Responses to Comments
Penobscot River Modeling Report (April 03)

Paul Mitnik, P.E., MDEP Jan 14, 2004

Opening Comments

Before I respond to the many individual comments that I have received, I will make some opening remarks.

A number of stakeholders were upset that DEP stated in 1998 that no licensed limit adjustments would be necessary if the river was upgraded from class C to B. Based upon the information that we had in 1998, I believed this to be true. However DEP did not anticipated that such a large increase (70%) of point source phosphorus inputs would occur in such a short time period (3 years). Most of the increase occurred at paper mills. I would be interested in the reasons for this. Was it simply the lack of management of phosphorus at treatment plants, or are there process changes to explain this?

It is particularly disappointing that this occurred when DEP was asking treatment plants to undertaken voluntary pollution prevention in 2001. The data in 1997 and modeling undertaken in 2000 showed that the Penobscot River was approaching threshold levels for dissolved oxygen attainment and eutrophic state. The voluntary approach was suggested as a way to avoid mandatory license reductions in the future should the river water quality decline more.

The data collection effort undertaken by some stakeholders in the summer of 2003 indicates that phosphorus discharges at the paper mills have been significantly reduced. This is encouraging and I would like to personally thank all involved. I would be interested in the efforts undertaken to make this happen.

Some have indicated that they believe that the low DO readings on the Penobscot measured in the summer of 2001 are a natural occurrence as indicated by equally low DO readings on the tributaries. This is not likely in a river with four paper mill discharges and eleven municipal discharges. The 2001 data indicate that over 1250 ppd of phosphorus was discharged to the Penobscot from point source discharges. This is a large amount of phosphorus for even a river as large as the Penobscot.

An even more important question is what will happen if point source discharges begin to reach their license limits? Right now point sources are collectively at about 40% of their licensed BOD load. If points sources are allowed to eventually reach their licensed limits, water quality in the Penobscot River will continue to show a trend of declining water quality. Actions must be taken to prevent this, as I believe you will agree, since many of you have expressed support for good water quality in the Penobscot. Hence the report is addressing both the water quality of the Penobscot River in the future as well as the improvements needed presently.

Many have expressed a need for more data collection. The Penobscot River project was organized with an extensive stakeholder process involving a Work Plan, data collection effort, data reports, and finally an interim modeling report with many stakeholder

meetings from 1996 to 2003. The Work Plans in 1997 and 2001 clearly indicate that the proposed data collection effort was being used to develop, calibrate, and verify a water quality model. The Work Plan followed the typical protocols used for calibrating a water quality model. Two data sets sampled under satisfactory low flow conditions are adequate for model calibration and verification. Stakeholders have had many opportunities to inform DEP that the data collection effort proposed for the model calibration was inadequate.

The data collected last summer indicates that point source inputs are quite different than what was experienced in 1997 and 2001. In particular, point source phosphorus is much lower now. As indicated in the cover letter, DEP is willing to cooperate and assistant any data collection effort that the stakeholders can provide this summer.

Some useful suugestions were made pertaining to the model. Some suggested that load reductions be focused on those discharges that are causing the impacts. This is an allocation issue, which can be investigated with additional model runs.

Some made the comment that a ratio should be derived to reflect that point sources would not likely be discharging their licensed load all at the same time at a 7Q10 event. I am open to this suggestion and EPA has informed me that they are ok with it as long as some conservatism is used to derive the ratio. I am interested in any other comments or ideas that you may have on allocation methods.

ENSR Comments

Data used to support model

- No periphyton measured

Response: The biomass of both periphyton and attached algae are highly variable in river environments. Characterization of biomass would be difficult to measure in the scope of a large project such as the Penobscot River which involves 103 miles of length. The measurements of biomass are not typically very accurate. Another way to characterize periphyton and attached algae is by model calibration to the diurnal dissolved oxygen ranges observed. The diurnal dissolved oxygen is a surrogate for bottom attached growth that factors in all of the variability of plant biomass. The diurnal ranges observed for environments with mainly phytoplankton (impoundments) were not large and hence the diurnal dissolved oxygen range accounts for all of the attached growth as the river flows over it. The diurnal data are readily available.

- Additional phosphorus measurements for effluents

Response: DEP is willing to incorporate phosphorus levels based upon more measurements, if the dischargers can supply this information. Some of the dischargers are currently required to monitor phosphorus as licensed conditions. Without any additional information, DEP will use the data collected during the surveys as the best available information.

BOD Calibration

- The nitrogenous BOD was double counted in the model.

Response: Disagree. The oxygen uptake values of nitrogen in the global constants input of the model was set equal to zero.

- Rationale should be given to explain assignment of the benthic BOD source rate

Response: This is explained in the report on page 15. More text could be added to better explain the rationale. All rivers typically have a source rate, which maintains BOD similar to background conditions at all locations, assuming no point source discharges. The report explains that a trial and error procedure was used to assign this. The benthic BOD source has a minor effect upon DO levels. (< 0.1 ppm depletion at all locations in Aug 2001 model run). It is also needed to obtain an accurate BOD calibration (without the source rate, the rate of decay would be overestimated). Another consideration is that the UBOD calibrated at the measured laboratory rate better with the assignment of a benthic CBOD rate.

Average DO Calibration

- The report should contain a qualitative assessment of sediments containing oxygen demand.

Response; The daily average DO calibrated is used to assign this rate**.** A report by USGS (Composition and Distribution of Streambed Sediments in the Penobscot River, Maine, May 1999) indicates that the main areas of the river channel from Weldon Dam to Milford consists primarily of gravel, sand, and rock. A low SOD rate would be expected with this substrate. The rates from the samples collected by EPA are very high when compared to other Maine rivers.

Dissolved Phosphorus Calibration

- No clear rationale for phosphorus flux to sediments. No rationale why this rate varies between reaches and data sets.

Response: This is explained in the report. The negative-P flux is actually the phosphorus uptake rate not a negative flux. It is a scheme worked to account for phosphorus uptake in excess of metabolic needs that could not ordinarily be accounted for in Qual2E (see page 19 modeling report). This rate can be expected to be highly variable from reach to reach and even from data set to data set. Levels of bottom attached plant growth are highly variable within a river system.

Chlorophyll Calibration

- Algae Settling Rate not consistent from reach to reach

Response: Qual2e provides for reach variable settling due to the fact that this can be highly variable from reach to reach. In Qual2e, the settling rates actually also include algal death and zooplankton predation, which would not otherwise be modeled. When you are calibrating chlorophyll a, by adjusting settling, you really are calibrating all three of these inputs. This is why the report refers to it as the algal loss coefficient rather than settling. There is no literature guidance for all three parameter inputs, but the algal loss rates assigned are within the range suggested in the literature for settling (Help and Limit Screens for EPA WASP4 / Eutro Model, Tetra Tech, 8/8/91).

The report explains that the high rate of settling below the Weldon impoundment is probably due to algal death. This is typical of riverine reaches below impoundments where algae adapted to quiescent situations cannot adapt to a flowing water situation. The algal loss coefficient follow a definite pattern of low losses in environments better suited for phytoplankton growth (West Branch impoundments, tidal river) and high losses in flowing environments that are better suited for periphyton growth rather than phytoplankton growth.

Validity of Sensitivity

- No sensitivity run of P-uptake rate and algae settling

. Sensitivity runs are not provided for all inputs and model parameters due to time considerations. DEP is willing to add some additional sensitivity analysis runs.

Confirmation of Wasteload Allocations and Additional Simulations

- ENSR has performed additional scenario allocation possibilities.

Response: MDEP acknowledges that different allocations are possible and this is a good suggestion. As stated in the opening comments we are open to exploring different allocation scenarios. However most of ENSR's run's assume the GNP west mill will close. The fate of the Millinocket mill is uncertain at this time

ENSR's modeling analysis fails to acknowledge the DO non-attainment that occurs in the tidal part of the Penobscot, just before its classification changes to the marine SB. This is significant, since its client, G-P, is the main point source contributor to the non-attainment here. Contrary to what ENSR states, MDEP's runs indicate reductions at Bangor and G-P were necessary to meet water quality in the tidal river.

Georgia Pacific Comments

Includes comments not included in ENSR comments

- Low Chlorophyll a threshold of 8 ug/l used in modeling report

Response: At the time the modeling report was written, 8 ug/l was used to define algae blooms in colored water such as the Penobscot. This number has been used in Maine's Lakes Program for more than 2 decades and is verified by large quantities of data. A chlorophyll a level of 8 ug/l is also recommended in EPA's Nutrient Criteria Technical Guidance Manual as a threshold level for algae bloom. More recently DEP is using a range of 8 to 12 ug/l for chlorophyll a to define the threshold level for an algae bloom.

- MDEP should proceed with additional data collection and re-issue another draft modeling report for comment.

Response: As stated in both the data and modeling reports, the 1997 and 2001 are excellent quality data collected under the preferred target low flows specified in the work plan. Only two data sets are needed to calibrate and verify a water quality model. The DEP is willing to cooperate and assist in any field collection effort that stakeholders can provide. As stated in the cover letter, due to prior commitments, we cannot guarantee any field assistance or monetary support.

NCASI Comments

- Chlorophyll a threshold of 8 ug/l for algae blooms conservative. Some of the literature suggests 10 ug/l.

Response: Both 8 and 10 ug/l are similar values and the latter would tend to strengthen the threshold value used in the report rather than question it. . More recently DEP is using a range of 8 to 12 ug/l for chlorophyll a to define the threshold level for an algae bloom.

- The Evidence of algae blooms in the river is not strong

Response: The data suggests that threshold levels for secchi depth and chlorophyll-a are exceeded at some locations. This is clearly a warning sign for more severe problems in the future on a river where phosphorus is currently not regulated. The Penobscot Nation's data collected over several years confirm that algae blooms within the Penobscot River occurred in many different years**.**

- Diurnal DO swings in Penobscot natural

Response: This is unlikely, since 1250 ppd of total phosphorus was discharged from point sources into the Penobscot River during the sampling survey in 2001. Comparison of the Penobscot River to the tributaries is an apples to oranges comparison. Each have different hydrologic, and chemical characteristics. The dissolved oxygen readings on tributaries do not necessarily reflect natural conditions. Tributary sites with high diurnal swings such as the Kenduskeag Stream and Soudabascook Stream are known to be impacted from non-point source pollution and cannot be considered to have naturally occurring diurnal DO swings. On tributaries such as the East Branch where water quality is known to be good, diurnal swings were low. The difference in the diurnal DO swings when comparing the 1997 data to the 2001 data on the Penobscot are evident, due to the higher point source phosphorus load in the 2001 data (figure 3 modeling report).

- Model Calibration parameters changed from calibration to verification data sets.

Responses: This point appears to be greatly exaggerated. Of the 34 model inputs reported for the model (Table 6,7 of modeling report), only 2 had rates that were varied from calibration to verification. The BOD decay rate varied from .03 to .05 per day, but this was directly measured over long term BOD tests of more than 60 days on many data points. The decay rates are considered good numbers. The other, the PO4-P uptake rate was only varied on 3 of the 39 model reaches. The higher rate in the 2001 can be explained by the higher attached algae during that year and hence more uptake.

MDEP disagrees that the input parameters always remain constant over many data sets. In fact, one of the reasons for obtaining more than one data set is to document this variability. Whenever possible, rates are held constant by the modeler from calibration to verification when this variability is low. Alternatively, the differences in parameter rates can be averaged at the compromise of the calibration.

- One data set (1997) is identical to the other (2001).

Response: Disagree. The river flows are nearly identical, but this is to be expected on a highly regulated river such as the Penobscot. Both the data sets are collected at a 7-day 5-year (7Q5) low flow event. Ideally you would want both data sets at 7Q10 flow which is the flow used for computing the river's assimilative capacity. As flow becomes lower, the model is much more sensitive to parameter rate adjustments resulting in a more credible calibration. When data are collected at higher flows, the model predictions at 7Q10 become an extrapolation.

The loading conditions of point sources was higher in 2001 than 1997. Point source BOD was 48% higher and point source phosphorus 69% . Also the river temperature in 2001 averaged 3 to 4 ^{o}C higher than 1997. Hence the data sets are much different.

- Which data set is calibration and which is verification? This is a minor point.

Response: The calibration / verification is really a trial and error process of trying to obtain the best fit for both data sets. One usually tries to start with the most sensitive of the data sets (Lower flow, higher temperature or higher loading) as the calibration data set. In this case, the model software was changed in 2001, and the algal model completely redone for 1997. Hence the calibration process was started all over again. The inconsistencies in the report for naming calibration and verification will be corrected.

- Reaeration Rate, Ka, may be in error. This could cause the SOD rate to be in error.

Response: There are several submodels for reaeration in Qual2e. This process is fairly well understood. Although the method of Covar for reaeration can be off for rivers for which it is not appropriate, it is well suited and perhaps tailor- made for the Penobscot, a large river of average depth and velocities that are usually under 1 fps

- No Uncertainty Analysis Undertaken

Response; The uncertainty analysis appears to be the most useful when water quality predictions are much different than what was actually measured in the field. The analysis is run to assure water quality predictions are real problems. In the Penobscot model, predictions of DO are not that much different from what was actually measured in 2001. Hence there is a high level of confidence that the water quality non-attainment is real. In fact, the error bar of DO predictions would be $\pm$0.1 ppm, which is the error of the measurement.

- Mills can provide weekly average DMR BOD data rather than using daily maximum BOD data.

Response: DEP is willing to run the model at the actual weekly average BOD as determined by the DMR's if the mills want this and can supply the discharge data. NCASI does not appear to understand the reason for using daily maximum BOD data in the model runs. The daily maximum DMR BOD was used in the 7Q10 model runs for a reason. Assuming points sources are regulated at actual BOD discharge levels, this allows for a buffer or margin of safety. The newly licensed daily maximum BOD would be increased from the DMR daily maximum by the ratio of weekly ave / daily max (see table 9 modeling report).

- Unlikely that point sources would be discharging their daily maximum simultaneously.

Response: This is ordinarily included as a factor of safety in TMDL's and modeling undertaken by MDEP. It may be possible to derive a factor with some conservatism to apply to waste loads. We are open to suggestions.

- NCASI makes a number of recommendations

Response: MDEP disagrees that any of the data collection recommended is necessary, but as suggested earlier, we are willing to cooperate with stakeholder with any additional data that they can provide.

Eastern Paper Comments

Includes additional comments not addressed in NCASI comments pertaining to the modeling

- .Eastern Paper states that they never had the opportunity to review the data.

Response: Disagree. The 1998 and 2002 data reports were sent to all stakeholders and a public comment period given to incorporate stakeholder's suggestions.

- The model input for Eastern Paper's BOD5 are overly conservative in the prediction runs.

Response: Disagree. MDEP must assume a worse case and the higher production tier for BOD5. Additional model runs can be provided with different production tiers.

- Eastern Paper requests that actual weekly average BOD5 supplied from their DMR's be used for the 7Q10 run at actual input loads

Response: As mentioned already, MDEP is willing to do this.

- BOD5 reductions are unnecessary:

Response: MDEP must use the allowable or licensed loads when undertaking a worse case analysis. This is what is permitted for discharge. State law maintains that in order to issue a waste discharge license, a finding must be made that this level of discharge will not cause or contribute to a violation of water quality standards when considered in combination with other point and non-point sources. The BOD reductions are needed to meet class B DO criteria.

- Phosphorus Loads Reductions unnecessary

Response: The limitation of diurnal responses are the limiting factor and not the Chlorophyll a threshold when establishing phosphorus limits. Both the data and the model support that the phosphorus reductions are necessary. When phosphorus inputs were lower in 1997, diurnal DO effects were lower and DO criteria were met everywhere except in one location.

Comments from Bangor, Brewer, Old Town, Orono, and Veazie

- River Mile 37 to 38 has been upgraded to class B. This can be updated.

Response: Agree. Similarly a 1.5 mile segment in tidal waters has been changed from class B to SC, due to redefining of the boundary of marine waters (based upon 2001 data).

- Chlorophyll a threshold level 8 ug/l not appropriate for rivers

Response: It is referenced in EPA's Nutrient Criteria Technical Guidance manual as a threshold level for eutrophication for rivers. More recently DEP has been using a range of 8 ug/l to 12 ug/l to define the threshold level for algae blooms.

- Statement that eutrophication problem forthcoming not accurate

Response: The data in 1997, and 2001 support this statement. The Penobscot nation data also support the high levels of algae that occasionally occur in different summers.

- Statement that the river is a well mixed system not accurate in tidal waters.

The differences in tidal waters vertically between DO, temperature, and salinity are not significant enough to call it a stratified estuary.

- Calibration and verification data sets – inconsistencies in report.

Response: Agree. This will be corrected.

- Benthic CBOD rate. How derived?

Response: All rivers have this due to settling of BOD. It is how a river maintains its background BOD. See ENSR comments under BOD calibration for more details.

- PO4-P uptake why positive in table and negative in model?

Response: Phosphorus uptake in excess of metabolic needs is occurring. Qual2e has no direct input for this. A negative flux rate is used to compensate for the model's deficiency. The phosphorus is actually being uptake in algae.

- Parameter Rate and constants 80% of bottom area is used for available periphyton growth. Field confirmation needed for this. The literature ranges of N half saturation constants listed in table 7 of the modeling report exceed those listed in Qual2e manual.

Response: Best professional judgement was used to assign the bottom area in the Penobscot available for periphyton growth. This would be difficult to verify with field measurements due to the vast size of this project (103 river miles). There are two sources used for literature values (see top of table 7 for these sources).

- Algae not suited to grow in free flowing environments. Want a reference.

Response: Maine DEP has observed this in many situations. The reason for the disappearance is not as important as the fact that it obviously occurred in both data sets and must be accounted for.

- Phosphorus overestimated by model from Old Town to Orono.

Response: The model values match well with observed data for the 2001 but are slightly over estimated by the model for 1997. The error associated with this should be minimal.

- Diurnal DO data biased to 2001 data. Why wasn't the 1997 data given equal standing?

Response: The 2001 data diurnal DO variations are a worse case. MDEP agrees that this may be a valid point and will be reconsidered in some of the model prediction runs. For the prediction run at licensed loads it is appropriate to use the worse case diurnal swings, but it may be appropriate to use a lower DO diurnal swing for prediction runs with reduced loads.

- Howland, Mattawamkeag, and Penobscot Nation's dilution ratios are omitted in Table 8 of report.

Response: They are not in the toxics program due to high dilution.

- How were the design temperatures for the model prediction runs determined in Figure 17 of the modeling report?

Response: The Eddington historical data clearly shows a trend of increasing water temperature over the period of record. For this reason a straight average was not deemed to be appropriate. The majority of summer months from the mid 80's to mid 90's had monthly average temperatures at or approaching 24 ^{o} C. This was used as the design monthly average temperature at Eddington. A value of 25 ^{o}C is inferred as an approximate weekly average temperature when observing the monthly maximum and monthly average temperature.

- NBODU loads for effluents are doubled counted in model prediction

Response: Disagree. The oxygen uptake values of nitrogen in the global constants input of the model was set equal to zero.

- Effluent nutrient data in Tables 9 and 10 of the modeling report limited.

Response: Acknowledge. This was the best available information during the development of the report. This can be updated with any new information provided by dischargers. Some are currently monitoring phosphorus as licensed requirements.

- Additional sensitivity analysis runs requested for CBOD benthic rate and fraction of bottom area available for periphyton growth..

The modeling report provides basic parameter sensitivity runs due to time considerations. Additional model sensitivity runs can be provided.

Many comments are made about the benthic CBOD rate.
Response: The benthic BOD is responsible for less than 0.1 ppm DO depletion in all modeled reaches of the August 2001 data set. Its impact would be too miniscule to plot.

- Source of effluent phosphorus data in figure 25 of report.

Response: Average of survey data.

- Why are non-point source phosphorus reductions ignored?

Response: It is a point source problem.

- Any X above dashed lines in figure 28 is a violation.

Response: Agree.

- July 15 light intensity used for August on input.

Response: Light is highly variable from day to day. There is no set value for any given day.

- Dispersion Rates for impoundments should be higher.

Response : Dispersion is generally not important in river situations. Advection is the main transport mechanism.

- Ommision of small dischargers .

Response: They do not effect dissolved oxygen depletion.

- Effluent DO modeled at 2 ppm. Actual effluent DO higher.

Response: This is not significant in model results. If the plants provide the effluent DO data, the changes will be made.

- Effluent Phosphorus loads – data insufficient.

Response: Previously addressed. DEP is willing to include any data that the dischargers can provide.

- 7Q10 design flow vs river 18 day travel time.

Response: This statement would be valid if there were only one DO sag point in which 18 days are needed to cumulatively lower the river DO. However, there are many problem areas of DO non-attainment typically affected by short travel times associated with benthal impacts from algae. An 18-day travel time is not needed to develop DO depletions under classification requirements.

- Thermal discharges contribution to DO depletion.

Response: The temperature inputs account for the thermal discharges since monitoring data is used to set the design temperatures.

- Include dams in analysis for abatement.

Response: Most of the DO problems are actually in the flowing shallow water where diurnal impacts from bottom attached plant occur.

- Report doesn't address non-attainment of tributaries.

Response: This effort was designed to focus on the Penobscot River. Assuming that the DO isn't natural, the tributaries could be addressed at a later date through the TMDL process.

- Why are phosphorus reductions needed in lower Penobscot?

Response: To prevent an increasing eutrophic state in the estuary.

- Dilution ratios and new 7Q10 flow – Why did the Eddington 7Q10 decline?

Response: The 7Q10 flows used for both Enfield and Eddington in the 2000 report were old (early 1980's) and needed to be updated. When the 7Q10's were derived, there wasn't a long enough record at the USGS gage at Eddington to derive a 7Q10. Rough flow estimated provided by Bangor Hydro Co were used to derive 7Q10. The 7Q10 appears to have been overestimated by this data. There is now 15 years of record at Eddington which is sufficient to derive a better estimate of 7Q10.

- Model's DO predictions temperature sensitive

Response: The difference in the DO in the plot appears to be from the inappropriate assigned boundary DO for the cooler water rather than temperature. DO saturation only varies by about 0.2 ppm for each degree centigrade. The boundary DO assignment of the cooler water that is about 0.5 ppm higher is erroneous.

- Five communities only affect DO by 0.12 ppm. Quadrupling phosphorus doesn't effect DO, chlorophyll a, or periphyton.

Response: The model runs presented only look at the daily average DO. The DO standard is a daily minimum, not a daily average. The issue is with diurnal variations of DO and the effect of algae on the daily minimum DO, not the daily average DO. (The daily average DO often increases with increasing phosphorus loads due to the fact that oxygen production from increased photsynthesis exceeds oxygen depletion from respiration.)

- Wet weather flows will make compliance of proposed BOD and TP limits difficult.

Response: Agree. We will have to come up with an innovative way to deal with this issue.

Lincoln Sanitary District Comments

All comments previously addressed.

Katahdin Paper Company Comments

All comments pertaining to the model have already been raised by others and have been addressed.

City of Brewers Comments

Additional comments not already addressed

- Metcalf and Eddy Report indicates that 90% of DO depletion in river originates from Non-point source and SOD.

Response: DEP is not familiar with this report. Can you provide a copy? Is the data to support this recent data? How does data collection effort compare to DEP's effort? Model used? Was the M&E report reviewed as extensively as DEP's report is being reviewed?

- DO problem is theoretical

Response: Disagree. The 2002 data report reveals that class B dissolved oxygen levels were not maintained in 10 of 14 of the locations sampled.

- Sharp changes in temperature and salinity in the estuary affects DO by 1 ppm.

Response: This is accounted for in the model. There is not a DO non-attainment issue in the estuary where the river classification changes to SC. There is a DO non-attainment issue in the tidal river where temperature is not significantly different than the river and no salinity is observed.

City of Bangor Comments

All comments pertaining to the model have already been raised by others and have been addressed.

Pierce Atwood Comments

All comments pertaining to the model have already been raised by others and have been addressed.

NRCM Comments

No additional issues were raised that need to be addressed.

Penobscot Nation Comments

Comments by Dr. Henry Rines not previously addressed in other comments:

- Nitrification not modeled?

Response: NBOD that was measured was so low, it would have been impossible to calibrate it individually and hence it is grouped as total BOD. Nitrification is modeled without oxygen depletion, since the oxygen uptake values of nitrogen in the global constants input of the model was set equal to zero.

- Sampling protocols not explained enough

Response: You should consult the Work Plan for sampling protocols.