Lower Androscoggin River Basin Water Quality Study
Modeling Report

March 2011

Prepared by Peter Newkirk, P.E.
Bureau of Land and Water
Division of Environmental Assessment

Table of Contents

Executive Summary

In 2009 an amendment to LD330 (appendix A) directed the Department of Environmental Protection to establish and implement a water quality sampling program for the lower Androscoggin River, to initiate the procedures for reclassification and to report to the Joint Standing Committee on the Environment and Natural Resources. It authorizes the committee to report out legislation relating to the water sampling program to the Second Regular Session of the 124th Legislature, but due to high river flows in 2009, the water sampling program was delayed to 2010 and is reported here to the First Regular Session of the 125^{th} Legislature.

The purpose of the water quality sampling program implemented under this section was to allow additional water quality data to be collected to determine if the section of the Androscoggin River from Worumbo Dam in Lisbon Falls to the line formed by the extension of the Bath-Brunswick boundary across Merrymeeting Bay in a northwesterly direction meets, or can reasonably be expected to meet, the criteria for reclassification from Class C to Class B.

The lower Androscoggin River from Gulf Island Pond Dam to the Bath-Brunswick town line in Merrymeeting Bay was sampled for three days each during July and August, 2010. Dissolved oxygen, temperature and pH readings were taken twice daily at incremental depths at thirteen predetermined sampling stations. Water quality samples were also taken at nine stations. In December, 2010 the data were posted on the Department's River Modeling and Data Reports web site and are included in Appendix B.

A water quality model was developed, calibrated and verified for the freshwater sections of the river from a location immediately downstream of the Little Androscoggin River in Auburn to the Brunswick Topsham Dam incorporating point source discharges from the Publicly Owned Treatment Works (POTWs); Lewiston-Auburn Water Pollution Control Authority (LAWPCA) and the Lisbon Wastewater Treatment Facility (LIS) The model was then used to evaluate water quality in terms of existing permitted point source discharges to the river. The computer model used, Water Quality Analysis Simulation Program (WASP) is recommended by the EPA to simulate the effects of nutrient and other pollutants on water bodies.

Maine's Water Classification Program criterion requires that dissolved oxygen content for Class B waters may not to be less than 7parts per million (mg/L) or 75% saturation, whichever is higher. In order to evaluate this criterion and determine the feasibility of reclassification from Class C to Class B, the model was run under Critical Water Quality Conditions (CWQC) of low river flow and maximum licensed discharge from the POTWs. The low river flow used for analysis is the lowest stream flow that would be expected to occur for seven consecutive days, once in ten years (7Q10) as required by statute (38 MRSA §464(4)(D)).

The dynamics of the tidal flows in the sections of the river from the Brunswick-Topsham Dam to the extension of the Brunswick Topsham town line requires a two-dimensional hydraulic analysis to account for tidal flows which, in order to provide recommendations to the Legislature in a timely manner, was not performed. Alternatively, a mass balance of Carbonaceous Biological Oxygen Demand was performed for these lower sections to predict the influence of the Brunswick Sewer District licensed discharge on dissolved oxygen content in these tidal sections.

These data and the results from the water quality model are presented in this report.

Summary of Results

Based on the 2010 water quality surveys and the subsequent modeling these are the following findings:

1. During the three-day July sample survey, the average morning dissolved oxygen (DO) readings (6.99, 6.86, and 6.84) in the Brunswick-Topsham Dam impoundment were below Class B criterion of 7.0 mg/L. On the second sample day, two tidal sample stations below the dam had readings at 7.0 mg/L. During the August sample survey no readings were below 7.0 mg/L. The river was not at critical low flow nor were the discharges at maximum licensed loads for this period.
2. During Critical Water Quality Conditions of low river flow, high water temperature, and maximum licensed discharge from the Publicly Owned Treatment Works, the water quality model predicts dissolved oxygen concentrations will be below the Class B criterion of 7.0 mg/L in eight of the twelve fresh water river segments from the confluence with the Little Androscoggin River in Auburn to the Brunswick-Topsham Dam. Predicted dissolved oxygen concentrations were below the Class B criterion of 7.0 mg/L of for the entire fresh water river segments proposed for reclassifications from the Worumbo Dam to the Brunswick-Topsham Dam. Non-attainment is primarily driven by periphyton respiration during non-daylight hours.
3. The tidal segments from the Brunswick-Topsham Dam the Bath-Brunswick town line in Merrymeeting Bay were not included in the water quality model, but were evaluated separately for the impact of the licensed load from the Brunswick Sewer District. Although measured DO readings during the sample surveys were at or slightly below 7.0 mg/L, a mass balance analysis showed little influence from the Brunswick Sewer District. Low DO readings are attributed to Biological Oxygen Demand from upstream sources and incoming tides from Merrymeeting Bay. Sediment Oxygen Demand in the lower portion of Merrymeeting Bay is also a likely contributor to these low DO readings.
4. The river sampling showed a nutrient loading from sources upstream of the study area. A separate model run was preformed to assess the effect of these upstream sources relative to the point source discharges within the study area. After completely removing the discharges from the Lewiston-Auburn Water Pollution Control Authority and the Lisbon Wastewater Treatment Facility, the water quality model predicted DO concentrations would still be below the Class B criterion of 7.0 mg/L in two of the twelve fresh water river segments.
5. An Aquatic Life Classification Attainment Study was performed at three sites on the river; within the impoundments of the Brunswick-Topsham Dam and Prejepscot Dam and downstream of the Prejepscot Dam. Both impoundment sites had aquatic communities that indicate organic pollution and siltation and met the Class C aquatic life criteria. The site downstream of Pejepscot consisted of a good number of sensitive organisms and attained the Class B aquatic life criteria.
6. The free flowing river segments encourage reaeration of the water from the atmosphere raising the DO concentration. The increased depth, volume, and decreased velocity in the impoundments diminish the reaeration rate and depress the overall DO concentration. These impoundments also create slow moving segments that accumulate organic sediment, which also decreases the DO concentration.

Water Quality Sampling Study

Two field surveys were completed; July 13-16 and August 2-5, 2010 by the Department with the assistance of volunteers from Friends of Merrymeeting Bay during the July study. Early morning and afternoon measurements for DO, temperature, pH and depth were taken at thirteen stations on the lower Androscoggin River from the impoundment of Deer Rips Dam in Lewiston to the Bath-Brunswick town line in Merrymeeting Bay to and the three tributary rivers. A suite of water chemistry samples were taken at nine of the river stations and all three tributaries.

Composite effluent samples were taken from the Lewiston-Auburn Water Pollution Control Authority (LAWPCA), the Lisbon Wastewater Treatment Facility (LIS), and the Brunswick Sewer District (BRW) for three days during the two study periods.

These data were used to document existing water quality conditions under low-flow, high temperature conditions in the river and to develop the input parameters for the water quality model.

Results of the sampling study are posted on the Department website:
http://www.maine.gov/dep/blwq/docmonitoring/modelinganddatareports/index.htm

Water Quality Model

Water quality models simulate the fate of pollutants and the state of selected water quality variables in water bodies. They incorporate a variety of physical, chemical, and biological processes that control the transport and transformation of these variables. Water quality models are driven by hydrodynamics, point and nonpoint source loadings, and key environmental forcing functions, such as temperature, solar radiation, wind speed, pH, and light attenuation coefficients.

The model chosen for this study is the Water Quality Analysis Simulation Program (WASP) version 7.41. WASP is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. WASP allows the user to investigate 1, 2, and 3 dimensional systems, and a variety of pollutant types. The time varying processes of advection, dispersion, point and diffuse mass loading and boundary exchange are represented in the model. WASP also can be linked with hydrodynamic and sediment transport models that can provide flows, depths velocities, temperature, salinity, and sediment fluxes.

The model was run for the fresh water segments of the lower Androscoggin River from the confluence of the river with the Little Androscoggin River in Auburn to the Brunswick-Topsham Dam impoundment. Table 1 depicts the stationing of these segments, their corresponding sample survey stations, and the contributing loadings from tributaries and POTWs. The purpose of the model is to estimate the response of the river to Critical Water Quality Conditions (CWQC) of low flow, high water temperature, and maximum licensed flow and pollutant discharge from the POTWs. The low flow conditions used for analysis are the lowest stream flow for seven consecutive days that would be expected to occur once in ten years (7Q10) as required by statute (38MRSA § 464(4)(D). The high water temperatures used for CWQC were the observed temperatures from the July survey study, an average of 26.4°C.

Table 1. WASP Model Segment Data

WASP Segment	Segment Name	Length (ft)	Length (mi)	River Mile		Sample		Discharge/ Extraction		Tributary	
				Begin	End	Code	RM	Name/Sample Name	RM	Trib/ Sample Name	RM
0	Boundary/Headwater										
0	Deer Rips Impoundment					A258	25.85				
0	Great Falls Dam Impoundment					A230	23.40				
0	DS Lewiston Falls Dam to Little Andy					A230B	22.35				
1	Little Androscoggin R. to Dresser'sRapids	6740.00	1.28	22.1	20.8					Little Androscoggin River/ LIAR	22.10
2	Dresser's Rapids	3588.00	0.68	20.8	20.1	A201	20.20	Lewiston Auburn/ LAWPCA	20.8 0		
3	Dresser's Rapids to Durham Boat Ramp	24877.00	4.71	20.1	15.4						
4	Durham Boat Ramp to Island	11872.00	2.25	15.4	13.2	A158	15.75				
5	Island to Sabattus Rapids	14262.00	2.70	13.2	10.5						
6	Sabattus Rapids	1558.00	0.30	10.5	10.2						
7	Worumbo Dam Impoundment	10804.00	2.05	10.2	8.1	A81	8.85			Sabattus River/SAR	10.05
8	Little River Segment	4613.00	0.87	8.1	7.2	A81B	7.85	Lisbon / LIS	7.50	Little River /LITR	7.50
9	Pejepscot Dam Impoundment	13534.00	2.56	7.2	4.7	A47	4.70				
10	Topsham Dam Impoundment US Reach	4355.00	0.82	4.7	3.9	A47B	4.55				
11	Topsham Dam Impoundment Main Reach	17093.00	3.24	3.9	0.6	A06	0.65				
12	Topsham Dam Impoundment At Dam	3189.00	0.60	0.6	0.0						
Not In Water Quality Model											
13	Estuary US Reach	11810.00	2.24	0.0	2.2	A06B	0.10	Brunswick/BRW	1.45		
						A0.9	0.75				
14	Estuary Island Reach	5090.00	0.96	2.2	3.2						
15	Estuary DS Reach	16840.00	3.19	3.2	6.4	A49	4.90				

River Hydraulics

The river was divided into twelve discrete segments based on cross-sectional flow characteristics; depth, width, flow resistance, and channel grade. A map depicting these segments is shown in Appendix C. ARC GIS data, FEMA Flood Insurance Studies and Rate Maps for Brunswick, Durham, and Lewiston, and a Maine Inland Fisheries and Wildlife bathymetric survey were used to estimate these parameters for each segment and calibrated to the field measurements of depth and velocity made during sampling surveys.

Hydrology

Main Stem. A USGS river gage (*USGS 01059000 Androscoggin River near Auburn, Maine*) located at river mile 20.7 was used for all main stem flow estimates during the July and August sampling periods (flow data from 7/13th, 15th, &16th and 8/2nd, 3rd, and 4th) and for 7Q10 flow. This station has approximately 100 years of record, but for the 7Q10 estimate, flow data was only extracted from 1963 to 2009 because 1963 was the last year of up-river log drives. See Table 2.

Tributary Flow. The Little Androscoggin River has a gage in South Paris (*USGS 01057000 Little Androscoggin River near South Paris, Maine*). Flow data for the Little Androscoggin at the confluence with the Androscoggin was proportionally increased from the South Paris gage values based on the increased watershed area for that river for both the July and August sampling periods and for the 7Q10 flow. See Table 2.

Neither the Sabattus nor the Little Rivers (WASP segments 7 and 8 respectively) are gaged rivers. Regression equations developed by USGS (*Estimating Monthly, Annual, and Low 7-Day, 10-Year Streamflows for Ungaged Rivers in Maine*, R. Dudley, USGS SI Report 2004-5026) were used to calculate the 7Q10 flow for each of these rivers. The Androscoggin River gage data was used to determine the July and August sample period flows for Sabattus River and Little River by using the ratios of 7Q10 flows in the tributaries and the main stem.

POTWs. Flows for each POTW were provided for the sampling period and an average value for that period was used in the model. For the CWQC, the licensed maximum flow was used. See Table 3.

Table 2 River and Tributary Flows

	CFS	CMS
July Average Flow used for Model Calibration		
Androscoggin River	2960	83.8
Little Androscoggin River	273	7.8
Sabattus River	41	1.2
Little River	11	0.3
August Average Flow used for Model Validation		
Androscoggin River	2247	63.6
Little Androscoggin River	170.4	4.8
Sabattus River	25.6	0.73
Little River	7.0	0.20
7Q10 Flow used for Critical Water Quality Conditions (CWQC)		
Androscoggin River	1548	43.8
Little Androscoggin River	35.5	1.0
Sabattus River	5	0.15
Little River	1.5	0.04

Table 3. POTW Flows

	CFS	MGD	CMS
July Sample Period (Average)			
LAWPCA	13.30	8.61	0.38
LIS	0.85	0.55	0.02
BRW	3.08	1.99	0.09
August Sample Period (Average)			
LAWPCA	13.14	8.49	0.37
LIS	0.74	0.48	0.02
BRW	3.02	1.95	0.09
Licensed Flow			
LAWPCA	21.97	14.20	0.62
LIS	3.13	2.03	0.09
BRW	5.96	3.85	0.17

Model Segment Parameters

Ideally each river segment should have a sampling station at the downstream end in order to calibrate and verify the reactions occurring within that segment. Because of the prohibitive cost of doing so, model input parameters for segments without field sample data were generated by interpolation values from adjoining river segments. Table 4 lists WASP segments that include sampling station data.

Table 4. WASP Model Segments with Field Survey Data Inputs

WASP Segment	Sample Station	Comment
2	A201	
4	A158	
7	A81	
8	A81B	DO Only
9	A47	
10	A47B	DO Only
11	A06	

Estimates of Sediment Oxygen Demand (SOD), reaeration rate and the percentage of benthic algae cover for each segment was estimated from observation and published and historic values for similar river systems in Maine. Adjustments to these values were made during model calibration to observed DO concentrations from the field survey.

Loadings

Four segments receive daily external loadings of nutrients, BOD, and DO from upstream sources, tributaries and point discharges. Those segments are shown in Table 5.

Table 5. WASP Model Segments with Source Loadings

Segment	Loading Source
1	Boundary, flow weighted from A230, A230B (DO only) and LIAR
2	LAWPCA POTW Discharge
7	Sabattus River
8	LIS POTW Discharge and the Little River

Calibration/Validation

The July field survey data were used to calibrate the model. A plot of the DO (mg/L) readings is shown in Figure 1. The black line (init cond) is a plot of the average observed field readings. The three red line plots are the model results for maximum, average, and minimum daily readings.

The divergence in the mean observed to the mean modeled readings in segments 6 and 8 are expected. These two segments are sections with rapids and high reaeration rates that the model simulated, but were not measured, therefore not shown in the observed reading plot. The diurnal spread in DO in the model is comparable to the field data; this is shown in Figure 2 for the seven river segments that had sample stations.

The August field survey data were used to validate the calibration run. A plot of the DO (mg/L) readings is shown in Figure 3. In comparison to the July sample survey, August had a decrease in average flow of approximately 24 percent (2960 cfs to 2247 cfs) and an average water temperature decrease from 26.4°C to 25.0°C. Loadings from the POTWs were comparable with July discharges. There is an unanticipated divergence in the July and August mean observed readings between segments 4 and 7 (corresponding to sample stations A158 - Durham Boat Ramp and A87-Worumbo impoundment). The July average DO readings decreased 0.14 mg/L between these stations and the initial model calibration run followed this same overall trend. But the August average DO readings increased by 0.15 mg/L between these stations. Any adjustment to the August validation run to demonstrate this increase upsets the July calibration run. Figure 3 compares the model run for August data to field measurements. Notice the difference between elevated field readings in segment 7 over modeled values. It was also observed that in the August field measurements the remaining downstream segments showed the same declining trend as July in average DO readings. Therefore, although the cause of this discrepancy between observed and modeled readings in the Worumbo impoundment has not been determined, it was determined to not be significant.

Figure 1. Model Calibration - Dissolved Oxygen Concentrations

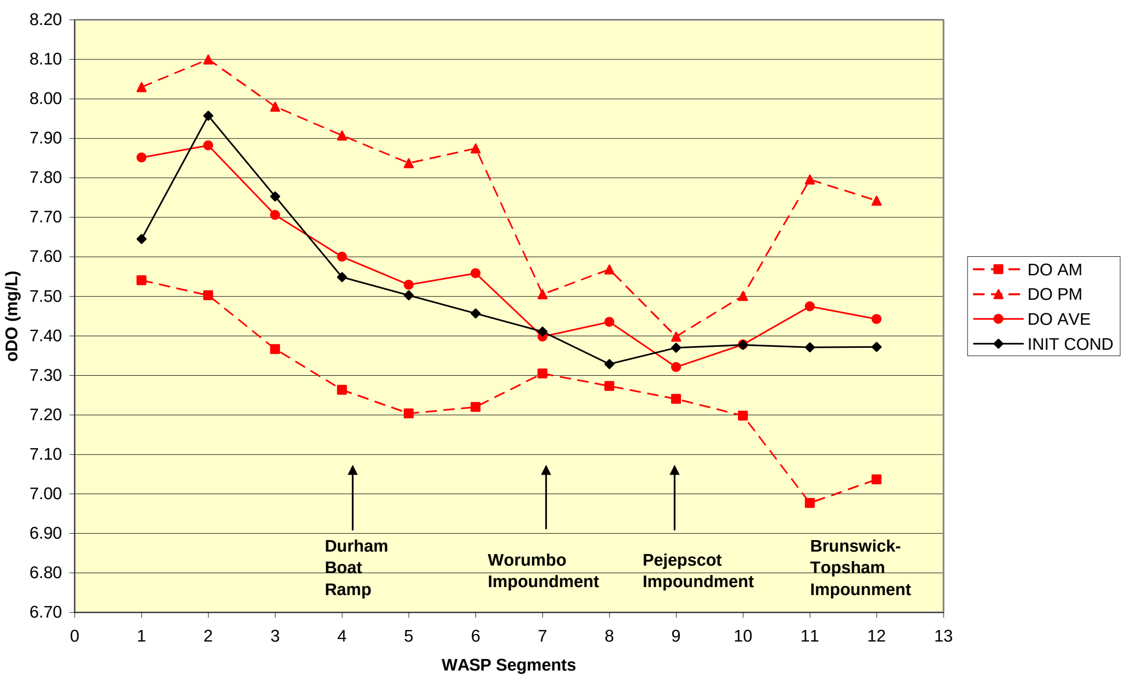


Figure 2. July Calibration - Comparing Modeled to Field Survey readings of Dissolved Oxygen

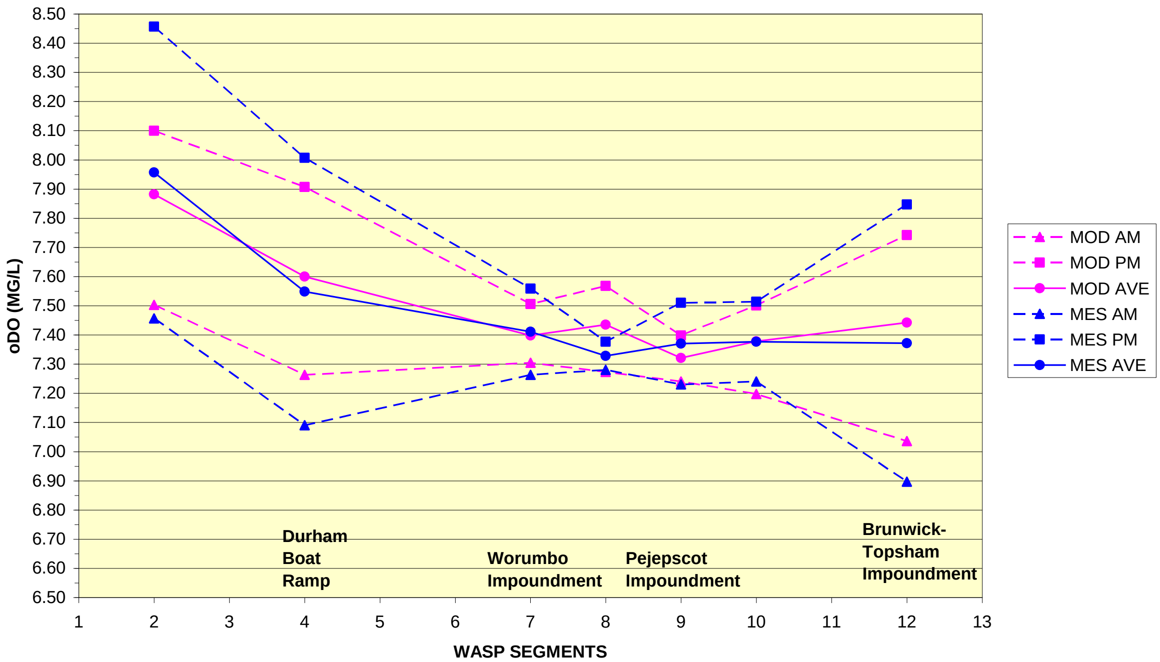
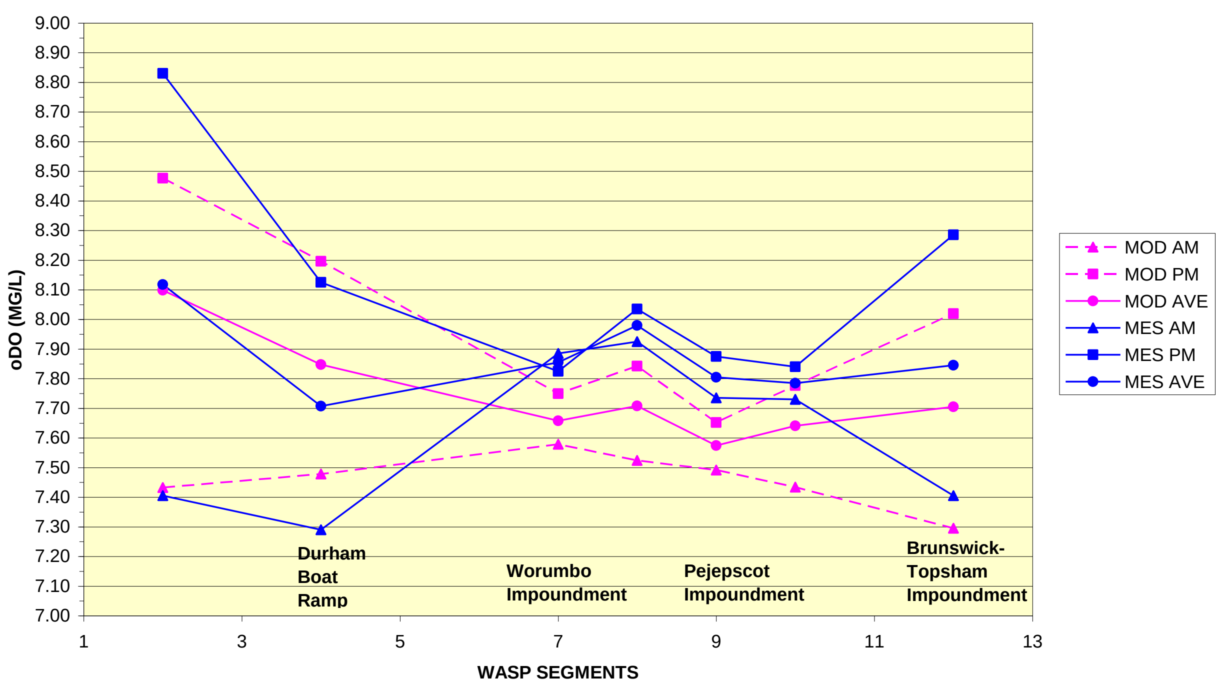


Figure 3. August Validation - Compareing Modeled to Field Survey Reading of Dissolved Oxygen



Critical Water Quality Conditions Results

River Model

A CWQC model run was developed with 7Q10 flows for the main stem and all tributaries. The LAWPCA and Lisbon POTW discharges were set at their licensed flows and the licensed pollutant weekly maximum of 45 mg/L of BOD5. Note that BOD5 is not an input to the WASP program. The licensed BOD5 load is converted to CBODu by multiplying it by the ratio of measured CBODu:BOD5 from the July sample survey.

Upstream boundary loadings to segment 1 were developed by taking the July concentrations and applying them to the 7Q10 flows. Water temperatures from the July survey were used.

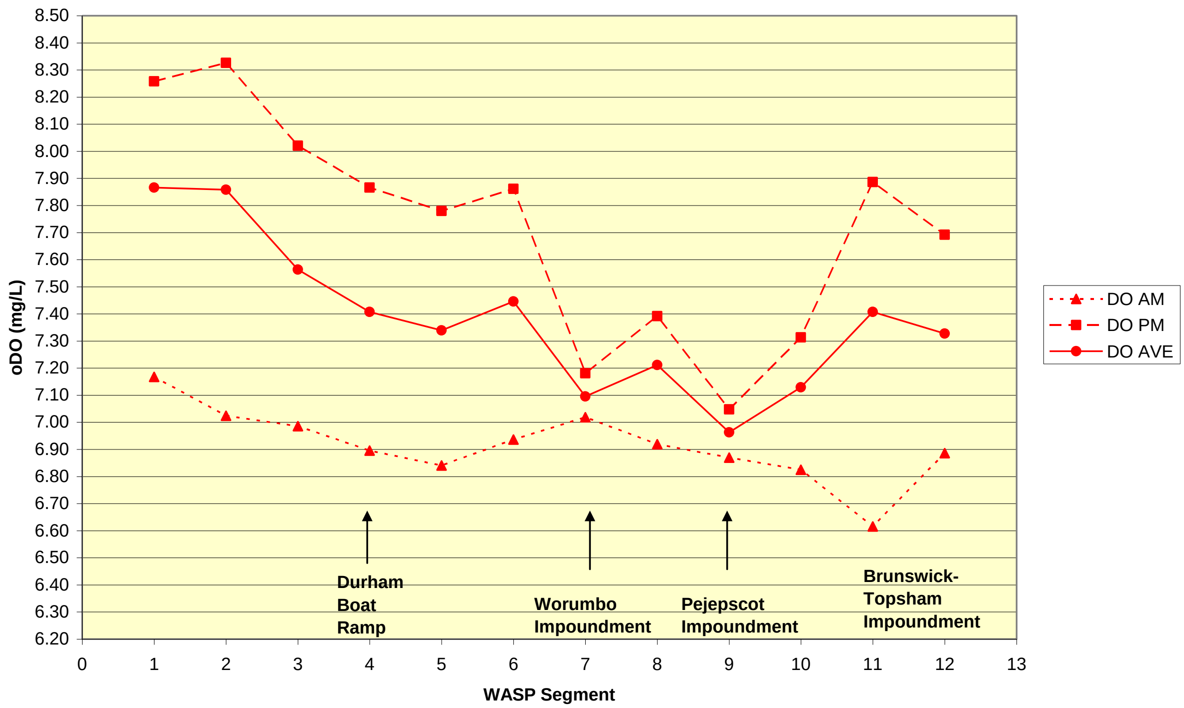
Results of the CWQC model run are shown in Figure 4. General trend of model matches calibration (July) run and the extent of the diurnal swing in each river segment is approximately equal to what was observed.

Plant respiration has the greatest effect on DO concentrations and early morning respiration drives values below 7.0 mg/L.

Segments 1, 2, 3 and 7 are the only segments that do not have DO concentrations below 7.0 mg/L.

The increased depth and volume in the impoundments behind the three dams diminish the reaeration rates in segments 7, 9, and 12 and depress the overall DO concentration. These impoundments also create slow moving segments that accumulate organic sediment, which also decreases the DO concentration. Worumbo and Pejepscot impoundments have a narrow diurnal range because of greater depths and the resulting low level and effect of benthic algae.

Figure 4. Critical Water Quality Conditions - Dissolved Oxygen



Tidal Segments

The tidal segments of the lower Androscoggin River were evaluated by determining the impact of the licensed discharge from the Brunswick Sewer District at the daily tidal flow and low flow of the river.

Base volume within the segments were determined by averaging the mean lowest low (MLL) tide depths from the NOAA Tide Charts and multiplying that depth by a delineated surface area from the same charts. The annual tidal range through these segments varies slightly from the average of 4.0 feet. This volume, twice daily, was added to the MML volume along with the total daily volume of the 7Q10 discharge from segment 12. The CBOD concentration from the upstream CWQC model run is applied to this volume. To this the total daily volume from the Brunswick Sewer District POTW and licensed BOD5, converted to CBOD, was applied.   This procedure was applied to the combined volumes of all three segments and also to segment 13 only.

Although measured DO readings during the sample surveys were at or slightly below 7.0 mg/L, a mass balance analysis showed little influence from the Brunswick Sewer District discharge. Low dissolved oxygen readings are attributed to BOD entering from upstream sources and incoming tides from Merrymeeting Bay. Sediment Oxygen Demand in the lower portion of Merrymeeting Bay is also a likely contributor to t these low DO readings.

When applied to the entire volume of the tidal river segments and to the segment that Brunswick Sewer District discharges to (segment 13 in table1), the increase in CBOD concentrations rose from a background of 4.80 mg/L to 4.91 and 5.18 mg/L respectively.

Gulf Island Pond Oxygenation Project Effect

The Gulf Island Pond Oxygenation Project (GIPOP) within that impoundment was installed to artificially introduce dissolved oxygen to Gulf Island Pond in order to meet the required class C standard for that segment of the river. It was operating during both sample surveys. Management of this facility is dependent on the incoming flow and water temperature readings. It is assumed that this facility has elevated the DO readings in the downstream impoundments of Deer Rips and Lewiston Falls Dam; sample stations A258 and A230 respectively. The input loading to the model segment 1 is the weighted average of the main stem and Little Androscoggin Rivers. It is assumed that GIPOP has an impact to the segments below Lewiston Falls, but how much can not be determined without further study.

The DO loading to segment 1 is based on an average concentration of 7.69 mg/L. In order to see what decreasing this concentration would have on the downstream segments; two scenarios were evaluated where the DO loading was adjusted downward to reflect the DO concentration of 7.0 mg/L and again for 5.0 mg/L.

Figures 5 and 6 show the results of these scenarios. There is a substantial initial decrease in DO concentration from the CWQC model run, with morning DO concentrations in segment 1, decreasing from 7.19 mg/L to 6.78, and 5.68 mg/L for both scenarios respectively. But concentrations then progressively increase downstream due to reaeration and photosynthesis from plant growth. Downstream of the Worumbo dam, in segment 9, the morning DO concentrations from these scenarios only decreased from 6.85 mg/L to 6.82 and 6.69 mg/L respectively.

Figure 5. Upstream Dissolved Oxygen Preset to 7.0 mg/L

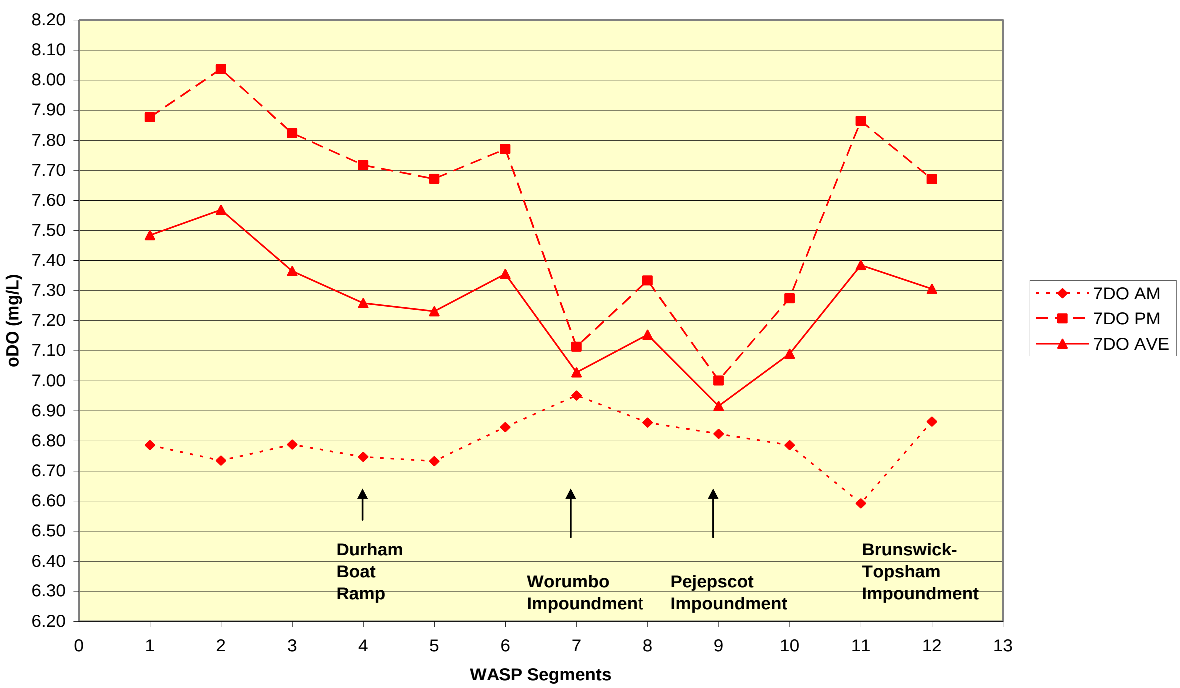
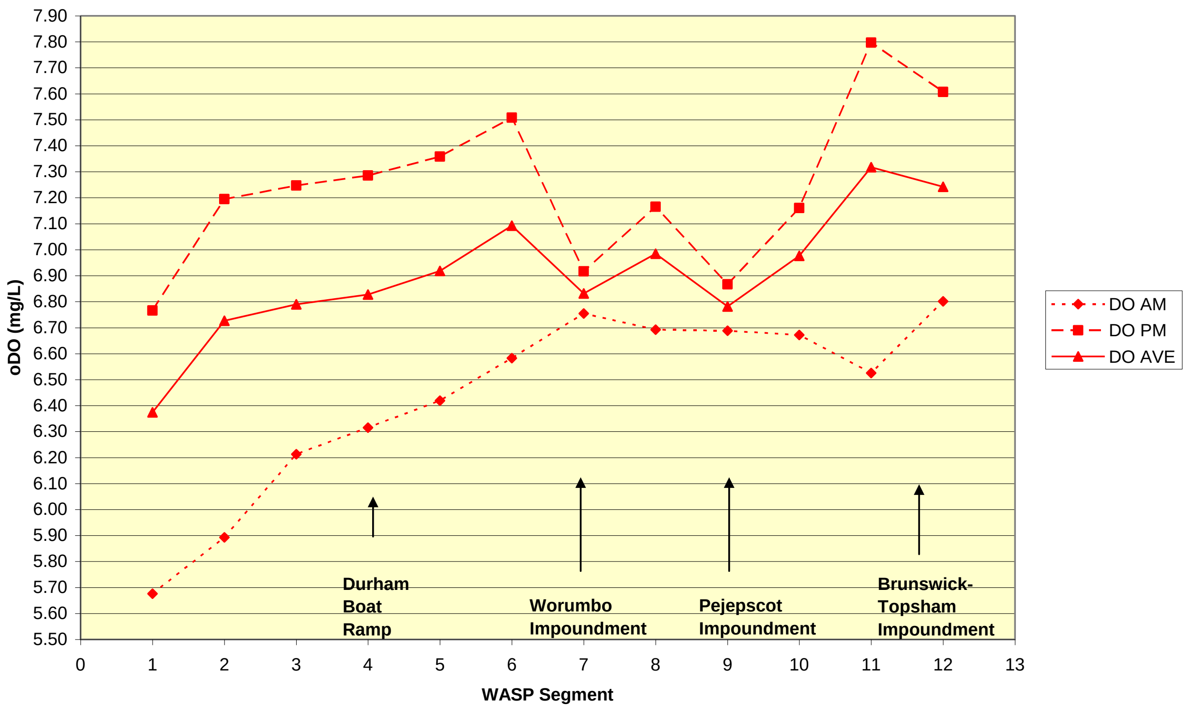


Figure 6. Upstream Dissolved Oxygen Preset to 5.0 mg/L

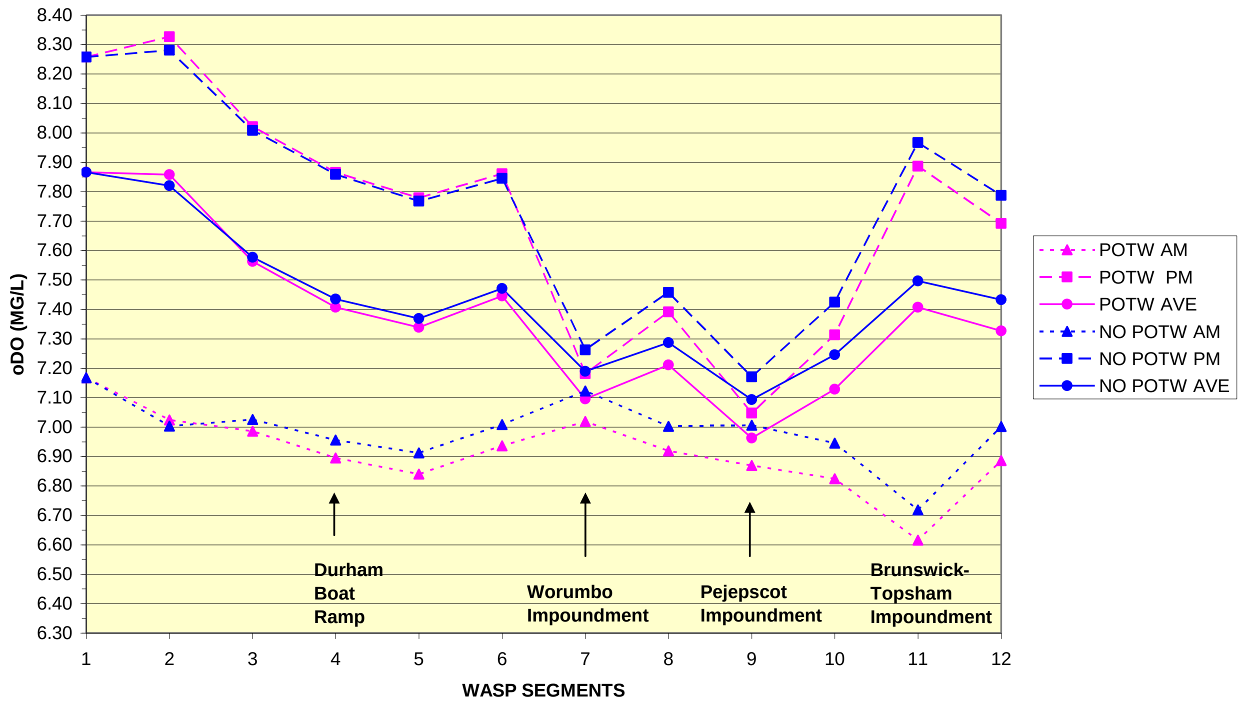


Effect of Upstream Nutrient Loading

While developing the initial loadings for the model, it was observed that a nutrient loading from upstream sources is entering the boundary to the model segment 1. The effect of nutrient loading and algae metabolism can be shown by the difference in DO values between AM and PM readings. Differences greater than 1.0 mg/L were observed in the July and August data sets. In order to assess the relative impact of this loading of nutrients, BOD, and DO a CWQC model run was performed removing all loadings from the two POTWs.

The results of removing the POTW discharges on the concentration of DO are shown in Figure 7. The low DO value and diurnal range response was marginal. This can be attributed to the nutrient loading in the upstream boundary that provides adequate nutrients for phytoplankton and benthic algal growth.

Figure 7. Comparing Critical WQ Conditions with POTW Loads and without POTW Loads



Sensitivity Analysis

The 7Q10 model was evaluated for sensitivity of the model results to changes in basic parameter rates. Model runs were made with each rate increased 50% and decreased 50% one at a time and the impact on model predictions tabulated. The maximum responses are shown in Table 6 and they demonstrate parameter confidence.

Table 6. Sensitivity Analysis Results

Condition	Constituent	Concentration Difference in mg/L	
		Maximum Difference	**Segment**
Reaeration Rate, Ka +50%	DO	0.34	11
Reaeration Rate, Ka –50%	DO	-0.67	11
Sediment Oxygen Demand +50%	DO	-0.25	9
Sediment Oxygen Demand -50%	DO	0.25	9
CBOD Decay Rate, Kd +50%	DO	-0.21	9
	CBOD	-0.54	12
CBOD Decay Rate, Kd -50%	DO	0.25	9
	CBOD	0.64	12

Aquatic Life Classification Attainment Study

An Aquatic Life Classification Attainment Study was performed at three sites within the river; within the impoundments of Pejepscot Dam and Brunswick-Topsham Dam downstream of the Pejepscot Dam. Rock sample baskets were installed and after approximately six weeks removed and assessed for organism type and population. The final report is included in Appendix D.

Both impoundment sites had aquatic communities that were more tolerant to organic pollution and siltation and met the Class C aquatic life standards. The site downstream of Pejepscot consisted of a good number of sensitive organisms and attained the Class B aquatic life criteria.

Appendix A – Legislative Directive

HP0266	First Regular Session - 124th Maine Legislature	LR 522
LD 330	C "A", Filing Number H-70	Item 2

Sec. 25. Lower Androscoggin River water quality sampling; report; legislation. The Department of Environmental Protection, with the assistance of and in consultation with volunteer river monitors, shall establish and implement a water quality sampling program for the lower Androscoggin River from Gulf Island Dam to the line formed by the extension of the Bath-Brunswick boundary across Merrymeeting Bay in a northwesterly direction.

1. Timing. The water quality sampling program must occur during the 2009 sampling season.

2. Purpose. The purpose of the water quality sampling program implemented under this section is to allow additional water quality data to be collected to determine if the section of the Androscoggin River from Worumbo Dam in Lisbon Falls to the line formed by the extension of the Bath-Brunswick boundary across Merrymeeting Bay in a northwesterly direction meets, or can reasonably be expected to meet, the criteria for reclassification from Class C to Class B.

3. Reclassification procedures. Unless the Department of Environmental Protection is unable to obtain the required monitoring data due to excessive rainfall or other unforeseen events, or unless the monitoring data indicate an upgrade is unwarranted, the department shall initiate the procedures for reclassification in accordance with the Maine Revised Statutes, Title 38, section 464, subsection 2 to upgrade the lower Androscoggin River from Worumbo Dam in Lisbon Falls to the line formed by the extension of the Bath-Brunswick boundary across Merrymeeting Bay in a northwesterly direction from Class C to Class B.

4. Report. By February 15, 2010, the Department of Environmental Protection shall submit a report, including recommendations and any necessary implementing legislation, in connection with the water quality sampling program required under this section to the Joint Standing Committee on Natural Resources.

5. Legislation authorized. The Joint Standing Committee on Natural Resources may report out legislation relating to the subject matter of this section to the Second Regular Session of the 124th Legislature.

Appendix B – Water Quality Survey Results

Figure B1. Dissolved Oxygen Measured During July Survey.

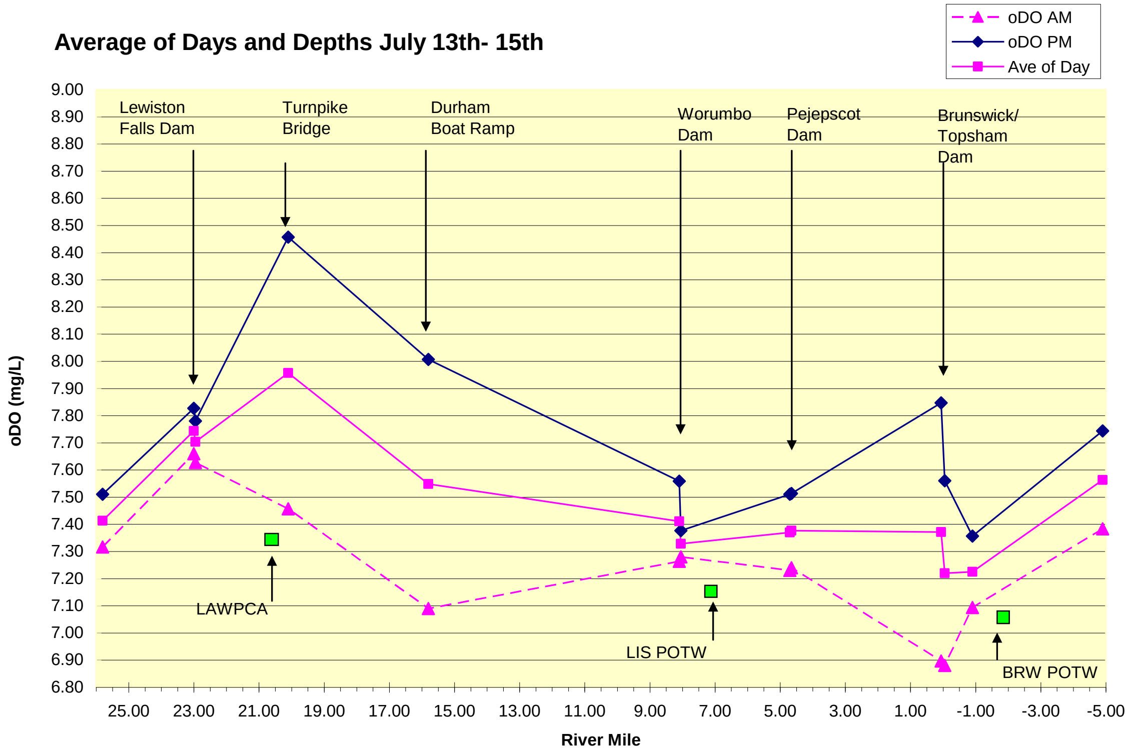


Figure B2. Dissolved Oxygen Measured During August Survey.

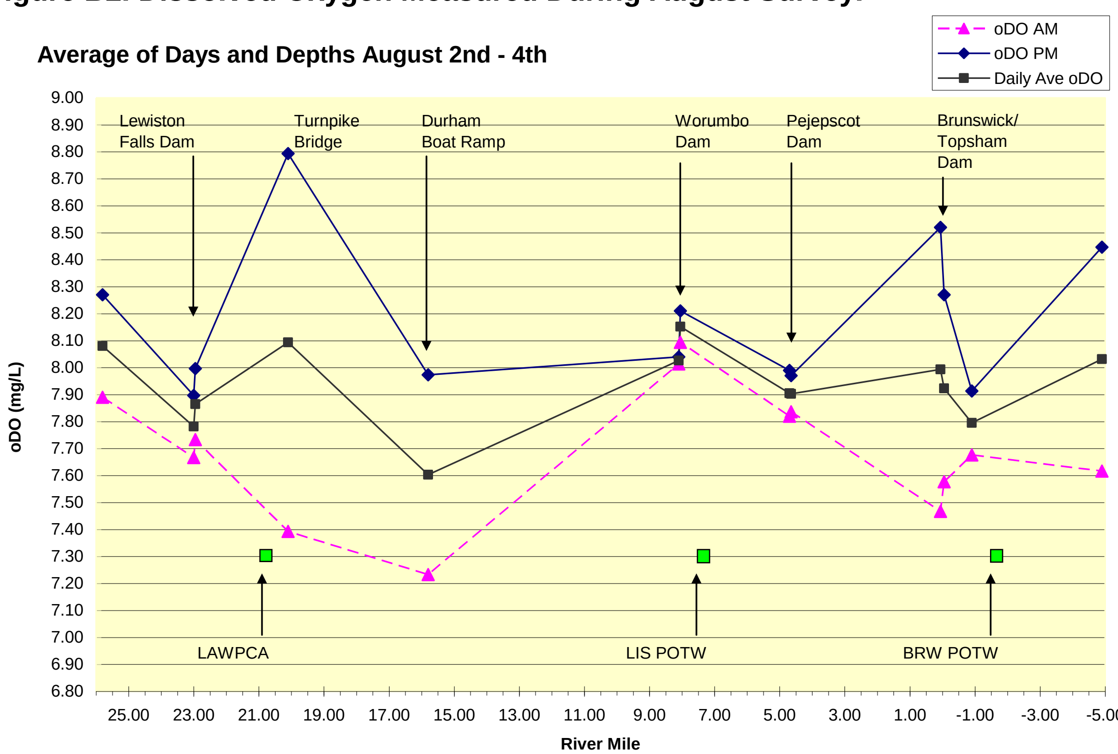


Table B1. Laboratory Data from July Field Survey

Station	Date	River Mile	Chl a © mg/l	BOD60 mg/l	BODu mg/l	NOx-N mg/l	NH3-N mg/l	TKN mg/l	Org-N mg/l	TP mg/l	ortho P ug/l	NBOD mg/l	CBODu mg/l	BOD5 mg/l	E. COLI MPN/100ML
A258	07/13/2010	25.8	0.0017	3.9	4.49	0.02	0.07	0.4	0.33	0.021	5	0.650	3.84	NA	NA
	07/15/2010	25.8	0.0033	5.7	5.85	0.03	0.08	0.5	0.42	0.021	4	1.126	4.73	NA	58
	07/16/2010	25.8	0.0019	5.4	5.58	0.03	0.08	0.4	0.32	0.019	3	0.953	4.63	NA	42
A230	07/13/2010	23.0	0.0019	4.1	4.61	0.02	0.07	0.3	0.23	0.022	5	0.563	4.05	NA	108
	07/15/2010	23.0	0.0025	4.7	4.91	0.04	0.07	0.3	0.23	0.020	4	0.736	4.17	NA	86
	07/16/2010	23.0	0.0019	5.0	5.21	0.04	0.08	0.4	0.32	0.018	3	0.650	4.56	NA	45
A201	07/13/2010	20.1	0.0028	4.4	4.88	0.05	0.06	0.4	0.34	0.029	7	0.650	4.23	NA	57
	07/15/2010	20.1	0.0019	5.0	4.99	0.06	0.07	0.4	0.33	0.021	5	0.866	4.13	NA	108
	07/16/2010	20.1	0.0028	5.3	5.81	0.06	0.08	0.4	0.32	0.029	4	0.823	4.99	NA	64
A158	07/13/2010	15.8	0.0028	4.8	5.06	0.07	0.06	0.4	0.34	0.047	11	0.693	4.37	NA	NA
	07/15/2010	15.8	0.0025	4.3	4.65	0.08	0.07	0.4	0.33	0.021	6	0.606	4.05	NA	90
	07/16/2010	15.8	0.0025	4.5	4.69	0.08	0.06	0.3	0.24	0.021	4	0.563	4.13	NA	66
A81	07/13/2010	8.1	0.0030	4.0	4.61	0.08	0.03	0.3	0.27	0.020	2	0.563	4.05	NA	NA
	07/15/2010	8.1	0.0030	4.2	4.93	0.09	0.06	0.3	0.24	0.026	6	0.563	4.36	NA	248
	07/16/2010	8.1	0.0025	4.1	4.64	0.08	0.03	0.3	0.27	0.020	3	0.476	4.17	NA	30
A47	07/13/2010	4.7	0.0030	3.9	4.45	0.09	0.03	0.3	0.27	0.038	8	0.433	4.02	NA	32
	07/15/2010	4.7	0.0028	3.9	4.46	0.10	0.14	0.4	0.26	0.021	6	0.390	4.07	NA	52
	07/16/2010	4.7	0.0028	4.5	4.98	0.10	0.04	0.4	0.36	0.026	6	0.563	4.42	NA	46
A06	07/13/2010	0.6	0.0041	3.7	4.28	0.10	0.02	0.3	0.28	0.023	4	0.476	3.81	NA	36
	07/15/2010	0.6	0.0028	3.6	4.52	0.10	0.03	0.3	0.27	0.020	5	0.390	4.13	NA	36
	07/16/2010	0.6	0.0025	4.0	4.90	0.11	0.04	0.3	0.26	0.021	6	0.520	4.38	NA	55
A-09	07/13/2010	-0.9	0.0039	3.8	4.35	0.10	0.02	0.3	0.28	0.023	4	0.476	3.88	NA	60
	07/15/2010	-0.9	0.0033	3.7	4.30	0.10	0.03	0.3	0.27	0.020	4	0.390	3.91	NA	42
	07/16/2010	-0.9	0.0030	4.0	4.44	0.10	0.03	0.3	0.27	0.021	4	0.520	3.92	NA	37
A-49	07/13/2010	-4.9	0.0050	3.8	4.42	0.12	0.02	0.3	0.28	0.027	5	0.476	3.94	NA	56
	07/15/2010	-4.9	0.0146	5.2	5.69	0.09	0.01	0.4	0.39	0.041	3	0.650	5.04	NA	44
	07/16/2010	-4.9	0.0152	6.9	7.07	0.06	0.01	0.5	0.49	0.040	3	0.996	6.07	NA	23

Color Code	Question value

Table B1. (continued) Laboratory Data from July Field Survey

Station	Date	River Mile	Chl a © mg/l	BOD60 mg/l	BODu mg/l	NOx-N mg/l	NH3-N mg/l	TKN mg/l	Org-N mg/l	TP mg/l	ortho P ug/l	NBOD mg/l	CBODu mg/l	BOD5 mg/l	E. COLI MPN/100ML
LIAR	07/13/2010	22.1	0.0025	3.1	3.33	0.13	NA	0.3	NA	0.021	4	0.346	2.98	NA	
	07/15/2010	22.1	0.0036	3.2	3.63	0.14	0.01	0.3	0.29	0.019	3	0.390	3.24	NA	93
	07/16/2010	22.1	0.0028	3.5	3.77	0.14	0.02	0.3	0.28	0.019	3	0.390	3.38	NA	38
SAR	07/13/2010	10.1	0.0039	5.1	5.67	0.20	0.03	0.4	0.37	0.042	9	0.650	5.02	NA	
	07/15/2010	10.1	0.0047	5.6	5.91	0.19	0.02	0.5	0.48	0.045	9	0.736	5.17	NA	148
	07/16/2010	10.1	0.0044	6.0	6.39	0.19	0.03	0.5	0.47	0.076	9	0.779	5.61	NA	80
LITR	07/13/2010	7.5	0.0028	5.0	5.62	0.20	0.03	0.5	0.47	0.040	6	0.606	5.01	NA	
	07/15/2010	7.5	0.0033	5.5	5.99	0.15	0.03	0.5	0.47	0.051	5	0.650	5.34	NA	651
	07/16/2010	7.5	0.0025	5.4	5.96	0.16	0.02	0.5	0.48	0.038	5	0.563	5.39	NA	219
LAWPCA	07/13/2010	20.2		55.0	55.15	1.30	7.30	9.1	1.8	1.100	930	33.341	21.81	7.6	NA
	07/14/2010	20.2		52.0	57.54	1.70	7.40	9.9	2.5	1.200	970	32.475	25.06	11	NA
	07/15/2010	20.2		56.0	59.84	1.30	6.20	8.9	2.7	1.100	690	29.877	29.96	15	NA
	07/16/2010	20.2								0.890	650				NA
LIS	07/13/2010	7.5		17.0	19.14	13.00	0.28	1.0	0.72	2.900	2700	4.330	14.81	3	NA
	07/14/2010	7.5		20.0	24.22	13.00	0.33	0.5	0.17	3.000	2800	4.330	19.89	3.9	NA
	07/15/2010	7.5		20.0	22.47	11.00	0.42	1.3	0.88	2.900	2600	4.330	18.14	4.2	NA
	07/16/2010	7.5								2.800	2400				NA
BRW	07/13/2010	-1.5		46.0	45.26	20.00	0.15	1.5	1.35	4.400	3800	8.660	36.60	10	NA
	07/14/2010	-1.5		39.0	40.92	22.00	0.10	2.1	2	4.200	3700	4.330	36.59	12	NA
	07/15/2010	-1.5		41.0	41.45	23.00	0.07	U	NA	4.100	3600	4.330	37.12	10	NA
	07/16/2010	-1.5								4.500	4000				NA

Color Code Question value

Table B2. Laboratory Data from August Field Survey

Station	Date	River Mile	Chl a © mg/l	BOD60 mg/l	BODu mg/l	NOx-N mg/l	NH3-N mg/l	TKN mg/l	Org-N mg/l	TP mg/l	ortho P ug/l	NBOD mg/l	CBODu mg/l	BOD5 mg/l	E. COLI MPN/100ML
A258	08/02/2010	25.8	0.0030	4.0	5.90	0.05	0.05	0.4	0.35	0.018	3	0.650	5.25	NA	29
	08/03/2010	25.8	0.0028	3.8	3.97	0.05	0.04	0.3	0.26	0.018	1	0.606	3.37	NA	26
	08/04/2010	25.8	0.0036	3.1	6.91	0.04	0.05	0.3	0.25	0.019	2	0.520	6.39	NA	14
A230	08/02/2010	23.0	0.0033	4.0	4.30	0.05	0.05	0.4	0.35	0.017	2	0.606	3.69	NA	37
	08/03/2010	23.0	0.0033	3.8	4.13	0.05	0.04	0.3	0.26	0.016	2	0.563	3.57	NA	26
	08/04/2010	23.0	0.0033	2.9	6.46	0.05	0.05	0.3	0.25	0.016	2	0.433	6.03	NA	28
A201	08/02/2010	20.1	0.0033	3.5	3.93	0.07	0.06	0.4	0.34	0.020	5	0.606	3.32	NA	102
	08/03/2010	20.1	0.0030	4.7	4.96	0.07	0.07	0.4	0.33	0.023	7	0.866	4.09	NA	131
	08/04/2010	20.1	0.0030	3.1	9.77	0.06	0.06	0.4	0.34	0.017	3	0.476	9.29	NA	57
A158	08/02/2010	15.8	0.0033	3.6	4.11	0.09	0.04	0.4	0.36	0.019	3	0.476	3.63	NA	50
	08/03/2010	15.8	0.0028	3.4	3.80	0.09	0.05	0.3	0.25	0.038	4	0.476	3.32	NA	52
	08/04/2010	15.8	0.0036	3.1	5.72	0.08	0.05	0.4	0.35	0.021	3	0.563	5.16	NA	49
A81	08/02/2010	8.1	0.0039	3.7	4.08	0.08	0.01	0.3	0.29	0.020	3	0.433	3.65	NA	20
	08/03/2010	8.1	0.0036	3.8	4.31	0.08	0.01	0.3	0.29	0.023	5	0.476	3.83	NA	16
	08/04/2010	8.1	0.0041	3.6	6.95	0.09	0.02	0.3	0.28	0.020	2	0.606	6.34	NA	32
A47	08/02/2010	4.7	0.0050	3.5	3.93	0.09	0.01	0.3	0.29	0.019	2	0.346	3.59	NA	11
	08/03/2010	4.7	0.0044	3.8	4.57	0.09	0.01	0.3	0.29	0.019	2	0.433	4.13	NA	8
	08/04/2010	4.7	0.0052	3.0	7.36	0.09	0.01	0.3	0.29	0.018	2	0.433	6.92	NA	6
A06	08/02/2010	0.6	0.0036	3.5	4.21	0.09	0.01	0.3	0.29	0.017	2	0.346	3.86	NA	10
	08/03/2010	0.6	0.0039	4.3	4.98	0.08	0.01	0.4	0.39	0.017	2	0.736	4.24	NA	15
	08/04/2010	0.6	0.0041	2.6	NA	0.08	0.02	0.3	0.28	0.021	2	0.520	NA	NA	20
A-09	08/02/2010	-0.9	0.0039	3.6	4.46	0.09	0.01	0.4	0.39	0.024	2	0.476	3.99	NA	20
	08/03/2010	-0.9	0.0036	3.6	4.50	0.08	0.01	0.3	0.29	0.018	2	0.346	4.15	NA	11
	08/04/2010	-0.9	0.0036	2.4	NA	0.08	0.01	0.3	0.29	0.024	2	0.433	NA	NA	7
A-49	08/02/2010	-4.9	0.0135	5.7	5.97	0.08	NA	0.5	NA	0.033	3	0.909	5.06	NA	8
	08/03/2010	-4.9	0.0141	4.8	5.24	0.05	0.01	0.4	0.39	0.031	2	0.606	4.63	NA	NA
	08/04/2010	-4.9	0.0105	4.0	5.77	0.08	0.01	0.3	0.29	0.030	3	0.736	5.04	NA	26

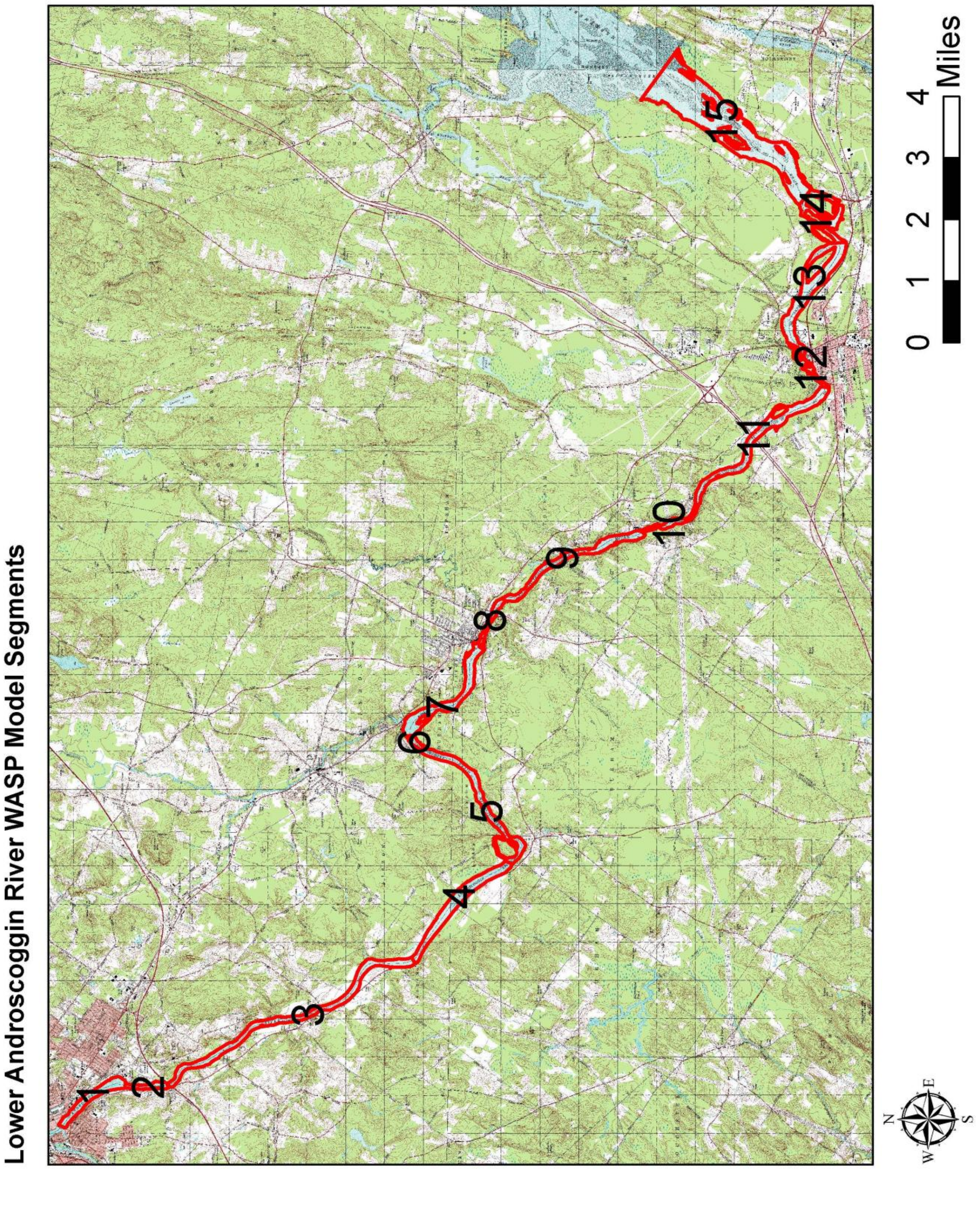
Color Code Question value

Table B2. (continued) Laboratory Data from August Field Survey

Station	Date	River Mile	Chl a © mg/l	BOD60 mg/l	BODu mg/l	NOx-N mg/l	NH3-N mg/l	TKN mg/l	Org-N mg/l	TP mg/l	ortho P ug/l	NBOD mg/l	CBODu mg/l	BOD5 mg/l	E. COLI MPN/100ML
	08/02/2010	22.1	0.0025	4.0	4.49	0.06	0.01	0.4	0.39	0.019	2	0.346	4.15	NA	38
LIAR	08/03/2010	22.1	0.0028	4.1	4.57	0.06	0.01	0.4	0.39	0.022	2	0.563	4.00	NA	75
	08/04/2010	22.1	0.0028	2.3	11.97	0.06	0.01	0.4	0.39	0.018	2	0.303	11.67	NA	50
	08/02/2010	10.1	0.0149	8.1	8.44	0.11	0.01	0.8	0.79	0.059	6	1.212	7.22	NA	23
SAR	08/03/2010	10.1	0.0232	9.3	9.41	0.07	0.01	0.8	0.79	0.062	4	1.516	7.89	NA	50
	08/04/2010	10.1	0.0536	10.0	11.28	0.03	NA	1.0	NA	0.072	3	2.208	9.07	NA	38
	08/02/2010	7.5	0.0044	3.9	5.16	0.14	0.01	0.5	0.49	0.029	5	0.390	4.77	NA	32
LITR	08/03/2010	7.5	0.0025	4.3	6.06	0.16	0.01	0.4	0.39	0.029	5	0.346	5.72	NA	31
	08/04/2010	7.5	0.0052	3.2	4.64	0.15	NA	0.4	NA	0.029	6	0.346	4.30	NA	17
	08/03/2010	20.2		65.0	77.04	2.40	7.80	11.0	3.2	0.870	1300	41.568	35.47	8.7	NA
LAWPCA	08/04/2010	20.2		59.0	67.66	1.10	5.40	8.5	3.1	0.870	560	29.011	38.65	18	NA
	08/05/2010	20.2		94.0	92.72	0.32	5.70	9.7	4	0.890	490	33.254	59.47	36	NA
	08/03/2010	7.5		39.0	46.06	12.00	5.60	6.7	1.1	3.000	2900	21.650	24.41	2.5	NA
LIS	08/04/2010	7.5		30.0	34.11	13.00	2.80	4.6	1.8	3.000	3000	17.320	16.79	4.5	NA
	08/05/2010	7.5		32.0	36.00	12.00	1.70	3.7	2	2.800	2700	8.660	27.34	7.6	NA
	08/02/2010	-1.5		33.0	37.10	23.00	0.11	NA	NA	3.800	3400	0.000	37.10	7.7	NA
BRW	08/03/2010	-1.5		34.0	42.30	24.00	0.12	1.1	0.98	3.800	3400	-4.330	46.63	4.5	NA
	08/04/2010	-1.5		37.0	34.79	21.00	0.29	3.3		4.300	3900	4.330	30.46	7.1	NA

Color Code Question value

Appendix C Map of Lower Androscoggin River Study



Appendix D - Aquatic Life Classification Attainment Report

To: Peter Newkirk From: Leon Tsomides
Subject: Lower Androscoggin River Date: January 18, 2011

The Biological Monitoring Unit sampled three locations on the Lower Androscoggin River in 2010 (Stations 954, 955, and 956). Station 956 is the upstream-most station, located in Brunswick above the Pejepscot Dam and accessed by boat from the public fishing park, off the River Road. This station is impounded by the Pejepscot Dam and is approximately 20 feet deep. Station 954 is located in Brunswick in the free-flowing section below the Pejepscot Dam, is about 3 feet deep and can also be accessed at the River Road public fishing park. Station 955 is located in Brunswick in the impoundment created by the Brunswick Topsham Dam, is about 10 feet deep and can be accessed from Route 1 at the Brunswick canoe portage parking area.

The Lower Androscoggin River is currently statutory Class C. Of the three stations sampled, two attained Class C aquatic life standards and one station attained Class B as detailed below.

Macroinvertebrate Results

The Biological Monitoring Unit uses a statistical model to predict the probability of samples attaining Class A, B, or C aquatic life criteria. The macroinvertebrate community attained Class B criteria at Station 954. The macroinvertebrate communities attained Class C criteria at Stations 955 and 956.

Station 956 (Log 1978 Above Pejepscot Dam; Impounded) **Attained Class C**

Station 956 attained Class C criteria for aquatic life (see attachment Log 1978). The number of total organisms at this site was much lower than at stations 954 and 955 (see below). The Generic Richness of sensitive taxa (EPT) made up only a quarter of the community present. The dominant taxa were represented by a tolerant mayfly (*Stenacron*) which is adapted to survive in high silt areas, a caddisfly (*Oecetis*) that is very tolerant of organic pollution and a tolerant snail which feeds by scraping detritus off the bottom.

Station 954 (Log 1956 Below Pejepscot Dam; Free-flowing) **Attained Class B**

Station 954 attained the Class B criteria for aquatic life (see attachment Log 1956). The community consisted of a good number of sensitive organisms. Ephemeroptera abundance (mayflies) was very good and the Generic Richness of sensitive taxa (EPT) made up over half the community. The dominant taxa generally consisted of sensitive organisms. The Hilsenhoff Biotic Index which measures the community's tolerance to organic pollution was low meaning the organisms that were present, in general, were sensitive to organic pollution. This indicates that organic pollution was not high enough to eliminate these sensitive taxa.

Station 955 (Log 1977 Above Brunswick-Topsham; Impounded) **Attained Class C**

Station 955 attained the Class C criteria for aquatic life (see attachment Log 1977). The Generic Richness of sensitive taxa (EPT) made up only a quarter of the community present. The dominant taxa consisted of tolerant organisms with the most dominant taxon present (*Oecetis*, a caddisfly) very tolerant to organic pollution. The Hilsenhoff Biotic Index was much higher at this station indicating that taxa present were more tolerant of organic pollution.

Conclusions

Station 954 consisted of a good number of sensitive organisms and attained the Class B aquatic life criteria while stations 955 and 956 had aquatic communities that were more tolerant to organic pollution and siltation and met the Class C aquatic life standards.

Appendix E. Review Comments and Responses

Comments in black **Responses in blue**

1A The model appears adequate to confirm what the field data demonstrated; that the river reaches being considered do not meet Class B criterion. The model would, however, need to be strengthened in order to conduct any predictive modeling, for instance in predicting responses to varying waste loads. If the Department intends to use the model extensively in the future as a predictive tool, then we would recommend that the model be further reviewed and refined to, at a minimum, address the concerns noted in the attached memo.

1B.The documentation lacks sufficient detail to fully assess the suitability of the modeling for predictive purposes beyond the above conclusion. Specifically, no evidence is given of the model's capability to predict any of the individual processes that affect dissolved oxygen. The model calibration discussion provides a comparison of model predictions to dissolved oxygen data. However, no evidence is given of the model's capability to predict any of the individual processes that affect dissolved oxygen (i.e. nitrification, CBOD deoxygenation, algal photosynthesis/respiration). In order for the model to any have any reliable predictive capacity, calibration results should be provided to demonstrate the ability of the model to accurately simulate observed CBOD, ammonia, and algal levels.

1. DEP agrees. If there is a requested to predict the affect of individual processes on dissolved oxygen documentation will be provided.

2. Minimum Dissolved Oxygen Values -In the draft report, all references to dissolved oxygen (DO) levels observed during the monitoring and as an outcome of the water quality model scenarios must refer to the minimum values (typically the AM DO), and not the maximum or average. Any references to averages and daily maximums are informative for model calibration and sensitivity analysis, but can be misleading as a basis for making policy decisions regarding compliance with water quality standards as they do not represent the actual "worst-case" values.

2. In both the Executive Summary and Summary of Results, discussion of DO levels does refer to the minimum standard and the minimum values measured or modeled. This is important to present the diurnal range of DO values to demonstrate the cause of the minimum values, i.e. plant respiration. The discussion or average DO values are in regards to the required loadings to the model and pertinent to the discussion.

3. The purpose of the water quality model used in this analysis is to predict the water quality under Critical Water Quality Conditions (CWQC). The model uses a variety of input data including actual field data collected during low flow and high temperature conditions. The evaluation of water quality classification specifically requires field data collected at or near the 7Q10 flow (38MRSA §464(4)(D)), or lowest stream flow for seven consecutive days expected to occur once in 10 years. We note that while the report does not go into detail, the discussion during the public meeting held by the DEP on November 29, 2010 indicated the field data was not collected during 7Q10 flow conditions of 1,397 cfs and in fact the actual river flows were nearly twice this critical low flow during the July and August sampling (approximately 2,960 and 2,200 cfs respectively). The report should contain a discussion of how this affects the model predictions, including the effect on model uncertainty.

3. Section 4.D. of 38MRSA §464. Classification of Maine Waters does not "require field data to

be collected at or near the 7Q10 flow", it states that "the assimilative capacity of the river or stream must be computed" using the 7Q10. The intent of the sample runs were to collect data during low flow conditions in order to develop the input parameters for the model, and once calibrated to those conditions, DEP uses the model to predict the response during the Critical Water Quality Conditions of 7Q10 and licensed loadings. That is why DEP models these systems. What is critical to the low flow sampling period and subsequent inputs to the model is the biological response (algal growth) of the system that occurred. The target flow for this study was the August base flow of 2790 cfs at the river gage. The river experienced that flow during the July survey at or below 3000 cfs.

4. The Executive Summary states that *"…a mass balance of Carbonaceous Biological Oxygen Demand was performed for these lower sections to predict the influence of the Brunswick Sewer District licensed discharge on dissolved oxygen content in these tidal sections."* Was a mass balance of DO performed; and if not, why not?

4. A working water quality model would be necessary to conduct a mass balance for DO. As state in the report time constraints prevented us from building a working model for the tidal influenced section of the river. There are numerous components of a DO mass balance (atmospheric reaeration, algal production/respiration, SOD, BOD, NOD, and boundary related influences). The purpose of the CBOD mass balance was to assess the relative influence of Brunswick Sewer District's BOD loading to the tidal portion of the lower Androscoggin.

5. The draft report does not specify which version of WASP was used. We recommend the report specify which version of software was used for this analysis.

5. Version 7.41, change made

6. We recommend references be included in the final report for the GIS data, FEMA Flood Insurance Rate Maps and USGS bathymetric survey data noted under the River Hydraulics section.

6. References will be added.

7. Under HYDROLOGY, Table 2 provides the July and August average flow used for model validation but it is not clear if this refers to the flow occurring during the field sampling periods or the full month. Same question for Table 3, POTW Flows.

7. It is just during the sample period, text has been corrected

8. Under the RESULTS Section, the report states *"The licensed BOD5 load is converted to CBODu through adjusting measured values from the July sample survey."* Please clarify if this statement means that the ratio of CBODu:BOD5 for each discharger in the July 13-16, 2010 survey was multiplied by the 45 mg/l permit limit.

8. It was and the text will be modified to state so.

9. Also in this section, the report states *"Although measured DO readings during the sample surveys were at or slightly below 7.0 mg/L, a mass balance analysis showed little influence from the Brunswick Sewer District. Low dissolved oxygen readings are attributed to incoming tides from Merrymeeting Bay."* Please clarify how the effect of the POTW's CBOD on DO was calculated.

9. See the previous paragraph of the text.

10. According to Table 3, the three municipal WWTPs discharging to the reach have flows that are well below their permitted flow. The effluent quality of these WWTPs was better than the “licensed” limit for BOD5 (i.e., 45 mg/l). The combination of these two factors means that the POTW loadings in the critical conditions (7Q10) model run would be substantially higher than the loadings experienced during the July/August 2010 sampling period.

10. That’s true, and that is why each of these sets of flows and load were used for their respective model run; calibration (July flow and concentrations), validation (August flow and concentration), and CWQC (licensed flow and average of July and August concentration, except for BOD5 which was weekly maximum).

11. The report notes there is a discrepancy in the model calibration/validation that could not be explained, but then determined that this discrepancy was insignificant. We recommend a more thorough review of this discrepancy be conducted.

11. As time permits.

12A. Under Section titled MODEL SEGMENT PARAMETERS, the report states that estimates of Sediment Oxygen Demand (SOD), reaeration rate and the percentage of benthic algae cover for each segment was estimated from observation and published and historical values for similar river systems in Maine. We recommend the report include specific references for this information, a discussion describing the basis for assuming similarity, and a discussion of the model’s sensitivity to different assumed values for these parameters.

12B. Reaeration and sediment oxygen demand are the two processes that dominate the dissolved oxygen balance. Better justification for how these processes were characterized in the model is necessary.

Reaeration and sediment oxygen demand are the two processes that dominate the dissolved oxygen balance, so it is important that they be characterized as accurately as possible. The current documentation is vague in justifying how these rates were selected:

> Estimates of Sediment Oxygen Demand (SOD), reaeration rate and the percentage of benthic algae cover for each segment was estimated from observation and published and historic values for similar river systems in Maine. Adjustments to these values were made during model calibration to observed DO concentrations from the field survey.

No mention is made of the specific observations available to support development of these inputs. Review of the WASP model input files indicate that sediment oxygen demand rates were specified on a segment-by-segment basis, ranging from 0 to 1.2 g/m2/day and kept constant between surveys. These values appear reasonable. Reaeration rates were primarily defined through the use of default algorithms provided by WASP, but manually over-ridden for some segments in the July survey. Justification should be given for the change in reaeration between surveys, as arbitrary (i.e. conducted with no underlying justification other than to match observed dissolved oxygen data) variation of reaeration rates between surveys greatly weakens the predictive capacity of the model.

12. The SOD rates were not from observed data, they were assumed and calibrate well with output variables, and they are reasonable. The concern regarding user-defined reaeration

rates is not actual. The rates referred to were not actually implemented during any model runs referenced in the report. Reaeration rates for these segments were generated by the WASP algorithm. The referenced inputs are artifacts from earlier model iterations and DEP apologizes for confusing this matter by not clearing them from the Segment Parameter input section. They were not activated in any of the final model runs (Parameter Data, field 10 deactivated).

DEP has included sensitivity analysis of three parameters (Ka, SOD and Kd), and will be included in the Sensitivity Analysis section of the report.

13. Additionally, weather information indicates that 0.5" of rain occurred during the study period on July 14th with some additional smaller amounts on August 3'd and 4th. Thunderstorms and other precipitation events can significantly impact non-point source runoff and consequently nutrient loading. This may or may not have a significant impact on the findings of this study, but it should be included in the draft report as a possible factor.

13. The rain event on July 14th, the contribution of non-point source was assessed. The lab data (ref.: Table B1 in Appendix B) does not show a significant effect from the rain. The DEP would not expect to see any response in the upper impoundments because of the prolonged travel and residence time, but there were concerns about the segments downstream of the Lewiston-Auburn stormwater outfalls. According to the Lewiston Weather Station (KMELEWIS2) the rainfall event began at approximately 3:00 AM on the 14th and ended by 7:00 AM. It cancelled the scheduled survey run for that day. There was approximately a 20 hour lag before sampling on the 15th began. Looking at the lab data, there could be an argument that the rise in Total or Ortho P in the Worumbo impoundment was attributed to NPS, but in comparison to other sample stations it was determined to be insignificant.

14A. Item 4 of the summary states that river sampling showed a substantial loading of nutrients from sources upstream of the study area. The data obtained concurrently in the upstream reaches; however, do not appear to support this assumption. We recommend at a minimum that the report be modified to instead note "an apparent loading of nutrients in some segments from unknown or unidentified sources."

14B. In the Summary of Results Section, Item 4, and again later in the report under a section titled, Effect of Upstream Nutrient Loading, the report states that, *"a substantial nutrient loading is entering the upstream boundary to the model segment."* This statement contrasts sharply with findings from the 2010 Androscoggin River and Gulf Island Pond Water Quality Monitoring Report. This report was submitted to the Department in late November 2010. Some of the more relative and notable findings in the report are as follows:

- *Point source discharges to the Androscoggin River upstream of Gulf Island Pond had no measurable effect on algae or dissolved oxygen levels in the pond during the 2010 sampling season (June 1 though September 30).*

- *The data presented in this report show that concentrations of dissolved ortho-phosphorus were below the critical levels necessary to support algae blooms in Gulf Island Pond during the entire sampling season of2010.*

- *There were no algae blooms visually observed by Acheron personnel in Gulf Island Pond during the 2010 sampling season.*

- *The visual water quality in Gulf Island Pond has improved dramatically since 2004. This* *is due to reductions of dissolved ortho-phosphorus concentrations in the upstream reaches of the Androscoggin River and in Gulf Island Pond.*

- *At no time during the summer of 2010 was secchi disk transparency less than 2.0 meters due to the growth of planktonic algae in the pond. Therefore, by the definition contained in the Code of Maine Regulations (CMR) Chapter* 581, *there were no algae blooms in Gulf Island Pond during the 2010 sampling season.*

- *The target phosphorus concentrations entering the pond as listed in Table* 3 *of the May 2004 TMDL report are* 34.6 *ppb or less of total phosphorus and* 5.5 *ppb or less of dissolved ortho-phosphorus. The goals published in the 2004 TMDL report were achieved during the 2010 study season.*

- *The chlorophyll-a goal as stated on page 20 in the May 2004 TMDL report is 10 ppb. That goal was achieved during the 2010 study season, as chlorophyll-concentrations were well below this critical value*

It is noteworthy that through the 2010 monitoring season the measured total phosphorus (TP) values in Gulf Island Pond and above, averaged approximately 57% of threshold of concern for TP. Ortho-phosphorous levels were measured at approximately 40% of the threshold of concern, and chlorophyll-concentrations averaged approximately 25% of the threshold of concern.

The vast preponderance of evidence from extensive upstream nutrient monitoring indicates that nutrient concentrations at Gulf island Pond upstream of the boundary of the modeled river segments are in fact well below the established levels of concern as outlined in the 2004 TMDL. As stated previously, these findings contrast with this statement(s) made in the draft report, "substantial loading of nutrients from sources upstream of the study area."

14C. Effect of Upstream Nutrient Loading -The draft report states that "substantial nutrient loading" is entering the upstream boundary of the modeled river segments. We (SIC) would like to remind the Department that extensive water quality monitoring of the river segments upstream of Gulf Island dam is performed every summer. The final report for the 2010 water quality monitoring was submitted to the Department in November 2010 and is available for your review. It is noteworthy that nutrient monitoring at the furthest downstream point of Gulf Island Pond (the Deep Hole) is performed weekly and samples were obtained during the same timeframe as the water quality study was taking place on the lower Androscoggin. One of the key nutrients of interest is ortho-phosphorus. Results of the Deep Hole monitoring for July 13, 2010 yielded an ortho-phosphorus value of 1.8 ug/L, and on August 3, 2010, a result of non-detect (<1 ug/L) was obtained. These results are significantly lower than the ortho-phosphorus values measured during the same time period at monitoring stations A258 (Deer Rips impoundment) and A230 (Great Falls impoundment) which are directly upstream of the first model segment. Perhaps the language in the draft report could be further clarified, since the Deep Hole monitoring data indicates that very little nutrient loading is coming from upstream of Gulf Island Pond Dam.

14. The loading input to segment 1 came from the field measured values from the July survey (comparable to the August survey) – this does support these values DEP used for the upstream loading to the model (ref. Tables B1 and B2 of Appendix B). There is an upstream loading of nutrients to this river reach and it is enough to grow phytoplankton in the downstream

segments. Considering there are two POTWs loadings, DEP has an obligation to make this statement.

DEP does not agree with the statement for the GIP report that upstream point sources have no effect on algae or DO. And orthophosphorus is not the only species of phosphorus of concern. Total phosphorus can be mineralized and become immediately available for plant growth. While phytoplankton blooms are the issue in GIP, the issue in riverine sections is attached algae and macrophytes, which grow in response to phosphorus, and impact DO.

15. Gulf Island Pond Oxygenation Project The third sentence of the discussion on oxygenation should be corrected to read "Management of this facility is dependent on the incoming flow and water temperature readings."

15. This change has been made

16. Gulf Island Pond Oxygenation Project Effect -The draft report appropriately discusses the potential consequential effect that the operation of this facility has on downstream dissolved oxygen. As a screening analysis, the Department performed alternate model scenarios that simulated lower dissolved oxygen entering the first segment of the model. This screening analysis shows significant differences in the predicted dissolved oxygen levels downstream. The comparison of minimum predicted dissolved oxygen values between the initial model scenario and the 5 mg/L model scenario show DO concentrations that range from 1.5 mg/L lower in the early segments of the model to 0.1 -0.2 mg/L lower in the latter model segments. This would seem to show that the DO model outputs for minimum DO concentrations are significantly different and perhaps the last sentence of that section of the report should be modified to indicate that there is a significant difference from the initial model run.

16. Agreed and the text has been modified.

17. The report states that DO loading to Segment was set at 7.69 ppm for dissolved oxygen. We appreciate the Department's further comparing two model runs as a sensitivity analysis regarding inflow conditions to the subject model reaches. It is noted that for both of the inflow conditions, either 7 ppm or 5ppm dissolved oxygen, the model predicts that the downstream reaches will not attain the 7 ppm Class B criterion. We note that in any case, the inflow condition to segment 1 should properly be set at a lower number, approaching 5 ppm, because that is the concentration that could be expected under critical conditions from the upstream reaches.

17. This will require further monitoring and analysis in the future because the GIP discharge is approximately six miles upstream from Segment 1 and it is assumed that the DO concentration will change between these two points.

18. We understand that the oxygen injection system at the upstream Gulf Island Pond was in operation this year during the DEP sampling period, and that the system was operating under new conditions. These new conditions may have resulted in oxygen injection in excess of what otherwise would be observed in the downstream reaches subject to this current report. It is not clear in the DEP draft report what effect the oxygen injection may have had on the conditions during the downstream sampling or modeling. It can be reasonably assumed that any oxygen that has been injected upstream can effect DO concentrations in the lower Androscoggin River. For example, if during this first year, excess oxygen was being injected over and above what might be necessary just to meet the criteria under current river conditions, then the field data from the lower Androscoggin River would not be representative of normal oxygen conditions for

these river and temperature conditions occurring during the sampling dates. We recommend that the Department examine any data that is available and modify the model input accordingly to account for any artificial oxygen levels that may bias the model validation runs.

18. DEP will as time permits. But in lieu of that and for the benefit audience for this report, DEP felt that demonstrating the effects of lowering the upstream loading of DO to 7.0 mg/L and 5.0 mg/L would demonstrate the magnitude of this effect.

19A. The following draft text proposed by DEP for addition to the model report was provided to us in a separate email:

"The free flowing river segments encourage reaeration of the water from the atmosphere raising the DO concentration. The increased depth and volume in the impoundments behind the three dams diminish the reaeration rate and depress the overall DO concentration. These impoundments also create slow moving segments that accumulate organic sediment, which also decreases the DO concentration."

These statements are based on general concepts that do not apply universally to all hydropower projects and the report provides no data to support these statements. The Worumbo and Pejepscot projects are small run-of-river facilities that have short residence time, especially during spring flows, and there was no site-specific data provided in the report, documenting significant organic sediment accumulation in the reservoirs. The report also did not provide any data that shows a diminishment of reaeration rate or that the dissolved oxygen concentrations in the subject reservoirs are "depressed". While the DO measurements below 7 mg/l were in the Topsham dam impoundment, the effect of the hydro operation on DO was not modeled and several free-flowing sample locations upstream were also modeled to have DO below 7 mg/l. Scientific rigor would require the report to include additional documentation on the evaluation of model parameters and the calibration/validation of other water quality constituents to support these statements relating to the actual effects of these specific hydro projects. Generalized statements unsupported by site-specific data and analysis should not be included in this technical report.

19B. The Department has noted that it may add a paragraph to the draft report as follows

> The free flowing river segments encourage reaeration of the water from the atmosphere raising the DO concentration. The increased depth and volume in the impoundments behind the three dams diminish the reaeration rate and depress the overall DO concentration. These impoundments also create slow moving segments that accumulate organic sediment, which also decreases the DO concentration."

We disagree with the proposed language. The existing hydro impoundments in these reaches (a designated use in both Class C and Class B waters) are relatively shallow, and the degree to which they may, or may not, accumulate sediments or decrease DO concentrations was not documented. Since these were not a subject of the data collection, and the broad assumptions add nothing to the report, the additional statements are neither applicable nor appropriate.

19. DEP disagrees that it is inappropriate to include a statement that impoundments depress DO levels. It is well documented that reaeration is generally the primary source of increase DO levels in rivers and that increased depth, and therefore volume in a river segment, decreases

the overall concentration of DO.

Regarding SOD, although these impoundments are run of the river and during high flow events there is a potential for scour of SOD, the geometry of impoundments reduce the velocity of the water compared to the free flowing segments, impoundments have a propensity to retain more sediment both mineral and organic. SOD will be higher. Also the two segments upstream of the Worumbo to Pejepscot impoundments have over 400 acres of cultivated crop land and it is logical to expect a recurring discharge of organic matter to enter the system. As noted in the review comments, “These values appear reasonable.