<0.01	0.09	0.5	0.41	0.039	21	3.69	ND	3.69	-	0.08
	08/21/2007	1.85	Bottom	7:00	0.002	3.1	2.60	<0.01	<0.01	0.05	0.5	0.45	0.031	20	2.60	ND	2.60	-	ND
	08/22/2007	1.85	Bottom	6:55	0.0021	2.1	2.79	<0.01	<0.01	0.04	0.6	0.56	0.031	18	2.79	ND	2.79	-	ND
	08/23/2007	1.85	Bottom	6:35	0.0021	<2.0	1.77	<0.01	<0.01	0.04	0.6	0.56	0.033	18	1.77	ND	1.77	-	ND
	07/24/2007	1.85	PM	11:45	0.0037	3.4	3.65	<0.01	0.09	0.08	0.4	0.32	0.035	18	3.65	ND	3.65	-	ND
	07/25/2007	1.85	PM	11:35	0.0027	3.1	3.25	<0.01	<0.01	0.08	0.3	0.22	0.03	15	3.25	ND	3.25	-	ND
	07/26/2007	1.85	PM	11:35	-	3.4	3.96	<0.01	<0.01	0.08	0.3	0.22	0.032	14	3.96	ND	3.96	-	ND
	08/21/2007	1.85	PM	12:00	0.002	2.6	3.01	<0.01	<0.01	0.07	0.4	0.33	0.036	22	3.01	ND	3.01	-	ND
	08/22/2007	1.85	PM	11:42	0.0024	2.7	3.20	<0.01	<0.01	0.08	0.4	0.32	0.034	21	3.20	ND	3.20	-	ND
	08/23/2007	1.85	PM	11:44	0.0021	2.3	1.93	<0.01	<0.01	0.09	0.6	0.51	0.038	26	1.93	ND	1.93	-	ND
	07/24/2007	1.85	AM	6:45	0.0035	3.2	3.19	<0.01	<0.01	0.06	0.4	0.34	0.03	14	3.19	ND	3.19	-	ND
	07/25/2007	1.85	AM	6:40	0.003	3	3.25	<0.01	<0.01	0.06	0.3	0.24	0.028	12	3.25	ND	3.25	-	ND
	07/26/2007	1.85	AM	6:28	0.0024	3.1	3.62	<0.01	<0.01	0.09	0.4	0.31	0.031	18	3.62	ND	3.62	-	ND
	08/21/2007	1.85	AM	6:40	0.0021	8.74	4.65	<0.01	<0.01	0.07	0.5	0.43	0.036	20	4.65	ND	4.65	-	ND
	08/22/2007	1.85	AM	6:38	0.0021	2.5	2.99	<0.01	<0.01	0.06	0.7	0.64	0.031	19	2.99	ND	2.99	-	ND
	08/23/2007	1.85	AM	6:20	0.0021	<2.0	1.95	<0.01	<0.01	0.06	0.4	0.34	0.032	21	1.95	ND	1.95	-	ND
UR-06	07/24/2007	2.75	AM	9:01	0.0029	3.2	3.46	<0.01	<0.01	0.05	0.3	0.25	0.026	11	3.46	ND	3.46	-	ND
	07/25/2007	2.75	AM	8:44	0.0027	2.7	2.95	<0.01	<0.01	0.05	0.2	0.15	0.024	11	2.95	ND	2.95	-	ND
	07/26/2007	2.75	AM	7:55	0.0045	3.2	3.34	<0.01	<0.01	0.04	0.4	0.36	0.025	10	3.34	ND	3.34	-	ND
	08/21/2007	2.75	AM	8:40	0.0019	2.4	2.80	<0.01	<0.01	0.06	0.3	0.24	0.032	19	2.80	ND	2.80	-	ND
	08/22/2007	2.75	AM	8:22	0.0018	2.4	2.88	<0.01	<0.01	0.06	0.4	0.34	0.031	18	2.88	ND	2.88	-	ND
	08/23/2007	2.75	AM	7:57	0.0022	<2.0	1.59	<0.01	<0.01	0.04	0.4	0.36	0.027	16	1.59	ND	1.59	-	ND
UR-07	07/25/2007	3.50	Bottom	8:25	0.004	2.6	2.62	<0.01	<0.01	0.02	0.4	0.38	0.021	3	2.62	ND	2.62	-	ND
	07/26/2007	3.50	Bottom	7:35	0.0029	2.5	2.44	<0.01	<0.01	0.02	0.7	0.68	0.019	3	2.44	ND	2.44	-	ND
	08/22/2007	3.50	Bottom	8:08	0.0022	2.3	1.83	<0.01	<0.01	0.02	0.6	0.58	0.026	14	1.83	ND	1.83	-	ND
	08/23/2007	3.50	Bottom	7:45	0.0019	<2.0	1.20	<0.01	<0.01	0.02	0.7	0.68	0.028	13	1.20	ND	1.20	-	ND
	07/24/2007	3.50	AM	8:45	0.0028	3.1	3.14	<0.01	<0.01	0.03	0.5	0.47	0.028	12	3.14	ND	3.14	-	ND
	07/25/2007	3.50	AM	8:14	0.0037	3	3.01	<0.01	<0.01	0.02	0.6	0.58	0.024	6	3.01	ND	3.01	-	ND
	07/26/2007	3.50	AM	7:28	0.0037	2.2	2.20	<0.01	<0.01	0.01	0.4	0.39	0.02	2	2.20	ND	2.20	-	ND
	08/21/2007	3.50	AM	8:15	0.0015	<2.0	1.86	<0.01	<0.01	0.03	0.5	0.47	0.031	20	1.86	ND	1.86	-	ND
	08/22/2007	3.50	AM	7:53	0.0024	<2.0	1.78	<0.01	<0.01	0.03	0.6	0.57	0.026	15	1.78	ND	1.78	-	ND
	08/23/2007	3.50	AM	7:33	0.0025	2.1	2.10	<0.01	<0.01	0.02	0.5	0.48	0.028	12	2.10	ND	2.10	-	ND
UR-08	07/24/2007	4.70	AM	8:30	0.0021	2.3	2.30	<0.01	<0.01	0.01	0.6	0.59	0.018	3	2.30	ND	2.30	-	ND
	07/25/2007	4.70	AM	7:47	0.0022	<2.0	1.94	<0.01	<0.01	0.01	0.6	0.59	0.016	1	1.94	ND	1.94	-	ND
	07/26/2007	4.70	AM	7:13	0.0027	2	2.00	<0.01	<0.01	0.01	0.5	0.49	0.015	1	2.00	ND	2.00	-	ND
	08/21/2007	4.70	AM	7:55	0.0036	2	1.90	<0.01	<0.01	0.01	0.4	0.39	0.026	11	1.90	ND	1.90	-	ND
	08/22/2007	4.70	AM	7:34	0.0021	2.2	1.85	<0.01	<0.01	0.01	0.8	0.79	0.022	10	1.85	ND	1.85	-	ND
	08/23/2007	4.70	AM	7:07	0.0024	<2.0	1.42	<0.01	<0.01	0.01	0.7	0.69	0.023	9	1.42	ND	1.42	-	ND
UR-09	07/24/2007	5.70	AM	7:49	0.0024	2.4	2.26	<0.01	<0.01	0.01	0.4	0.39	0.02	3	2.26	ND	2.26	-	ND
	07/25/2007	5.70	AM	7:20	0.002	<2.0	1.91	<0.01	<0.01	0.01	0.5	0.49	0.021	2	1.91	ND	1.91	-	ND
	07/26/2007	5.70	AM	6:51	U	<2.0	1.92	<0.01	<0.01	0.01	0.4	0.39	0.014	1	1.92	ND	1.92	-	ND
	08/21/2007	5.70	AM	7:20	0.0036	2.1	2.10	<0.01	<0.01	0.01	0.8	0.79	0.029	12	2.10	ND	2.10	-	ND
	08/22/2007	5.70	AM	7:16	0.0024	<2.0	1.75	<0.01	<0.01	0.01	0.9	0.89	0.022	10	1.75	ND	1.75	-	ND
	08/23/2007	5.70	AM	6:52	0.002	<2.0	1.20	<0.01	<0.01	0.01	0.6	0.59	0.023	9	1.20	ND	1.20	-	ND
WWTP	07/24/2007	0.70	Effluent		-	97	175.74	1.4	24	24	29	5	5.5	4800	-	97.86	77.88	39	22.6
	07/25/2007	0.70	Effluent		-	170	172.617	1.1	24	24	30	6	4.8	3900	-	99.16	73.46	41	22.9
	07/26/2007	0.70	Effluent		-	250	299.54	0.53	26	25	28	3	6.1	5200	-	110.29	189.25	-	25.47
	08/21/2007	0.70	Effluent		-	160	208.7	0.52	27	31	37	6	8.8	8300	-	114.66	94.04	29	26.48
	08/22/2007	0.70	Effluent		-	140	173.58	0.87	-	22	28	6	3.3	2900	-	-	-	14	-
	08/23/2007	0.70	Effluent		-	210	252.35	0.48	28	29	34	5	8.3	7500	-	119.16	133.19	26	27.52

Union River Intensive Survey
Leonard Lake Dam to Tupper Ledge
Maine DEP / Woodard & Curran / Ellsworth WWTP

Jul 24, 2007 Day 1 of 3 day survey

			Morning Run								Afternoon Run							
Station	Location	GIS	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Model Comment	Note	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Secchi Depth (m)*	Note
UR-01A	Just below dam at Leonard Lake	N 44.54391, W 068.42870	6:30 AM	<1 (mid depth)	8.3	95.3%	22.2	0.0	Uniform/Fresh	Flow ~160cfs**	1:34 PM	<1 (mid depth)	8.4	97.2%	22.6	0.0	>1.0	Flow ~160cfs**
UR-02	Main Street Bridge	N 44.54087, W 068.42591	7:12 AM	0	7.9	90.7%	22.2	0.0	Uniform/Fresh		1:45 PM		8.4	97.2%	22.6	0.0	-	
				1	8.0	91.8%	22.2	0.0					8.3	96.0%	22.6	0.0		
				2	7.8	89.6%	22.2	0.0										
UR-03	Indian Point	N 44.53120, W 068.41776	9:45 AM	0	8.0	92.7%	21.7	3.3	Upper 0.5 meter fresh - remainder is salt		4:00 PM	0	8.3	99.4%	24.0	1.5	3.0	
				1	7.2	85.0%	20.0	12.0				1	8.3	100.8%	23.9	4.1		
				2	7.2	86.7%	17.6	23.1				2	8.0	95.6%	18.8	18.0		
				3	7.2	86.5%	17.2	24.1				3	7.4	89.3%	17.6	23.6		
UR-04	Card Brook (bridge)	N 44.52115, W 068.42463	8:00 AM	<1 (mid depth)	9.0	97.8%	19.4	0.0	Uniform/Fresh	***	1:56 PM	<1 (mid depth)	8.4	95.7%	21.8	0.0	-	
UR-05A	Whittaker Point (core)	N 44.52063, W 068.42456	6:44 AM	0	7.8	89.9%	20.0	7.9	Upper 0.5 meter fresh - remainder is salt	[PM water samples collected near 11:45 AM]	3:43 PM	0	8.5	103.8%	22.6	9.3	-	
				1	8.0	95.3%	17.7	21.0				1	8.3	102.5%	22.2	12.6		
				2	7.8	93.5%	16.8	25.0				2	7.6	91.2%	17.5	23.0		
				3	8.3	99.1%	16.3	26.0				3	7.7	92.5%	16.7	25.7		
				4	8.3	99.1%	16.0	27.0				4	8.0	95.3%	16.3	25.6		
				5	8.4	99.7%	15.7	27.0										
				6	8.6	102.1%	15.7	27.0										
				7	8.5	101.1%	15.7	27.3										
UR-05B	Whittaker Point (bottom)	N 44.52063, W 068.42456	-							Messenger lost to river; unable to sample bottom								
UR-06	Ginny Mae Way	N 44.50889, W 068.42902	9:01 AM	0	7.9	91.5%	20.8	6.2	Upper 0.5 meter fresh - remainder is salt		3:30 PM	0	8.3	101.5%	20.9	15.0	3.8 (PM - sketchy; scoping, choppy)	scoping likely
				1	7.6	89.6%	19.0	15.0				1	8.2	99.8%	19.8	17.8		
				2	8.1	97.0%	16.9	24.5				2	7.9	95.7%	18.1	22.5		
				3	8.4	100.4%	16.3	26.1				3	8.1	97.1%	16.4	26.4		
				4	8.6	102.6%	15.8	27.5				4	8.1	96.7%	16.1	26.7		
												5	8.0	95.5%	16.1	26.7		
												6	8.1	96.9%	16.2	26.7		
UR-07A	Spindle Point (core)	N 44.50086, W 068.43159	8:45 AM	0	8.7	103.6%	17.1	23.0	Upper 0.5 meter fresh - remainder is salt		3:18 PM	0	8.8	108.9%	20.5	18.4	2.7 (PM - sketchy; very choppy)	
				1	8.8	104.9%	15.6	28.0				1	8.8	108.9%	20.0	20.0		
				2	9.0	106.7%	15.2	28.4				2	8.6	106.2%	18.8	23.5		
				3	9.0	105.8%	14.6	29.0				3	9.0	109.2%	17.2	25.7		
				4	8.8	102.8%	14.3	29.0				4	9.5	114.4%	16.1	28.0		
UR-07B	Spindle Point (bottom)	N 44.50086, W 068.43159	-							Messenger lost to river; unable to sample bottom								
UR-08	Weymouth Point	N 44.48275, W 068.43026	8:30 AM	0	8.9	108.4%	17.6	25.0	Upper 0.5 meter fresh - remainder is salt		3:00 PM	0	8.9	111.5%	18.6	26.6	Unsafe for Secchi reading attempt	
				1	9.3	113.6%	16.7	28.5				1	8.9	111.2%	18.3	27.0		
				2	9.6	116.1%	16.1	28.8				2	9.2	113.5%	17.4	27.9		
				3	10.1	117.5%	14.0	29.3				3	9.6	113.3%	15.1	28.0		
				4	10.1	115.5%	13.1	29.5										
UR-09	Tupper Ledge	N 44.47217, W 068.43949	7:49 AM	0	8.8	109.1%	17.9	27.0	Upper 0.5 meter fresh - remainder is salt		2:30 PM	0	9.1	123.6%	22.6	27.7	Unsafe for Secchi reading attempt	
				1	9.1	111.6%	17.1	27.9				1	9.1	114.3%	18.4	27.7		
				2	9.5	115.5%	16.3	29.0				2	9.0	112.9%	18.2	28.0		
				3	9.8	115.9%	14.8	29.3				3	9.5	114.8%	16.0	29.0		
				4	10.0	116.3%	14.0	29.3				4	9.9	117.7%	15.1	29.2		
				5	10.1	115.5%	13.1	29.5				5	10.0	115.0%	13.4	29.5		
				6	10.1	114.7%	12.8	29.5				6	9.5	106.1%	12.0	29.4		
				7	9.5	105.2%	11.6	29.5				7	9.4	104.6%	11.8	29.5		
				8	9.2	101.7%	11.5	29.6				8	9.2	102.1%	11.7	29.5		
				9	8.6	94.1%	11.0	29.6				9	9.3	103.2%	11.7	29.5		
				10	8.2	89.1%	10.7	29.6				10	9.2	100.8%	11.2	29.2		
				11^	8.6	93.1%	10.5	29.7										
DUPR1	UR-01A (Just below dam at Leonard Lake)	N 44.54391, W 068.42870	6:45 AM	<1 (mid depth)	8.4	96.4%	22.2	0.0										
DUPR2	UR-09 (Tupper Ledge)	N 44.47217, W 068.43949	8:00 AM	0	8.8	109.2%	18.0	26.9										
				1	9.2	113.3%	17.3	27.9										
				2	9.2	113.0%	16.9	28.7										
				3	9.9	117.1%	14.9	29.0										
				4	10.1	117.1%	13.8	29.4										
				5	9.9	112.0%	12.6	29.5										

Samplers: Jim Sohns (DEP), Clarissa Trasko (DEP), Laurel Grosjean (W&C), Travis Hamel (W&C), Mike Harris (Ells WWTP), Ray Robidoux (Ells WWTP)
* All Secchi depth recorded as (>) indicates that Secchi disk was visible on the river bottom.
** Estimated flow data from PPL-Maine's Scott Hall.
*** FLOW ~9.6cfs [culv. Width 13ft10in; length of displ 30ft; ave. depth 17.3in; ave. time to travel displ 62.5sec (3 total trials, eddied trial dropped)]
^ Depth greater than 11m, but cord limits reached.
Ellsworth (elevation ~32m) P = 1atm used for conversion from DO - ppm to DO - % saturation

Union River Intensive Survey
Leonard Lake Dam to Tupper Ledge
Maine DEP / Woodard & Curran / Ellsworth WWTP

Jul 25, 2007 Day 2 of 3 day survey

			Morning Run								Afternoon Run						
Station	Location	GIS	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Secchi Depth (m)*	Note	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Note
UR-01A	Just below dam at Leonard Lake	N 44.54391, W 068.42870	6:52 AM	<1 (mid depth)	8.0	92.4%	22.5	0.0	>1*	Flow ~160cfs**	12:34 PM	<1 (mid depth)	8.0	93.8%	23.3	0.0	Flow ~160cfs**
UR-02	Main Street Bridge	N 44.54087, W 068.42591	7:18 AM	0	7.9	91.2%	22.5	0.0			12:59 PM	0	8.0	93.6%	23.2	0.0	
				1	7.8	90.1%	22.5	0.0				1	8.1	94.6%	23.1	0.0	
				2	7.8	90.1%	22.5	0.0									
UR-03	Indian Point	N 44.53120, W 068.41776	9:14 AM	0	7.6	89.1%	22.7	2.0	3.7	Depth 4.6m	3:00 PM	0	8.4	101.5%	24.5	1.4	
				1	6.8	82.0%	20.6	13.7				1	8.4	100.6%	23.9	1.8	
				2	6.8	82.1%	18.3	21.3				2	7.2	87.9%	19.2	20.3	
				3	6.8	82.4%	18.1	22.5				3	6.5	78.5%	17.6	23.6	
				4	6.5	78.5%	17.8	23.0									
UR-04	Card Brook (bridge)	N 44.52115, W 068.42463	8:15 AM	<1 (mid depth)	8.8	95.8%	19.5	0.0		***	12:40 PM	<1 (mid depth)	8.3	97.1%	23.2	0.0	
UR-05A	Whittaker Point (core)	N 44.52063, W 068.42456	6:40 AM	0	7.2	83.8%	20.0	9.5	3.75	Depth 6m [PM water samples collected at 11:35 AM]	2:49 PM	0	7.9	97.9%	24.4	6.1	
				1	7.1	86.4%	18.8	21.0				1	7.8	94.7%	22.7	8.0	
				2	7.0	85.9%	18.3	24.0				2	7.1	86.8%	19.1	20.8	
				3	6.8	83.5%	18.2	24.5				3	6.9	84.1%	18.5	22.2	
				4	6.8	83.3%	18.1	24.5									
				5	6.7	82.2%	18.1	24.7									
				6	6.7	82.4%	18.2	24.8									
UR-05B	Whittaker Point (bottom)	N 44.52063, W 068.42456	7:02 AM							sampled at 5m							
UR-06	Ginny Mae Way	N 44.50889, W 068.42902	8:44 AM	0	7.3	86.0%	20.4	10.3	4.25	Depth 6.9m	2:42 PM	0	8.0	99.8%	24.0	8.5	
				1	7.3	89.0%	18.8	21.3				1	7.4	89.6%	21.3	12.1	
				2	7.2	89.0%	18.4	25.0				2	7.3	89.0%	18.7	21.6	
				3	7.3	90.2%	18.1	25.9				3	7.3	89.3%	18.4	23.2	
				4	7.3	90.7%	18.1	26.7				4	7.2	88.3%	18.3	24.0	
				5	7.1	88.1%	18.0	26.9				5	7.0	86.1%	18.2	24.7	
				6	7.1	88.2%	18.0	27.1									
UR-07A	Spindle Point (core)	N 44.50086, W 068.43159	8:14 AM	0	7.6	92.3%	18.6	21.3	3.8	Depth 5.1m	2:30 PM	0	8.1	101.0%	22.6	13.0	
				1	7.7	94.8%	18.3	24.6				1	7.7	93.7%	19.1	20.0	
				2	8.3	103.4%	18.0	27.5				2	7.4	91.3%	18.5	24.4	
				3	8.0	99.6%	17.9	27.7				3	8.2	101.9%	18.5	25.5	
				4	8.2	102.0%	17.8	27.9				4	8.8	109.9%	18.1	27.6	
				5	8.0	99.6%	17.8	28.0									
UR-07B	Spindle Point (bottom)	N 44.50086, W 068.43159	8:25 AM							sampled at 4m							
UR-08	Weymouth Point	N 44.48275, W 068.43026	7:47 AM	0	8.1	100.2%	18.1	26.0	>5*	Depth 4.7m	2:03 PM	0	8.5	109.5%	20.8	24.3	
				1	8.5	105.8%	17.7	28.3				1	8.7	111.7%	20.6	24.4	
				2	8.7	107.5%	17.3	28.5				2	9.5	116.5%	17	28.2	
				3	9.0	109.8%	16.6	28.6				3	9.9	120.4%	16.5	28.4	
				4	8.9	108.2%	16.4	28.7									
				5	8.4	100.2%	15.8	27.5									
UR-09	Tupper Ledge	N 44.47217, W 068.43949	7:20 AM	0	8.1	99.2%	17.6	26.0	5.05	Depth 13.9m	1:43 PM	0	8.5	109.0%	20.0	26.1	
				1	8.3	103.6%	18.0	27.9				1	8.6	108.2%	18.7	27.0	
				2	8.6	105.8%	17.0	28.7				2	9.4	116.1%	17.4	28.0	
				3	8.8	106.4%	16.1	28.8				3	9.5	115.2%	16.3	28.6	
				4	8.9	107.0%	15.8	28.8				4	9.8	116.7%	15.3	28.8	
				5	9.1	108.3%	15.2	29.0				5	9.7	115.2%	15.2	28.8	
				6	9.1	106.4%	14.3	29.2				6	9.9	115.8%	14.4	28.9	
				7	9.4	107.8%	13.3	29.3				7	9.9	114.2%	13.7	29.0	
				8	8.0	88.2%	11.4	29.5				8	9.9	112.7%	13.0	29.2	
				9	7.7	83.5%	10.6	29.6				9	9.8	110.9%	12.7	29.2	
				10	7.6	81.9%	10.3	29.6				10	9.6	107.5%	12.2	29.2	
				11^	7.5	80.6%	10.2	29.6				11	8.5	92.7%	10.9	29.4	
DUPR1	UR-02 (Main Street Bridge)	N 44.54087, W 068.42591	7:36 AM	0	7.9	91.2%	22.5	0.0									
				1	7.9	91.2%	22.5	0.0									
				2	8.0	92.4%	22.5	0.0									
DUPR2	UR-08 (Weymouth Point)	N 44.48275, W 068.43026	8:04 AM	0	8.1	100.2%	18.1	26.0									

Samplers: Jim Sohns (DEP), Matt Young (DEP), Laurel Grosjean (W&C), Travis Hamel (W&C), Mike Harris (Ells WWTP), Ray Robidoux (Ells WWTP)
* All Secchi depth recorded as (>) indicates that Secchi disk was visible on the river bottom.
** Estimated flow data from PPL-Maine's Scott Hall.
*** FLOW ~10cfs [culv. Width 13ft10in; length of displ 30ft; ave. depth 17.3in; ave. time to travel displ 60sec (3 total trials, eddied trial dropped)]
^ Depth greater than 11m, but cord limits reached.
Ellsworth (elevation ~32m) P = 1atm used for conversion from DO - ppm to DO - % saturation

Union River Intensive Survey
Leonard Lake Dam to Tupper Ledge
Maine DEP / Woodard & Curran / Ellsworth WWTP

Jul 26, 2007 Day 3 of 3 day survey

			Morning Run								Afternoon Run						
Station	Location	GIS	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Secchi Depth (m)*	Note	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Note
UR-01A	Just below dam at Leonard Lake	N 44.54391, W 068.42870	6:35 AM	<1 (mid depth)	7.8	91.1%	23.1	0.0	>1*	Flow ~160cfs**	12:45 PM	<1 (mid depth)	7.8	94.2%	24.9	0.0	Flow ~160cfs** [yet higher-than-AM flow from dam was observed]
UR-02	Main Street Bridge	N 44.54087, W 068.42591	7:15 AM	0	7.7	89.8%	23.0	0.0			12:41 PM	0	7.8	94.0%	24.8	0.0	
				1	7.8	90.9%	23.0	0.0				1	7.9	95.1%	24.7	0.0	
				2	7.7	89.8%	23.0	0.0				2	7.8	94.0%	24.8	0.0	
UR-03	Indian Point	N 44.53120, W 068.41776	8:22 AM	0	7.6	88.9%	22.9	1.0	3.9		2:37 PM	0	7.9	97.6%	25.6	1.7	
				1	6.9	81.8%	21.6	7.4				1	7.9	96.9%	24.7	3.3	
				2	6.4	79.0%	20.0	19.5				2	6.7	82.4%	19.8	19.6	
				3	6.4	79.3%	19.8	20.9				3	5.6	68.4%	18.6	22.4	
				4	6.4	79.4%	19.7	21.4									
UR-04	Card Brook (bridge)	N 44.52115, W 068.42463	7:45 AM	<1 (mid depth)	8.5	93.5%	20.0	0.0		failed to remember flow measrmnts	12:34 PM	<1 (mid depth)	7.5	88.1%	23.4	0.0	
UR-05A	Whittaker Point (core)	N 44.52063, W 068.42456	6:28 AM	0	7.2	85.0%	21.1	8.4	3.65	[PM water samples collected at 11:35 AM]	2:00 PM	0	7.5	93.2%	24.9	4.9	
				1	6.8	83.9%	20.7	17.2				1	7.3	89.9%	23.5	7.9	
				2	6.5	81.3%	20.0	21.9				2	7.1	87.6%	20.4	18.2	
				3	6.3	78.9%	19.7	22.9									
				4	6.3	78.7%	19.6	22.8									
				5	6.3	78.7%	19.6	22.8									
				6	6.1	76.2%	19.6	22.8									
UR-05B	Whittaker Point (bottom)	N 44.52063, W 068.42456	6:37 AM							sampled at 4m							
UR-06	Ginny Mae Way	N 44.50889, W 068.42902	7:50 AM	0	7.0	84.6%	21.1	12.4	4.15		2:19 PM	0	7.3	91.0%	24.0	8.5	
				1	7.2	90.8%	20.3	22.3				1	7.3	90.5%	23.4	9.4	
				2	7.5	94.7%	19.9	23.8				2	7.0	86.8%	21.3	16.2	
				3	7.5	96.0%	19.7	26.7				3	6.8	84.9%	20.3	20.5	
				4	7.5	96.0%	19.6	26.9				4	6.9	87.1%	20.0	23.4	
				5	7.6	97.1%	19.5	27.0									
				6	7.5	96.1%	19.6	27.2									
UR-07A	Spindle Point (core)	N 44.50086, W 068.43159	7:28 AM	0	7.6	96.4%	20.1	23.8	4.2		2:09 PM	0	7.1	89.4%	20.6	21.1	
				1	8.1	104.2%	19.9	26.8				1	7.0	88.3%	20.5	21.6	
				2	8.2	105.4%	19.8	27.0				2	7.2	91.0%	20.1	23.3	
				3	8.2	105.0%	19.4	27.7				3	7.2	91.1%	19.9	24.0	
				4	8.3	106.0%	19.2	27.8				4	7.8	98.5%	19.5	25.1	
				5	8.2	103.7%	18.6	28.1									
UR-07B	Spindle Point (bottom)	N 44.50086, W 068.43159	7:35 AM							sampled at 4m							
UR-08	Weymouth Point	N 44.48275, W 068.43026	7:13 AM	0	8.0	100.5%	18.9	26.0	>4.3*		1:55 PM	0	8.0	102.9%	21.9	20.6	
				1	8.4	107.5%	19.3	27.9				1	8.4	109.3%	21.8	22.8	
				2	8.8	110.4%	17.9	29.0				2	9.3	118.8%	19.5	27.0	
				3	9.2	112.3%	16.6	28.7				3	9.8	119.5%	16.8	27.8	
				4	9.4	112.6%	15.6	28.9									
				5	9.0	107.5%	15.5	28.7									
UR-09	Tupper Ledge	N 44.47217, W 068.43949	6:51 AM	0	8.3	106.8%	19.9	27.0	4.9		1:38 PM	0	8.2	109.0%	22.3	25.0	
				1	8.4	107.8%	19.4	28.1				1	8.2	108.6%	22.0	25.3	
				2	9.1	112.9%	17.4	28.8				2	8.7	111.3%	19.4	27.6	
				3	9.4	113.8%	16.1	28.9				3	8.9	110.8%	17.8	28.1	
				4	9.4	112.0%	15.3	29.0				4	9.1	110.4%	16.4	28.3	
				5	9.5	111.6%	14.5	29.2				5	9.3	109.7%	14.9	28.6	
				6	9.7	112.6%	13.9	29.3				6	9.6	112.3%	14.5	28.6	
				7	9.6	108.6%	12.6	29.5				7	9.2	104.5%	13.0	28.8	
				8	9.3	103.4%	11.8	29.5				8	8.7	97.0%	12.1	28.9	
				9	8.6	94.7%	11.3	29.6				9	8.5	93.2%	11.3	28.9	
				10	8.6	94.3%	11.1	29.6				10	8.3	90.5%	11.0	29.0	
				11^	8.2	89.3%	10.8	29.6				11	8.1	87.8%	10.8	28.9	
DUPR1	UR-04 (Card Brook)	N 44.52115, W 068.42463	8:11 AM	<1 (mid depth)	8.5	93.9%	20.2	0.0									
DUPR2	UR-06 (Ginny Mae Way)	N 44.50889, W 068.42902	8:02 AM	0			21.3	12.3									

Samplers: Jim Sohns (DEP), Matt Young (DEP), Laurel Grosjean (W&C), Travis Hamel (W&C), Mike Harris (Ells WWTP), Ray Robidoux (Ells WWTP)
* All Secchi depth recorded as (>) indicates that Secchi disk was visible on the river bottom.
** Estimated flow data from PPL-Maine's Scott Hall.
^ Depth greater than 11m, but cord limits reached.
Ellsworth (elevation ~32m) P = 1atm used for conversion from DO - ppm to DO - % saturation

Union River Intensive Survey
Leonard Lake Dam to Tupper Ledge
Maine DEP / Woodard & Curran / Ellsworth WWTP

Aug 21, 2007 Day 1 of 3 day survey

			Morning Run								Afternoon Run						
Station	Location	GIS	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Secchi Depth (m)*	Note	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Note
UR-01A	Just below dam at Leonard Lake	N 44.54391, W 068.42870	6:30 AM	<1 (mid depth)	8.0	89.0%	20.6	0.0	>1.0		1:15 PM	<1 (mid depth)	8.7	96.8%	20.6	0.0	
UR-02	Main Street Bridge	N 44.54087, W 068.42591	7:05 AM	0	8.0	89.0%	20.6	0.0	-		1:30 PM	0	8.8	101.2%	22.3	0.0	
				1	8.0	89.2%	20.7	0.0				1	8.8	101.2%	22.3	0.0	
				2	7.6	81.8%	18.9	0.0								0.0	
UR-03	Indian Point	N 44.53120, W 068.41776	9:08 AM	0	8.0	90.9%	19.6	6.8	>3.5		3:00 PM	0	8.6	101.7%	23.0	2.5	
				1	8.0	94.4%	17.3	20.8				1	8.3	99.6%	20.3	13.8	
				2	7.4	87.7%	16.1	25.5				2	8.5	101.8%	17.2	23.5	
				3	7.1	84.1%	15.9	26.0				3	8.4	100.1%	16.5	25.0	
UR-04	Card Brook (bridge)	N 44.52115, W 068.42463	7:20 AM	<1 (mid depth)	9.4	92.2%	14.5	0.0	-	***	1:15 PM	<1 (mid depth)	9.9	104.6%	18.0	0.0	
UR-05A	Whittaker Point (core)	N 44.52063, W 068.42456	6:40 AM	0	7.9	87.0%	17.8	7.7	>4.2	[PM water samples collected near noon]	2:52 PM	0	8.7	103.9%	20.0	14.0	
				1	7.5	88.5%	16.6	23.0				1	8.6	102.2%	18.8	17.0	
				2	7.6	89.8%	15.6	26.6				2	8.2	98.0%	17.5	22.2	
				3	7.6	90.0%	15.5	27.2				3	8.1	96.0%	16.4	24.4	
				4	7.8	92.2%	15.4	27.3				4	8.1	96.3%	16.4	25.0	
				5	7.8	92.3%	15.4	27.5									
UR-05B	Whittaker Point (bottom)	N 44.52063, W 068.42456	7:00 AM														
UR-06	Ginny Mae Way	N 44.50889, W 068.42902	8:40 AM	0	8.0	88.6%	17.4	10.0	Too choppy for Secchi reading		2:40 PM	0	8.7	105.5%	18.0	23.1	
				1	7.8	88.8%	17.2	15.2				1	8.6	104.5%	17.9	23.7	
				2	7.5	88.7%	16.0	25.5				2	8.6	104.6%	17.5	25.1	
				3	7.6	89.7%	15.8	25.8				3	8.6	104.0%	16.7	26.8	
				4	7.5	88.8%	15.6	27.0				4	8.6	103.7%	16.6	26.7	
				5	7.7	91.1%	15.4	27.5				5	8.8	106.3%	16.5	27.2	
				6	7.7	91.2%	15.4	27.6				6	8.8	105.5%	16.0	27.6	
UR-07A	Spindle Point (core)	N 44.50086, W 068.43159	8:15 AM	0	7.7	89.7%	15.7	24.0	>2.6		2:30 PM	0	8.9	108.8%	17.9	24.7	
				1	7.7	90.7%	15.2	27.4				1	8.8	108.0%	17.7	26.0	
				2	7.7	90.7%	15.1	27.7				2	8.9	108.6%	17.4	26.0	
				3	7.6	89.5%	15.0	28.0				3	9.1	110.7%	16.7	27.8	
												4	9.4	113.3%	16.1	28.2	
UR-07B	Spindle Point (bottom)	N 44.50086, W 068.43159	-							Too shallow, would have been same as 07A core if done							
UR-08	Weymouth Point	N 44.48275, W 068.43026	7:55 AM	0	8.7	101.9%	14.4	29.1	>3.8		2:15 PM	0	9.3	113.4%	16.7	28.1	
				1	8.9	104.2%	14.4	29.1				1	9.3	113.0%	16.5	28.2	
				2	8.9	104.3%	14.4	29.2				2	9.8	115.8%	14.8	29.2	
				3	8.9	104.4%	14.4	29.3				3	9.8	115.1%	14.5	29.2	
UR-09	Tupper Ledge	N 44.47217, W 068.43949	7:20 AM	0	8.5	96.5%	13.6	26.8	4.43		1:55 PM	0	9.4	113.1%	15.9	28.6	
				1	8.7	101.6%	14.3	28.9				1	9.6	115.1%	15.7	28.7	
				2	8.9	104.3%	14.4	29.2				2	9.6	114.6%	15.4	28.9	
				3	9.0	105.0%	14.1	29.4				3	10.0	117.5%	14.5	29.3	
				4	9.0	103.8%	13.5	29.6				4	10.1	117.2%	13.9	29.3	
				5	8.9	102.3%	13.3	29.7				5	10.1	117.1%	13.8	29.4	
				6	8.8	101.1%	13.3	29.7				6	10.0	114.6%	13.2	29.6	
				7	8.7	99.8%	13.2	29.7				7	9.2	104.5%	12.8	29.5	
				8	8.6	98.4%	13.1	29.7				8	8.5	95.8%	12.4	29.5	
				9	8.3	94.4%	12.8	29.7				9	8.0	89.8%	12.2	29.6	
				10	7.8	88.2%	12.5	29.8				10	7.9	88.3%	12.0	29.6	
				11^	7.2	80.6%	12.0	29.8				11	7.7	85.9%	11.9	29.6	
DUPR1	UR-01A (Just below dam at Leonard Lake)	N 44.54391, W 068.42870	6:35 AM	<1 (mid depth)	8.0	89.0%	20.6	0.0									
DUPR2	UR-09 (Tupper Ledge)	N 44.47217, W 068.43949	7:40 AM	0	8.6	96.7%	13.4	25.8									
				1	8.8	103.0%	14.4	29.0									
				2	8.9	104.3%	14.4	29.2									
				3	9.1	105.6%	13.8	29.6									
				4	9.1	105.2%	13.6	29.6									
				5	9.0	103.4%	13.3	29.7									
				6	8.9	102.1%	13.2	29.7									
				7	8.7	99.6%	13.1	29.7									
				8	8.5	96.9%	12.9	29.7									
				9	8.3	94.5%	12.8	29.8									
				10	7.6	85.4%	12.2	29.8									
				11	7.0	78.0%	11.8	29.8									

Samplers: Don Albert (DEP), Jim Sohns (DEP), Clarissa Trasko (DEP), Laurel Grosjean (W&C), Travis Hamel (W&C), Mike Harris (Ells WWTP)
* All Secchi depth recorded as (>) indicates that Secchi disk was visible on the river bottom.
** Estimated flow data from PPL-Maine's Scott Hall.
*** FLOW ~9.9cfs [culv. Width 13ft10in; length of displ 30ft; ave. depth 17.3in; ave. time to travel displ 60.3sec (3 total trials)]
^ Depth greater than 11m, but cord limits reached.
Ellsworth (elevation ~32m) P = 1atm used for conversion from DO - ppm to DO - % saturation

Union River Intensive Survey
Leonard Lake Dam to Tupper Ledge
Maine DEP / Woodard & Curran / Ellsworth WWTP

Aug 22, 2007 Day 2 of 3 day survey

			Morning Run								Afternoon Run						
Station	Location	GIS	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Secchi Depth (m)*	Note	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Note
UR-01A	Just below dam at Leonard Lake	N 44.54391, W 068.42870	6:27 AM	<1 (mid depth)	8.4	93.3%	20.5	0.0	>1*		1:20 PM	<1 (mid depth)	8.7	98.5%	21.5	0.0	
UR-02	Main Street Bridge	N 44.54087, W 068.42591	6:46 AM	0	8.1	89.4%	20.2	0.0	-		1:30 PM	0	8.8	100.3%	21.8	0.0	
				1	8.0	88.5%	20.3	0.0				1	8.7	99.1%	21.8	0.0	
				2	7.7	84.0%	19.6	0.0									
UR-03	Indian Point	N 44.53120, W 068.41776	8:47 AM	0	8.1	91.5%	19.6	5.8	>4.0		3:26 PM	0	7.7	90.9%	22.8	2.9	
				1	7.6	88.4%	18.0	16.0				1	8.2	98.7%	21.3	11.0	
				2	7.4	88.3%	17.1	23.2				2	8.1	97.3%	17.6	22.8	
				3	7.3	87.2%	16.9	24.2				3	7.7	92.5%	17.3	23.7	
				4	6.8	81.0%	16.4	25.3									
UR-04	Card Brook (bridge)	N 44.52115, W 068.42463	7:18 AM	<1 (mid depth)	9.5	91.8%	13.8	0.0	-	***	1:19 PM	<1 (mid depth)	9.1	95.7%	17.8	0.0	
UR-05A	Whittaker Point (core)	N 44.52063, W 068.42456	6:38 AM	0	7.9	87.5%	17.4	10.0	4.2	[PM samples at 11:42 AM]	3:13 PM	0	8.0	95.7%	20.1	13.9	
				1	7.5	87.9%	17.2	20.0				1	7.6	91.2%	18.7	19.0	
				2	7.5	89.9%	16.5	26.0				2	7.2	86.6%	17.1	24.6	
				3	7.5	90.0%	16.4	26.5				3					
UR-05B	Whittaker Point (bottom)	N 44.52063, W 068.42456	6:55 AM							too shallow							
UR-06	Ginny Mae Way	N 44.50889, W 068.42902	8:22 AM	0	7.9	88.9%	17.4	12.6	4		3:01 PM	0	8.0	96.8%	19.0	19.5	
				1	7.9	89.7%	17.1	15.0				1	7.9	96.3%	18.5	22.3	
				2	7.4	88.5%	16.8	24.6				2	7.8	94.7%	17.6	24.5	
				3	7.6	91.3%	16.4	26.6				3	7.9	96.0%	17.6	24.7	
				4	7.7	92.1%	16.1	27.0				4	7.9	96.2%	17.5	25.3	
				5	7.6	91.1%	15.9	28.0				5	7.8	94.6%	17.2	25.6	
UR-07A	Spindle Point (core)	N 44.50086, W 068.43159	7:53 AM	0	7.9	93.8%	16.0	26.0	>4.3		2:50 PM	0	8.2	100.1%	19.0	20.9	
				1	7.9	94.5%	15.8	28.0				1	8.1	99.6%	18.2	24.7	
				2	8.0	95.8%	15.6	28.7				2	8.0	98.0%	17.5	26.3	
				3	8.2	98.2%	15.6	28.8				3	7.9	96.8%	17.3	27.1	
				4	8.3	99.3%	15.5	28.9				4	8.3	101.3%	17.0	27.4	
UR-07B	Spindle Point (bottom)	N 44.50086, W 068.43159	8:08 AM							too shallow							
UR-08	Weymouth Point	N 44.48275, W 068.43026	7:34 AM	0	8.8	103.3%	14.7	28.4	4.3		2:32 PM	0	8.5	103.0%	16.2	28.7	
				1	8.9	105.9%	15.2	29.1				1	8.6	104.3%	16.3	28.6	
				2	8.9	105.9%	15.2	29.1				2	8.7	105.6%	16.3	28.7	
				3	9.0	106.9%	15.1	29.1				3	8.9	107.7%	16.1	28.8	
				4	9.0	106.8%	15.0	29.2					9.1	110.1%	16.1	28.9	
UR-09	Tupper Ledge	N 44.47217, W 068.43949	7:16 AM	0	8.6	100.2%	14.7	27.2	5		2:18 PM	0	8.8	106.7%	16.2	28.9	
				1	8.9	105.6%	15.1	28.9				1	8.8	106.7%	16.2	28.9	
				2	9.0	107.2%	15.2	29.2				2	8.9	107.6%	16.0	29.0	
				3	9.0	107.2%	15.2	29.2				3	8.9	107.2%	15.8	29.1	
				4	9.1	107.9%	15.0	29.2				4	9.1	108.3%	15.2	29.1	
				5	9.1	107.7%	14.9	29.2				5	9.1	107.9%	15.0	29.1	
				6	8.9	103.4%	13.9	29.5				6	9.3	109.1%	14.4	29.3	
				7	8.2	93.1%	12.7	29.7				7	8.6	98.1%	13.0	29.5	
				8	7.8	88.0%	12.4	29.7				8	8.0	90.2%	12.4	29.6	
				9	7.2	80.4%	11.9	29.7				9	7.8	87.7%	12.3	29.6	
				10	6.9	76.7%	11.7	29.7				10	7.4	82.9%	12.1	29.6	
				11^	6.8	75.4%	11.6	29.7				11	6.5	72.2%	11.7	29.6	
DUPR1	UR-02 (Main Street Bridge)	N 44.54087, W 068.42591	6:58 AM	0	8.1	89.4%	20.2	0.0									
				1	8.1	89.6%	20.3	0.0									
				2	7.7	83.8%	19.5	0.0									
DUPR2	UR-03 (Indian Point)	N 44.53120, W 068.41776	8:57 AM	0	8.1	91.9%	19.5	6.9	>4.0								
				1	7.5	89.5%	17.9	20.7									
				2	7.4	88.3%	17.2	23.0									
				3	7.2	86.0%	16.9	24.2									
				4	6.7	79.8%	16.4	25.3									

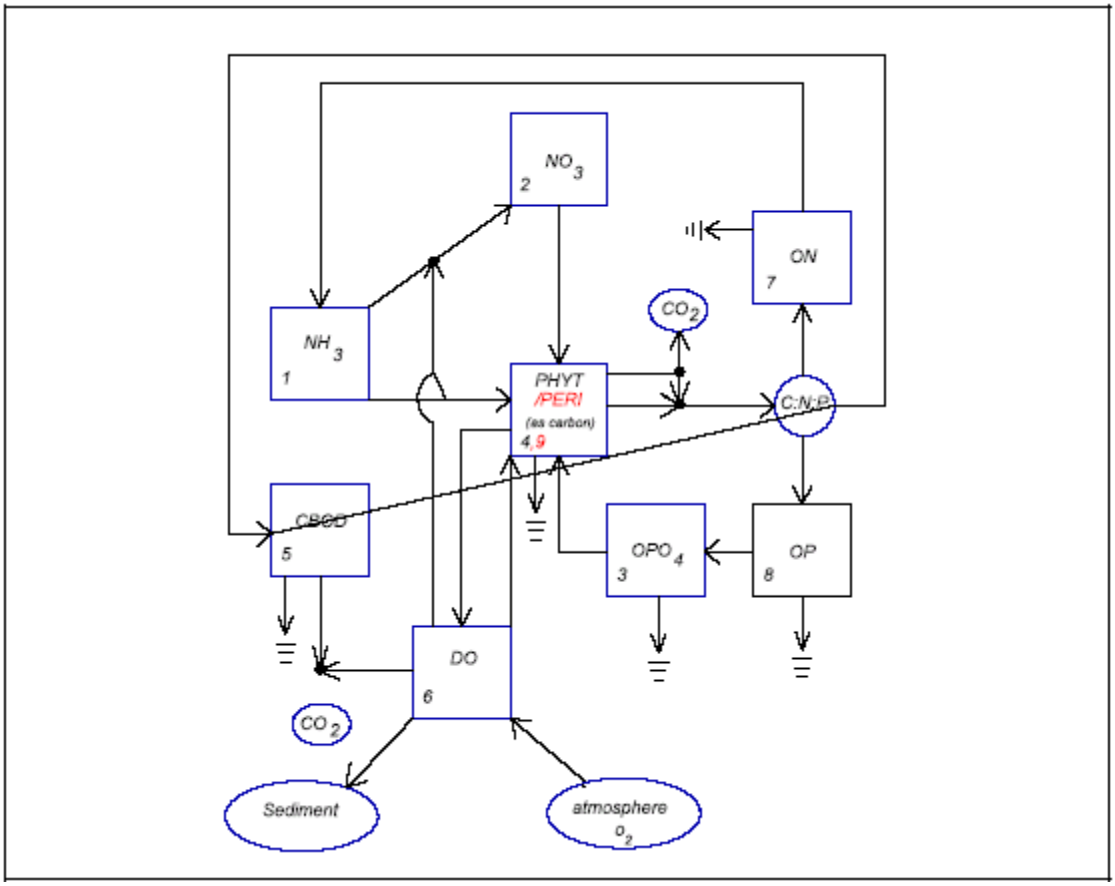
Samplers: Jim Sohns (DEP), Clarissa Trasko (DEP), Laurel Grosjean (W&C), Travis Hamel (W&C), Mike Harris (Ells WWTP), Ray Robidoux (Ells WWTP)
* All Secchi depth recorded as (>) indicates that Secchi disk was visible on the river bottom.
** Estimated flow data from PPL-Maine's Scott Hall.
*** FLOW ~8.4cfs [culv. Width 13ft10in; length of displ 30ft; ave. depth 17.3in; ave. time to travel displ 71.3 sec (3 total trials)]
^ Depth greater than 11m, but cord limits reached.
Ellsworth (elevation ~32m) P = 1atm used for conversion from DO - ppm to DO - % saturation

Union River Intensive Survey
Leonard Lake Dam to Tupper Ledge
Maine DEP / Woodard & Curran / Ellsworth WWTP

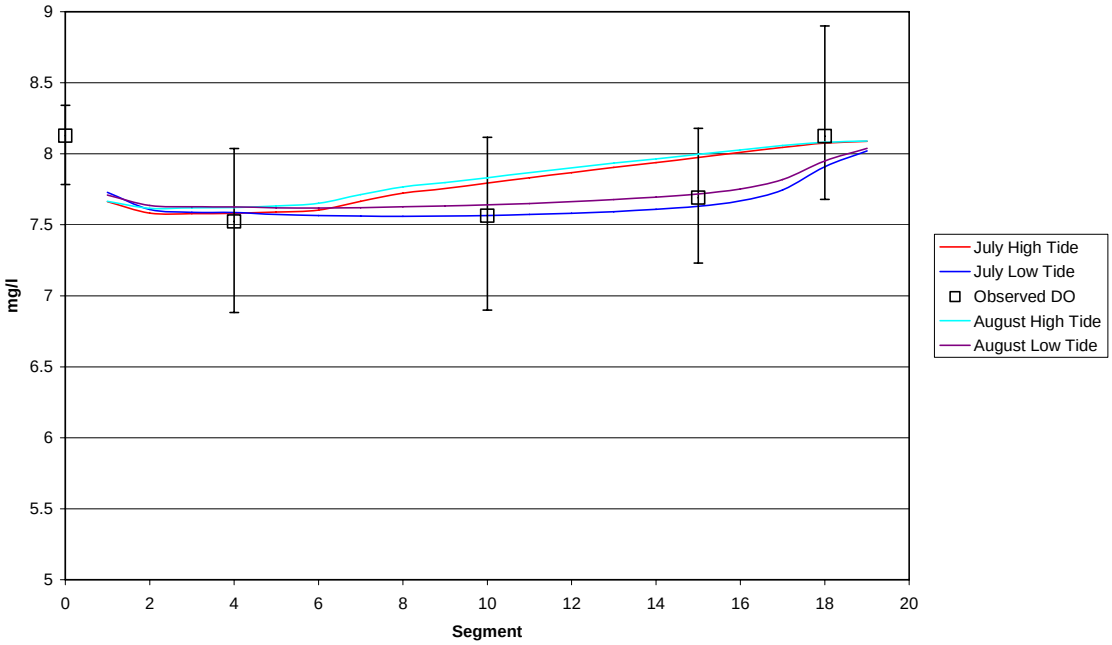
Aug 23, 2007 Day 3 of 3 day survey

			Morning Run								Afternoon Run						
Station	Location	GIS	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Secchi Depth (m)*	Note	Time	Depth (m)	D.O. (ppm)	D.O. (% Sat.)	Temp (C)	Salinity (ppt)	Note
UR-01A	Just below dam at Leonard Lake	N 44.54391, W 068.42870	6:22 AM	<1 (mid depth)	8.2	91.3%	20.6	0.0	>1*		12:55 PM	<1 (mid depth)	8.8	98.1%	20.7	0.0	
UR-02	Main Street Bridge	N 44.54087, W 068.42591	6:43 AM	0	8.0	88.9%	20.5	0.0			12:56 PM	0	8.7	97.4%	20.9	0.0	
				1	7.9	87.9%	20.6	0.0				1	8.7	97.4%	20.9	0.0	
				2	7.4	82.4%	20.6	0.0									
UR-03	Indian Point	N 44.53120, W 068.41776	8:15 AM	0	7.8	87.3%	19.8	3.7			2:12 PM	0	8.5	97.0%	20.8	3.6	
				1	7.3	86.9%	18.3	19.0				1	8.3	95.9%	20.5	6.7	
				2	7.1	85.5%	17.7	22.8	4.05			2	7.5	90.8%	17.8	23.5	
				3	6.9	83.3%	17.5	23.9				3	7.6	92.0%	17.4	24.7	
				4	6.8	82.3%	17.4	24.6									
UR-04	Card Brook (bridge)	N 44.52115, W 068.42463	7:01 AM	<1 (mid depth)	9.1	89.3%	14.5	0.0			12:45 PM	<1 (mid depth)	9.4	97.0%	16.8	0.2	
UR-05A	Whittaker Point (core)	N 44.52063, W 068.42456	6:20 AM	0	7.7	86.4%	17.1	13.0		[PM water samples collected at 11:44 AM]	2:05 PM	0	8.4	97.3%	20.0	8.8	
				1	6.9	83.1%	17.4	23.9				1	8.4	97.3%	19.8	9.4	
				2	6.8	82.5%	17.3	25.4	4.82			2	8.2	98.7%	18.3	20.9	
				3	7.0	85.1%	17.1	26.3				3	8.0	96.7%	17.9	22.8	
				4	7.0	85.0%	17.0	26.5				4	7.4	90.0%	17.2	26.1	
				5	7.1	86.4%	17.0	26.9									
UR-05B	Whittaker Point (bottom)	N 44.52063, W 068.42456	6:35 AM							sampled at 4m							
UR-06	Ginny Mae Way	N 44.50889, W 068.42902	7:57 AM	0	7.6	86.4%	17.3	14.5			1:57 PM	0	8.3	96.7%	19.4	11.8	
				1	7.2	86.5%	17.1	24.5	Scoping (no Secchi reading)			1	7.7	92.7%	18.0	21.8	
				2	7.4	89.6%	16.7	27.0				2	7.6	91.5%	17.7	22.8	
				3	7.4	89.7%	16.5	27.8				3	7.4	89.7%	17.4	25.0	
				4	7.4	89.8%	16.5	28.0				4	7.4	89.9%	17.1	26.2	
UR-07A	Spindle Point (core)	N 44.50086, W 068.43159	7:33 AM	0	7.5	90.6%	16.5	27.3			1:50 PM	0	8.3	97.8%	18.6	16.2	
				1	7.8	94.7%	16.4	28.5				1	7.5	91.5%	17.5	25.6	
				2	7.9	95.9%	16.3	28.8				2	7.5	90.9%	17.1	25.9	
				3	8.0	97.2%	16.3	28.9	4.35			3	7.3	88.6%	17.0	26.5	
				4	8.0	96.7%	16.0	29.0				4	7.5	90.8%	16.7	27.0	
				5	7.9	95.5%	16.0	29.1									
				6	7.9	95.5%	16.0	29.1									
UR-07B	Spindle Point (bottom)	N 44.50086, W 068.43159	7:45 AM							sampled at 4m							
UR-08	Weymouth Point	N 44.48275, W 068.43026	7:07 AM	0	8.4	101.3%	15.8	29.2			1:44 PM	0	8.1	98.7%	17.2	26.4	
				1	8.4	101.3%	15.8	29.2				1	8.1	98.9%	17.2	26.8	
				2	8.5	102.5%	15.8	29.2	4.35			2	8.8	106.9%	16.4	28.6	
				3	8.6	103.7%	15.8	29.2				3	9.1	110.7%	16.3	29.1	
				4	8.6	103.3%	15.6	29.3									
UR-09	Tupper Ledge	N 44.47217, W 068.43949	6:52 AM	0	8.5	102.7%	16.0	29.0			1:38 PM	0	8.7	106.4%	16.7	28.6	
				1	8.6	104.2%	16.1	29.0				1	8.9	108.7%	16.6	28.7	
				2	8.7	105.4%	16.1	29.1				2	8.9	108.7%	16.6	28.7	
				3	8.7	105.3%	16.0	29.2				3	9.0	109.4%	16.3	28.9	
				4	8.7	104.9%	15.8	29.3				4	9.2	111.3%	16.0	29.1	
				5	8.9	105.2%	14.8	29.3				5	9.2	110.9%	15.8	29.2	
				6	7.7	87.0%	12.5	29.7	4.65			6	9.3	111.1%	15.4	29.1	
				7	7.1	79.7%	12.2	29.7				7	9.0	103.6%	13.4	29.6	
				8	6.6	73.7%	11.9	29.7				8	8.0	90.3%	12.5	29.5	
				9	6.7	74.6%	11.8	29.7				9	7.2	80.7%	12.1	29.7	
				10	6.6	73.3%	11.7	29.7				10	6.6	73.2%	11.6	29.7	
				11^	6.5	72.1%	11.6	29.7				11	6.0	66.5%	11.6	29.6	
DUPR1	UR-04 (Card Brook)	N 44.52115, W 068.42463	7:12 AM	<1 (mid depth)	9.2	90.1%	14.4	0.0									
DUPR2	UR-08 (Weymouth Point)	N 44.48275, W 068.43026	7:17 AM	0	8.4	101.3%	15.8	29.2									
				1	8.4	101.3%	15.8	29.2									
				2	8.5	102.7%	15.9	29.2									
				3	8.6	103.9%	15.9	29.2									
				4	8.7	104.5%	15.6	29.3									

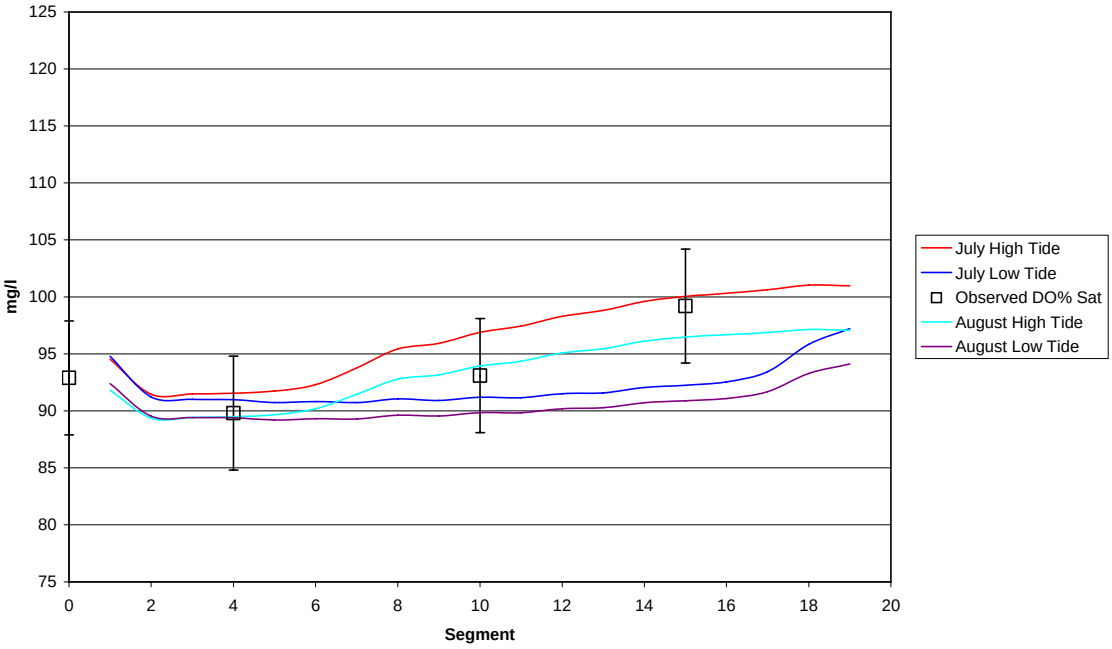
Samplers: Jim Sohns (DEP), Rob Mohlar (DEP), Laurel Grosjean (W&C), Travis Hamel (W&C), Mike Harris (Ells WWTP), Ray Robidoux (Ells WWTP)
* All Secchi depth recorded as (>) indicates that Secchi disk was visible on the river bottom.
** Estimated flow data from PPL-Maine's Scott Hall.
*** FLOW ~8.5cfs [culv. Width 13ft10in; length of displ 30ft; ave. depth 17.3in; ave. time to travel displ 70.3 sec (3 total trials)]
^ Depth greater than 11m, but cord limits reached.
Ellsworth (elevation ~32m) P = 1atm used for conversion from DO - ppm to DO - % saturation


NO3
2
ON
7
CO2
NH3
1
PHYT
/PERI
(as carbon)
4,9
C:N:P
CBOD
5
OPO4
3
OP
8
DO
6
CO2
Sediment
atmosphere
O2

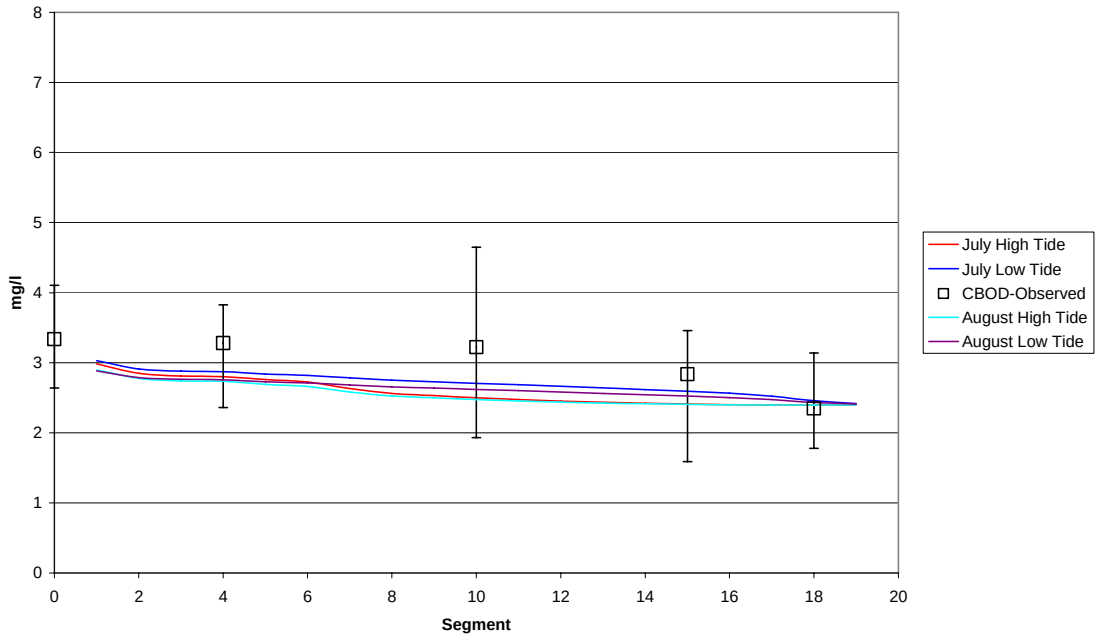
Dissolved Oxygen
Model vs. Observed



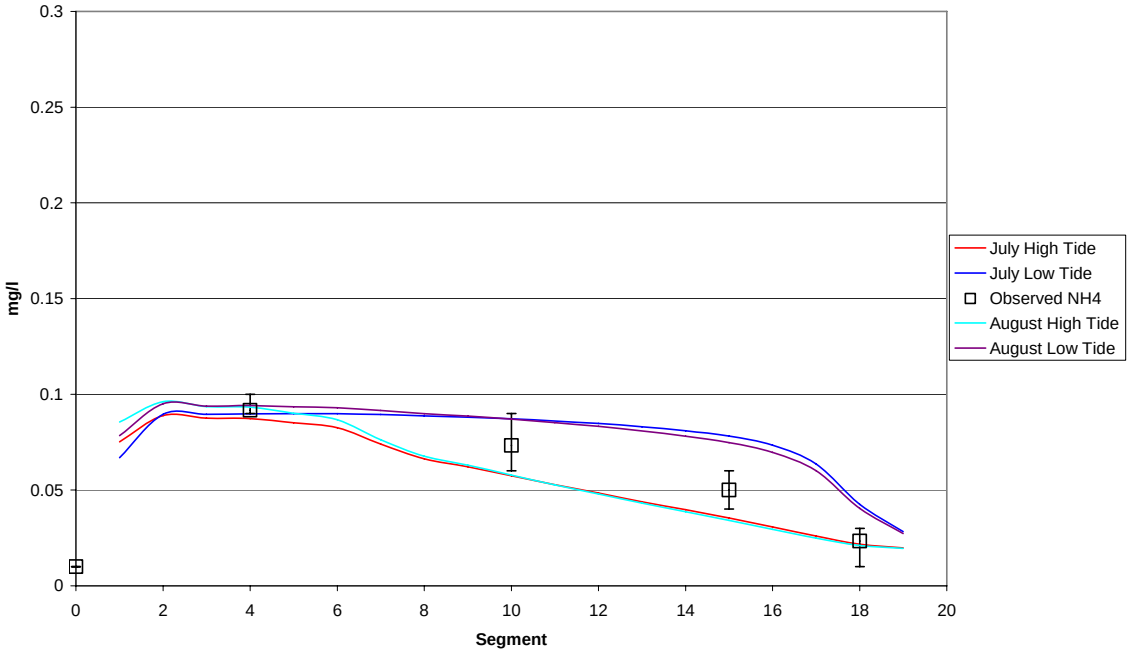
Dissolved Oxygen % Saturation
Model vs. Observed

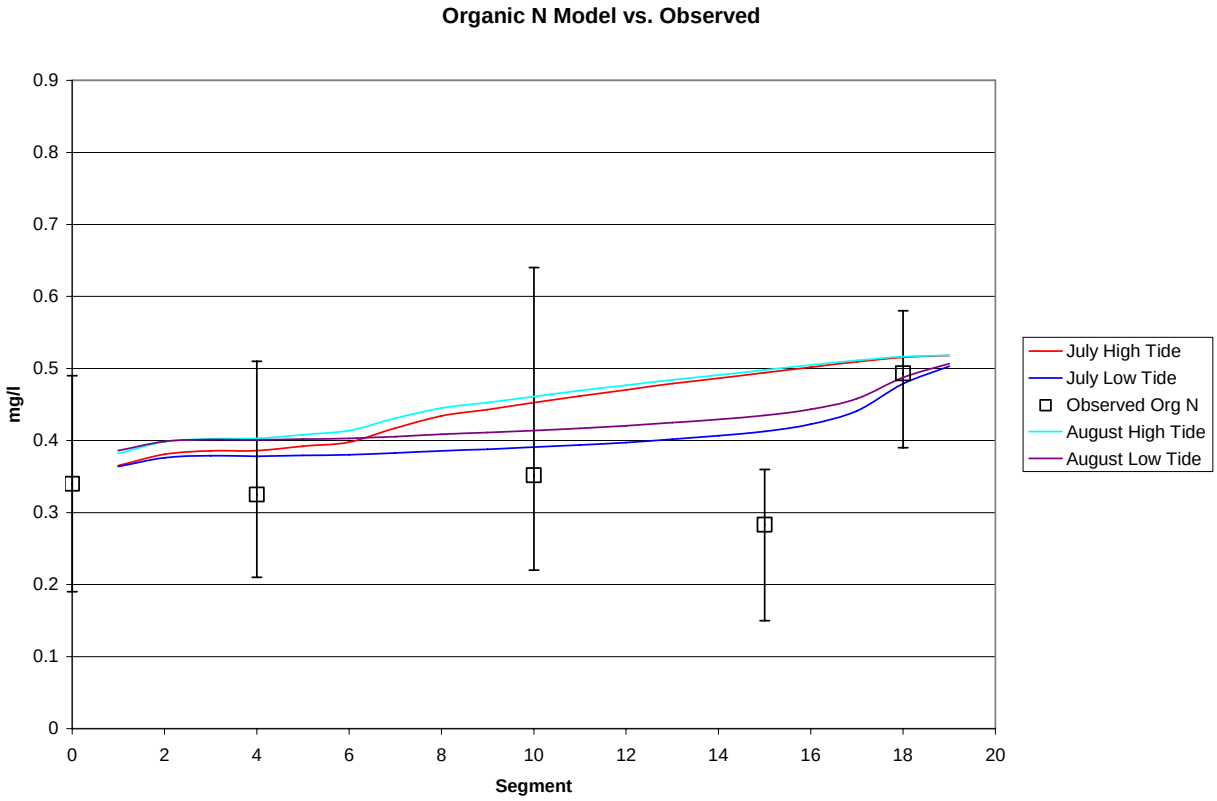


CBOD
Model vs. Observed



NH4
Model vs Observed




Organic N Model vs. Observed
mg/l
Segment
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
2
4
6
8
10
12
14
16
18
20
July High Tide
July Low Tide
Observed Org N
August High Tide
August Low Tide

Model Parameters

Description	WASP			Literature Values		Royal Model
	type	name	#	WASP	units	
CBOD						
CBOD decay	Constant Parameter	KDC, KD, K1	71 31	0.01-5.6	day^{-1}	0.1
CBOD decay temperature correction	Constant	KDT, θD	72	1.047 (1.02-1.075) **1.0**	-	1.07
Half saturation coefficient for CBOD limitation	Constant Parameter	KBOD	75 32			-
SOD	Parameter	SOD1D, SOD	9	0.1-10	gm/m^2-day	1.5
SOD temperature correction	Parameter	SODTA, θs	12		-	1.08
CBOD flux multiplier (Benthic CBOD source rate for QUAL)	Parameter	FBOD	35			-
CBOD benthic flux**	Time Func	TFBOD	36		-	-
Salinity						
Salinity	Parameter	SAL	2			-
Salinity function	Time Func	SALFN	20		ppt	-
Temperature						
Segment temperature multiplier	Parameter	TMPSG	3			variable - different for each dataset
Segment temperature pointer	Parameter	TMPFN	4			-
Temperature time functions (1-16)	Time Func	TEMP()	1-4 24-35			-
Reaeration						
Reaeration multiplier	Parameter	REARSG	14			-
Reaeration rate	Hyd Func	K2	82			0.05 - 1.0
Wind	Time Func	WIND	7		m/sec	NA
Airtemp	Time Func	AIRTEMP	21		C	NA
Ice Cover	Time Func	XICEVR	22	0-1 (1= no ice)		NA
Reaeration time function	Time Func	REAR	23			NA
Velocity						
Velocity function pointer	Parameter	VELFN	1			-
Velocity time function (1-4)	Time Func	VELN()	15-18			-
Dispersion						
Longitudinal	Time Func	Data group B			m/sec^2	100
Verticle	Time Func	Data group B			m/sec^2	-
NITROGEN						
Nitrification rate	Constant Parameter	K12C, k12	11 22	.25, (0.1-10), (0.09-0.13*)	day^{-1}	0.45
Nitrification rate temperature correction	Constant	K12T, θ12	12	1.085, 1.08* **1.0**	-	1.08
Half saturation constant for nitrification	Constant Parameter	KNIT	13 23	2.0*	mg/l	-
Denitrification rate	Constant Parameter	K20C, K2D	21 24	0.09*	day^{-1}	0.09
Denitrification rate temperature correction	Constant	K20T	22	1.045* **1.0**	-	1.04
Half saturation constant for denitrification O limitation	Constant Parameter	KNO3	23 25	0.1*	mg/l	-
Mineralization of dissolved organic N	Constant Parameter	K71C	91 33	0.075*	day^{-1}	0.25
Mineralization of dissolved organic N temperature correction	Constant	K71t	92	1.08* **1.0**	-	1.08
Fraction dead phyto to ON	Constant	FON	95	0.5*, (0-1.0) **1.0**	-	-
Ammonia flux multiplier	Parameter	FNH4	7	var	mg/m2/day	-
Ammonia benthic flux**	Time Func	TFNH4	13	var	-	-
ON settling rate	flow func	vs3	-	var	m/sec	-
Fraction dissolved ON	initial cond	FD7	-	0-1, 1*, (1=dissolved)	-	-
Fraction phyto N uptake from ammonia pool	-	calculated	-	-	-	-
Fraction peri N uptake from ammonia pool						-

*Potomac Estuary Model

Model defaults in **bold**

**Active if no bed segments specified