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## MEMORANDUM

**Date:** **September 22, 2008**

**To:** **Brian Howes, Ph.D., School for Marine Science and Technology, University of Massachusetts, Dartmouth**

**From:** **Sean Kelley, P.E. and John Ramsey, P.E.**

**Subject:** **Pleasant Bay Water Quality Model Update and Scenarios**

The Pleasant Bay model, updated recently to include the new north inlet (Kelley, 2008), was used to model N concentrations in the system to estimate the effect of the new breach on water quality. The hydrodynamic data to support the post breach conditions was collected in November 2008.

In addition to the update of the water quality model to include the north breach, two model scenarios were run to simulate water quality conditions under 2 different possible future hydrodynamic conditions. The scenarios are for 1) worst-case conditions where a single inlet has migrated to the maximum southerly position near Monomoy Island (similar to the pre 1987 breach condition of the system) and 2) a possible future configuration of the system with one north inlet, based on the historical behavior of Nauset Beach after past breaches.

The dispersion coefficients determined in the calibration of the 2006 Massachusetts Estuary Project (MEP) report (Howes, *et al*., 2006) were used for the updated post-breach model and scenarios simulations. The hydrodynamic input for each water quality case was modeled using the same tidal open boundary used for the MEP report in order to facilitate the comparison of each scenario with the modeled 2004 conditions. A map of water quality stations used for this comparison is presented in Figure 1. As with the MEP analysis, the bioactive component of TN (DIN+PON) was modeled for all the scenarios in this analysis. A plot showing the gradient in bio-active N concentrations throughout the Pleasant Bay System under 2004 (pre-breach) hydrodynamic conditions is shown in Figure 2.

### A. Post North Breach, 2007 Conditions

The water quality model run of 2007 Pleasant Bay with the north breach and south inlet (post-breach conditions) uses the present N loading developed as part of the MEP report for the system. The N loading by embayment is presented in Table 1. A


Figure 1. Estuarine water quality monitoring station locations in the Pleasant Bay estuary system. Stations are monitored by the Pleasant Bay Alliance and Town of Chatham Water Quality Monitoring Programs.

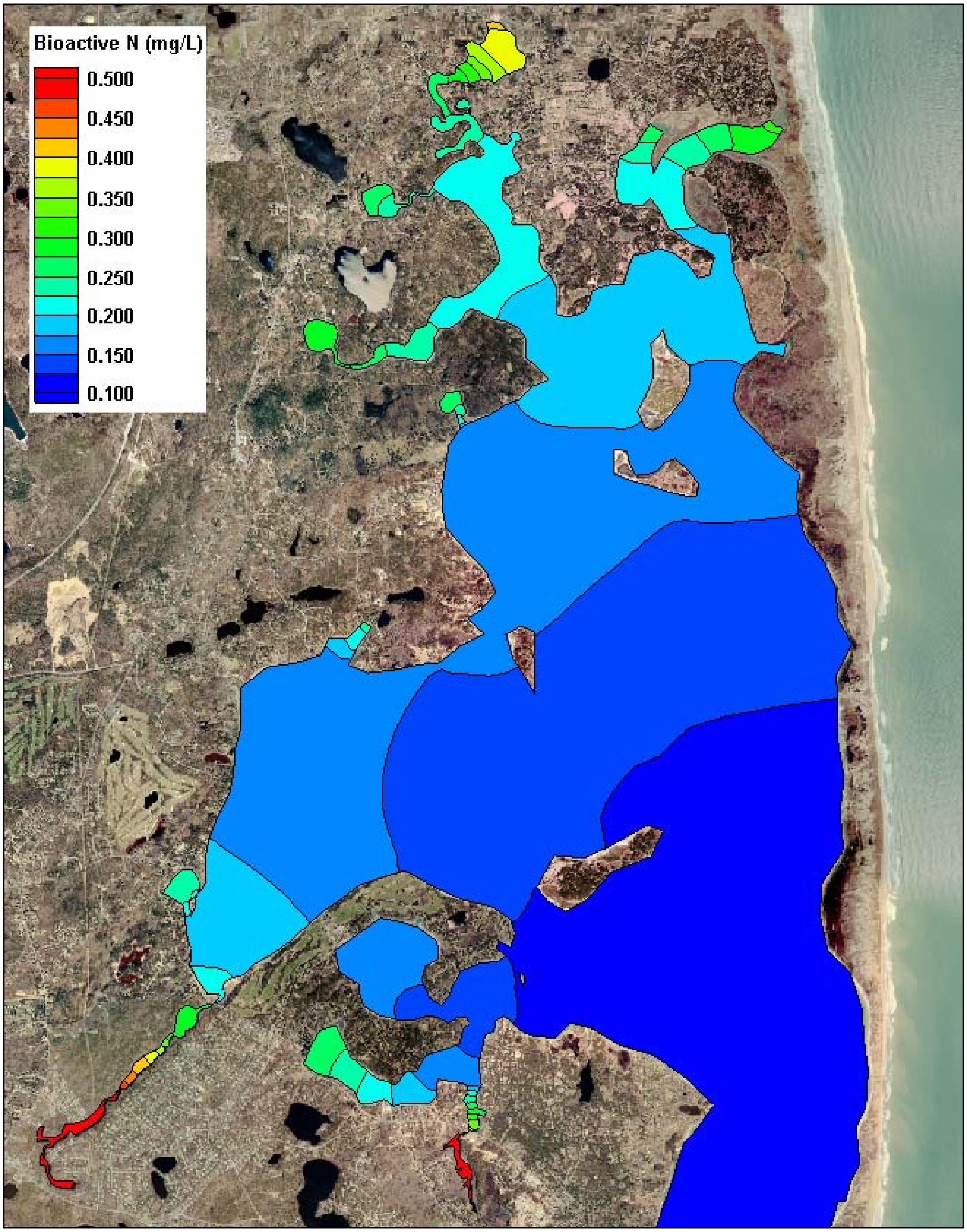


Figure 2. Color contour plot of model results representing present watershed loading and pre-breach hydrodynamic conditions. Contours indicate bioactive N concentrations, in mg/L.

Table 1. Sub-embayment and surface water loads used for total nitrogen modeling of the Pleasant Bay system, with total watershed N loads, atmospheric N loads, and benthic flux. These loads represent **present loading** conditions for the listed sub-embayments. Loads are from Howes, *et al*. (2006).

| sub-embayment | watershed load (kg/day) | direct atmospheric deposition (kg/day) | benthic flux net (kg/day) |
|---|---|---|---|
| Meetinghouse Pond | 6.197 | 0.584 | 14.365 |
| The River – upper | 2.773 | 0.288 | 6.263 |
| The River – lower | 3.879 | 2.241 | 10.480 |
| Lonnies Pond | 2.441 | 0.225 | 1.591 |
| Areys Pond | 1.304 | 0.181 | 5.996 |
| Namequoit River | 2.737 | 0.523 | 14.570 |
| Paw Wah Pond | 1.860 | 0.082 | 3.630 |
| Pochet Neck | 8.422 | 1.767 | -0.791 |
| Little Pleasant Bay | 7.496 | 24.023 | 37.226 |
| Quanset Pond | 1.781 | 0.170 | 5.988 |
| Tar Kiln Stream | 6.123 | 0.066 | - |
| Round Cove | 4.225 | 0.170 | 8.416 |
| The Horseshoe | 0.638 | 0.063 | - |
| Muddy Creek - upper | 9.981 | 0.162 | 4.560 |
| Muddy Creek - lower | 8.477 | 0.205 | -1.226 |
| Pleasant Bay | 23.159 | 19.153 | 149.013 |
| Pleasant Bay/Chatham Harbor Channel | - | 17.786 | -40.192 |
| Bassing Harbor - Ryder Cove | 9.819 | 1.296 | 9.356 |
| Bassing Harbor - Frost Fish Creek | 2.904 | 0.096 | -0.154 |
| Bassing Harbor - Crows Pond | 4.219 | 1.389 | 0.612 |
| Bassing Harbor | 1.668 | 1.071 | -4.976 |
| Chatham Harbor | 17.099 | 14.153 | -40.208 |
| **TOTAL - Pleasant Bay System** | **127.203** | **85.693** | **184.519** |

complete discussion of the loads and how they are applied in the model is provided in the MEP report.

Tidally averaged bio-active N concentrations from the simulation period are presented in Figure 2 and Table 2, for the post-breach simulation. N concentrations decrease at all locations in the system compared to the 2004 pre-breach conditions. Changes at the monitoring stations range between a 23.4% decrease (relative to the background N concentration of the ocean) in lower Muddy Creek to a smaller 3.1% decrease at the Chatham Harbor monitoring station.

The difference between pre- and post-breach water quality conditions is shown in Figure 4. For this plot, pre-breach tidally averaged N concentrations were subtracted from the results of the post-breach simulation and the resulting difference in bioactive N, as mg/L. mapped. Again, both model runs used hydrodynamic model output based on the measured 2004 offshore tide used in the original MEP analysis. This map of change shows that the greatest change occurs in the embayments farthest from the inlet. Muddy Creek and Meetinghouse Pond have the darkest contours, which indicate the greatest decrease in N concentrations from pre-breach conditions.

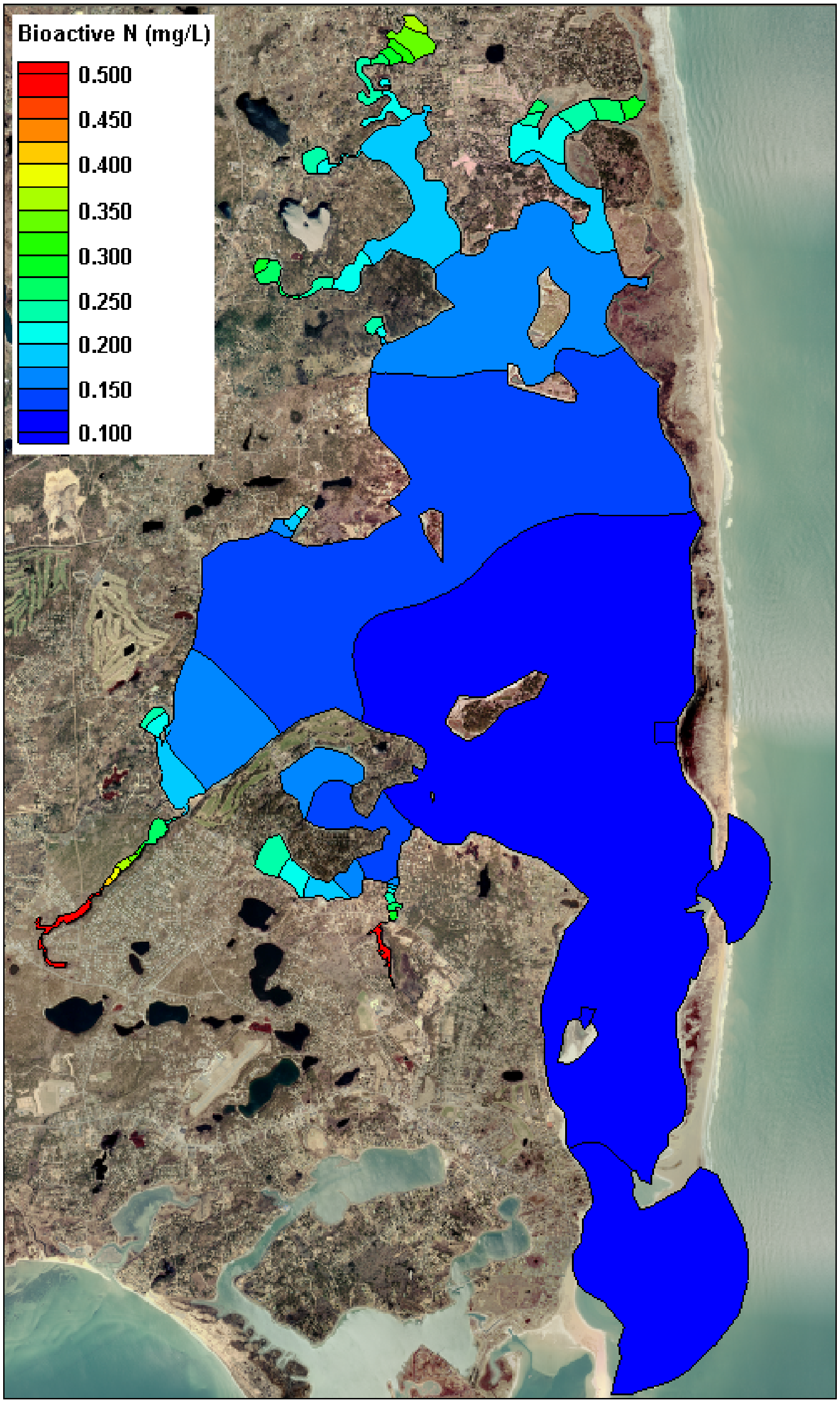


Figure 3. Color contour plot of bioactive N concentrations throughout the Pleasant Bay System for present watershed loading conditions with 2007 post-breach hydrodynamic conditions.

Table 2. Comparison of model average bioactive N (DIN+PON) concentrations from present loading with 2004 pre- and 2007 post-breach hydrodynamic conditions, with percent change, for the Pleasant Bay system. Both model runs use the 2004 measure offshore Atlantic tide as the forcing boundary condition. The percent change is computed relative to N concentrations above the background offshore N concentration (0.094 mg/L). The threshold stations for eelgrass restoration are shown in bold print (0.16 mg/L at PBA-12 and the average of PBA-03 and CM-13) and for benthic infauna restoration are shown in italics (0.21 mg/L at WMO-10, WMO-8, WMO-6, WMO-5, PBA-11, WMO-12, and PBA-05).

| Sub-Embayment | monitoring station | 2004 (mg/L) | 2007 (mg/L) | % change from backgound |
|---|---|---|---|---|
| Meetinghouse Pond | PBA-16 | 0.380 | 0.340 | -14.1% |
| *Meetinghouse Pond (Outer)* | *WMO-10* | *0.261* | *0.243* | *-11.1%* |
| The River – upper | WMO-09 | 0.239 | 0.221 | -12.3% |
| The River – mid | WMO-08 | 0.211 | 0.191 | -17.1% |
| *Lonnies Pond (Kescayo Ganset Pond)* | *PBA-15* | *0.250* | *0.227* | *-14.8%* |
| Areys Pond | PBA-14 | 0.297 | 0.274 | -11.1% |
| *Namequoit River - upper* | *WMO-6* | *0.239* | *0.220* | *-12.9%* |
| Namequoit River - lower | WMO-7 | 0.216 | 0.196 | -16.1% |
| The River – lower | PBA-13 | 0.195 | 0.174 | -20.4% |
| *Pochet – upper* | *WMO-05* | *0.269* | *0.253* | *-8.9%* |
| Pochet - lower | WMO-04 | 0.209 | 0.203 | -5.3% |
| Pochet – mouth | WMO-03 | 0.183 | 0.170 | -14.9% |
| **Little Pleasant Bay - head** | **PBA-12** | **0.178** | **0.158** | **-23.4%** |
| Little Pleasant Bay - main basin | PBA-21 | 0.162 | 0.144 | -26.1% |
| *Paw Wah Pond* | *PBA-11* | *0.257* | *0.230* | *-16.8%* |
| *Little Quanset Pond* | *WMO-12* | *0.229* | *0.211* | *-13.1%* |
| Quanset Pond | WMO-01 | 0.191 | 0.173 | -18.4% |
| *Round Cove* | *PBA-09* | *0.241* | *0.224* | *-11.5%* |
| Muddy Creek – upper | PBA-05a | 0.674 | 0.626 | -4.8% |
| *Muddy Creek – lower* | *PBA-05* | *0.286* | *0.251* | *-10.5%* |
| Pleasant Bay – head | PBA-08 | 0.149 | 0.133 | -30.2% |
| Pleasant Bay - off Quanset Pond | WMO-02 | 0.160 | 0.142 | -27.8% |
| Pleasant Bay- upper Strong Island | PBA-19 | 0.117 | 0.112 | -23.5% |
| Pleasant Bay - mid west basin | PBA-07 | 0.168 | 0.149 | -25.4% |
| Pleasant Bay - off Muddy Creek | PBA-06 | 0.192 | 0.173 | -18.9% |
| Pleasant Bay - Strong Island channel | PBA-20 | 0.124 | 0.117 | -24.8% |
| **Ryders Cove – upper** | **PBA-03** | **0.250** | **0.229** | **-13.0%** |
| **Ryders Cove – lower** | **CM-13** | **0.158** | **0.150** | **-11.3%** |
| Frost Fish – lower | CM-14 | 0.243 | 0.236 | +2.3% |
| Crows Pond | PBA-04 | 0.162 | 0.151 | -15.8% |
| Bassing Harbor | PBA-02 | 0.127 | 0.122 | -16.3% |
| Pleasant Bay - lower | PBA-18 | 0.116 | 0.113 | -14.8% |
| Chatham Harbor - upper | PBA-01 | 0.104 | 0.104 | -3.1% |

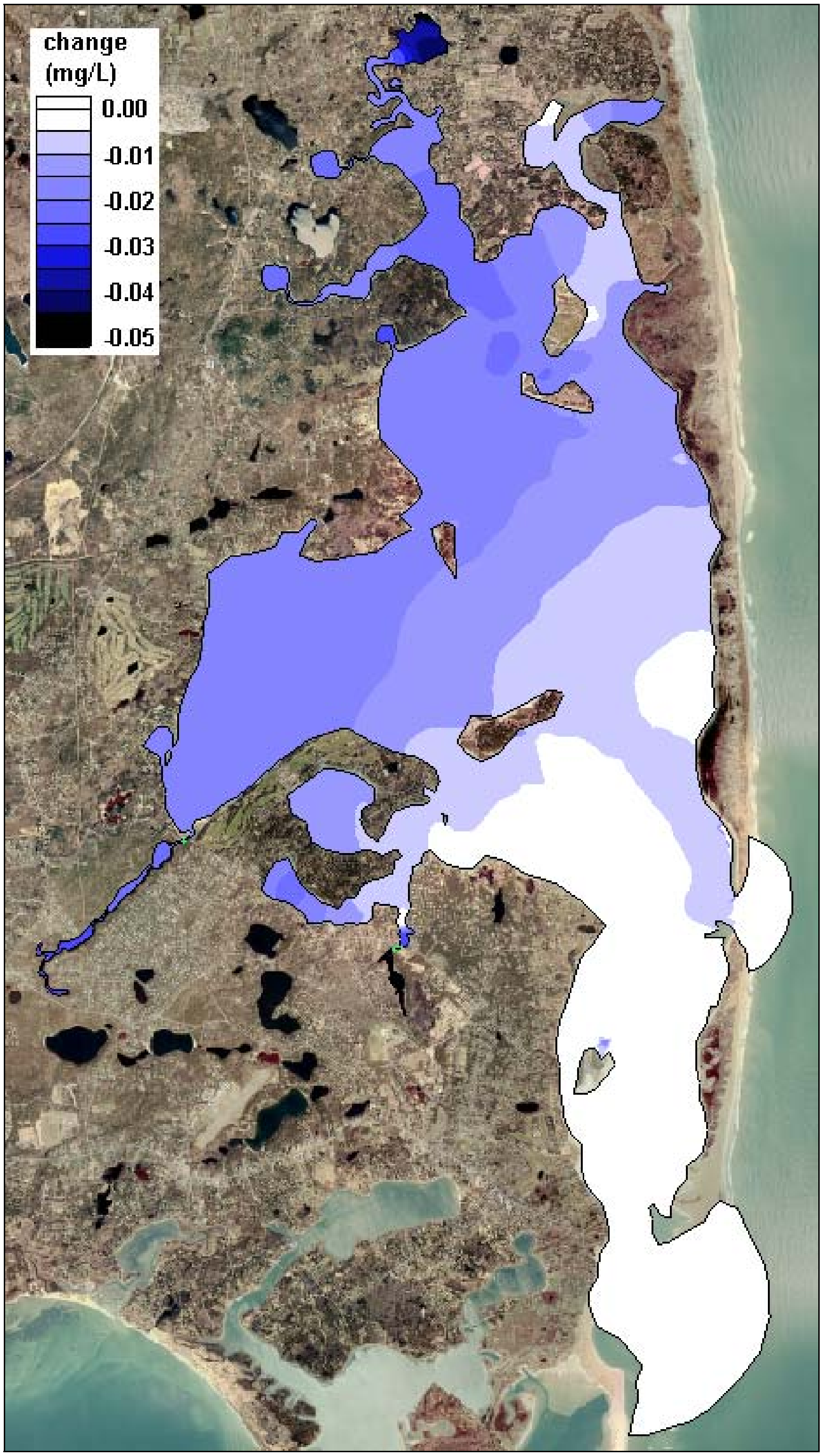


Figure 4. Color contours showing change in bioactive N concentration between post- (2007) and pre-breach (2004) hydrodynamic conditions for Pleasant Bay. Negative values indicate a decrease in post-breach concentrations compared to pre-breach condition. Both simulations were run using measured 2004 tides and present watershed loading.

The reductions at the primary critical N threshold stations are not enough to achieve the 0.16 mg/L level that is restorative to eelgrass. The primary threshold stations are at PBA-12 (at the head of Pleasant Bay), and the mid-point between PBA-3 and CM-13, in Ryder Cove. The reduction also is not enough to meet the requirements of the secondary benthic infauna threshold (0.21 mg/L) at any of the secondary threshold stations (indicated in Table 2). Therefore, though there is an improvement in N concentrations throughout the system, further reductions in the watershed load would be required in order to achieve conditions that are completely restorative to eelgrass and benthic infauna habitat.

**B. Worst Case Inlet Scenario**

The first model scenario is designed to simulate the likely worst case hydrodynamic conditions for the Pleasant Bay system. This scenario is based on the location of the southern inlet prior to the 1987 breach. Tidal flushing in Pleasant Bay is reduced in this scenario due to two main factors: first, a long inlet channel which has a greater drag on hydrodynamic flow; and second, a reduced tide range resulting from the greater influence of Nantucket Sound. The tide range at the entrance to Stage Harbor is approximately 60% of the range offshore Nauset Beach near Tern Island.

Since no tidal record exists for the inlet from the pre 1987 breach, it was necessary to develop a tidal boundary condition for the first scenario based on assumptions of the condition of the Pleasant Bay system in the 1950's. This time represents the earliest period for which the extent of eel grass across the system has been estimated (MassDEP Eelgrass Mapping Program). The inlet then was also located at its historical maximum southern excursion. Therefore, we derived an estimate of the 1950 total N load and then using this load, the tide range at the inlet was adjusted until the simulated distribution of N concentrations across Pleasant Bay that were supportive of the eel grass distribution determined for the 1950's.

The estimate of N loading for 1950 is an approximation, based on a reduced atmospheric deposition load, as well as a reduced upland nitrogen load. As a first estimate, 100% of the attenuated septic load was removed relative to existing conditions. This septic load removal was intended to account for groundwater travel times and to offset other loads that were unchanged from present conditions, including fertilizer and run-off. The watershed and atmospheric load to the bay estimated for 1950 was 45% lower than that for today. The benthic flux loading was also reduced (according to the method described in Howes, *et al*., 2006) to account for the effect of a reduced N load to the system.

Using the 1950 estimated load, the tide range at the inlet was adjusted until the N concentrations in the areas where eel grass existed in 1950 were equal to or less than 0.16 mg/L, which is the threshold bio-active N concentration determined for eel grass in Pleasant Bay. The adjusted tide that achieved this level was 90% of the range of the open Atlantic tide.

Finally, using the adjusted tide, a model run was made to determine N concentrations in Pleasant Bay using present loading with 100% septic removal. By removing all septic loads in this scenario, the effect of the combination of the best case

N loading and worst-case hydrodynamic can be simulated. A tabulation of loads used in this simulation is provided in Table 3.

Model output for this scenario is presented in Table 4. At both primary sentinel stations, in upper Pleasant Bay and in Ryder Cove, the bio-active N concentration exceeds the threshold limit of 0.16 mg/L. The secondary benthic infauna threshold level of 0.21 mg/L is achieved at all secondary stations. Therefore, even with removal of all septic loads, the primary threshold would not be met.

Table 3. Sub-embayment and surface water loads used for total nitrogen modeling of the Pleasant Bay system, with total watershed N loads, atmospheric N loads, and benthic flux. These loads represent "**no-septic**" conditions (present loading with 100% septic removal) for the listed sub-embayments.

| sub-embayment | watershed load (kg/day) | direct atmospheric deposition (kg/day) | benthic flux net (kg/day) |
|---|---|---|---|
| Meetinghouse Pond | 1.058 | 0.584 | 7.857 |
| The River – upper | 0.701 | 0.288 | 3.740 |
| The River – lower | 1.008 | 2.241 | 7.581 |
| Lonnies Pond | 0.811 | 0.225 | 1.017 |
| Areys Pond | 0.526 | 0.181 | 3.862 |
| Namequoit River | 0.726 | 0.523 | 9.894 |
| Paw Wah Pond | 0.351 | 0.082 | 2.343 |
| Pochet Neck | 1.808 | 1.767 | -0.531 |
| Little Pleasant Bay | 2.984 | 24.023 | 33.373 |
| Quanset Pond | 0.378 | 0.170 | 3.586 |
| Tar Kiln Stream | 4.326 | 0.066 | - |
| Round Cove | 1.063 | 0.170 | 4.224 |
| The Horseshoe | 0.164 | 0.063 | - |
| Muddy Creek - upper | 2.825 | 0.162 | 2.080 |
| Muddy Creek - lower | 2.137 | 0.205 | -0.632 |
| Pleasant Bay | 10.082 | 19.153 | 120.498 |
| Pleasant Bay/Chatham Harbor Channel | - | 17.786 | -36.009 |
| Bassing Harbor - Ryder Cove | 2.682 | 1.296 | 5.822 |
| Bassing Harbor - Frost Fish Creek | 0.704 | 0.096 | -0.087 |
| Bassing Harbor - Crows Pond | 0.893 | 1.389 | 0.444 |
| Bassing Harbor | 0.268 | 1.071 | -4.014 |
| Chatham Harbor | 2.904 | 14.153 | -36.727 |
| **TOTAL - Pleasant Bay System** | **38.400** | **85.693** | **128.319** |

## C. Single North Inlet Scenario

For the single north inlet scenario, a hydrodynamic model was developed based largely on the model for 2007 conditions, but also an estimate of how the north-south inlet complex will change through the coming decades. The estimate of the future condition of the inlet was in turn based present and historical data including the record of past breaches, present shoreline erosion/recession of Nauset Beach, and present inlet cross-sectional area. Graham Giese of the Provincetown Center for Coastal Studies provided input in the development of this inlet scenario. The shoreline used for this scenario is presented in Figure 5.

Table 4. Comparison of model average bioactive N (DIN+PON) concentrations from present loading with 2004 pre-breach and the no-septic loading scenario using 1986 hydrodynamic conditions, with percent change, for the Pleasant Bay system. Both model runs use the 2004 measure offshore Atlantic tide as the forcing boundary condition. The percent change is computed relative to N concentrations above the background offshore N concentration (0.094 mg/L). The threshold stations for eelgrass restoration are shown in bold print (0.16 mg/L at PBA-12 and the average of PBA-03 and CM-13) and for benthic infauna restoration are shown in italics (0.21 mg/L at WMO-10, WMO-8, WMO-6, WMO-5, PBA-11, WMO-12, and PBA-05).

| Sub-Embayment | monitoring station | 2004 (mg/L) | scenario one (mg/L) | % change from backgound |
|---|---|---|---|---|
| Meetinghouse Pond | PBA-16 | 0.380 | 0.270 | -38.5% |
| *Meetinghouse Pond (Outer)* | *WMO-10* | *0.261* | *0.211* | -30.1% |
| The River – upper | WMO-09 | 0.239 | 0.200 | -26.9% |
| The River – mid | WMO-08 | 0.211 | 0.186 | -21.1% |
| *Lonnies Pond (Kescayo Ganset Pond)* | *PBA-15* | *0.250* | *0.207* | *-27.6%* |
| Areys Pond | PBA-14 | 0.297 | 0.245 | -25.7% |
| *Namequoit River - upper* | *WMO-6* | *0.239* | *0.206* | *-22.5%* |
| Namequoit River - lower | WMO-7 | 0.216 | 0.191 | -20.3% |
| The River – lower | PBA-13 | 0.195 | 0.178 | -16.9% |
| *Pochet – upper* | *WMO-05* | *0.269* | *0.201* | *-38.9%* |
| Pochet - lower | WMO-04 | 0.209 | 0.182 | -23.7% |
| Pochet – mouth | WMO-03 | 0.183 | 0.171 | -13.1% |
| **Little Pleasant Bay - head** | **PBA-12** | **0.178** | **0.167** | **-12.7%** |
| Little Pleasant Bay - main basin | PBA-21 | 0.162 | 0.156 | -7.9% |
| *Paw Wah Pond* | *PBA-11* | *0.257* | *0.209* | *-29.3%* |
| *Little Quanset Pond* | *WMO-12* | *0.229* | *0.182* | *-35.1%* |
| Quanset Pond | WMO-01 | 0.191 | 0.172 | -19.6% |
| *Round Cove* | *PBA-09* | *0.241* | *0.196* | *-30.4%* |
| Muddy Creek - upper | PBA-05a | 0.674 | 0.357 | -54.6% |
| *Muddy Creek - lower* | *PBA-05* | *0.286* | *0.206* | *-41.9%* |
| Pleasant Bay – head | PBA-08 | 0.149 | 0.149 | -1.4% |
| Pleasant Bay - off Quanset Pond | WMO-02 | 0.160 | 0.156 | -6.1% |
| Pleasant Bay- upper Strong Island | PBA-19 | 0.117 | 0.123 | +23.9% |
| Pleasant Bay - mid west basin | PBA-07 | 0.168 | 0.161 | -9.8% |
| Pleasant Bay - off Muddy Creek | PBA-06 | 0.192 | 0.174 | -18.8% |
| Pleasant Bay - Strong Island channel | PBA-20 | 0.124 | 0.128 | +13.6% |
| **Ryders Cove - upper** | **PBA-03** | **0.250** | **0.187** | **-40.4%** |
| **Ryders Cove - lower** | **CM-13** | **0.158** | **0.145** | **-20.7%** |
| Frost Fish – lower | CM-14 | 0.243 | 0.181 | -41.8% |
| Crows Pond | PBA-04 | 0.162 | 0.148 | -20.2% |
| Bassing Harbor | PBA-02 | 0.127 | 0.129 | +4.8% |
| Pleasant Bay – lower | PBA-18 | 0.116 | 0.121 | +22.9% |
| Chatham Harbor - upper | PBA-01 | 0.104 | 0.110 | +64.3% |


Figure 5. Conceptualization of a single north inlet used for the development of the water quality model run of scenario two.

The 1850's breach that occurred in a location similar to the 2007 breach (Giese, 1988) was used as the model for the future behavior of the inlet. As the inlet continues to evolve, it is likely that the existing Nauset Beach remnant between the two inlets will move landward, and eventually weld to the mainland in a way similar to the progression of the south inlet after the breach in 1987. The north inlet will migrate south as Nauset Beach spit (which forms the north boundary of the north inlet) grows southward.

The landward migration of Nauset Beach into pleasant bay will also continue, as a result of continued sea level rise and shoreline retreat. In the next five decades the Nauset Beach shoreline is expected to move approximately 330 feet (100 meters) landward, based on past trends in shoreline change.

The inlet cross section used in the model of this scenario was based on the cross sectional area of the south inlet in 2004, prior to the north inlet breach. From the pre-breach bathymetry, the minimum inlet mid-tide cross-sectional area was determined to be approximately 15,200 $ft^2$. The cross section of the channel for the single north inlet scenario was made approximately 15% smaller to account for the reduced tide prism of the future scenario, since Chatham Harbor is not connected to the main basin of Pleasant Bay.

With the development of the model grid for the second scenario, hydrodynamics were run using the same 2004 time period used in the modeling of 2007 and in the first scenario. The water quality model was then run using the present N loading (Table 1) with the Chatham Harbor load removed. The bioactive N concentrations and the computed percent change from model 2004 conditions are presented in Table 5.

The resulting tidally averaged N concentrations are comparable to those computed in the simulation of 2007 post-breach conditions. The computed change from 2004 conditions is therefore also comparable. The second scenario results show a slight improvement over modeled 2007 conditions, with the greatest relative improvements seen in the main basin of Pleasant Bay . The single north inlet would offer further minor improvement in water quality compared to 2007 conditions, since the main basin of Pleasant Bay would have a more direct connection with the open Atlantic Ocean in this scenario. However, similar to 2007 post-breach conditions, the changes are not great enough to meet the threshold concentrations set for the restoration of eel grass and benthic infauna.

**D. References**

Giese, G.S. (1988). “Cyclical Behavior of the Tidal Inlet at Nauset Beach, Massachusetts: Application to Coastal Resource Management.” In: Lecture Notes on Coastal and Estuarine Studies, Volume 29, Symposium on Hydrodynamics and Sediment Dynamics of Tidal Inlets (D. Aubrey and L. Weishar, eds.), Springer-Verlag, NY, pp. 269-283.

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2006). Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA. 227pp. Available online at http://www.oceanscience.net/estuaries/

Kelley, S.W., J.S. Ramsey (2008). Hydrodynamic Model of Chatham Harbor/Pleasant Bay including 2007 North Breach. Technical Memo. Applied Coastal Research and Engineering, Mashpee, MA. 24 pp.

Table 5. Comparison of model average bioactive N (DIN+PON) concentrations from present loading with 2004 pre- and projected future single north inlet hydrodynamic conditions, with percent change, for the Pleasant Bay system. Both model runs use the 2004 measure offshore atlantic tide as the forcing boundary condition. The percent change is computed relative to N concentrations above the background offshore N concentration (0.094 mg/L). The threshold stations for eelgrass restoration are shown in bold print (0.16 mg/L at PBA-12 and the average of PBA-03 and CM-13) and for benthic infauna restoration are shown in italics (0.21 mg/L at WMO-10, WMO-8, WMO-6, WMO-5, PBA-11, WMO-12, and PBA-05).

| Sub-Embayment | monitoring station | 2004 (mg/L) | scenario two (mg/L) | % change from backgound |
|---|---|---|---|---|
| Meetinghouse Pond | PBA-16 | 0.380 | 0.355 | -8.7% |
| *Meetinghouse Pond (Outer)* | *WMO-10* | *0.261* | *0.247* | *-8.4%* |
| The River - upper | WMO-09 | 0.239 | 0.225 | -9.7% |
| The River – mid | WMO-08 | 0.211 | 0.195 | -13.4% |
| *Lonnies Pond (Kescayo Ganset Pond)* | *PBA-15* | *0.250* | *0.233* | *-10.7%* |
| Areys Pond | PBA-14 | 0.297 | 0.280 | -8.3% |
| *Namequoit River - upper* | *WMO-6* | *0.239* | 0.224 | -10.6% |
| Namequoit River - lower | WMO-7 | 0.216 | 0.200 | -13.0% |
| The River - lower | PBA-13 | 0.195 | 0.178 | -16.3% |
| *Pochet – upper* | *WMO-05* | *0.269* | *0.264* | *-2.8%* |
| Pochet - lower | WMO-04 | 0.209 | 0.209 | 0.0% |
| Pochet – mouth | WMO-03 | 0.183 | 0.175 | -9.3% |
| **Little Pleasant Bay - head** | **PBA-12** | **0.178** | **0.162** | **-18.9%** |
| Little Pleasant Bay - main basin | PBA-21 | 0.162 | 0.147 | -22.1% |
| *Paw Wah Pond* | *PBA-11* | *0.257* | *0.238* | *-11.6%* |
| *Little Quanset Pond* | *WMO-12* | *0.229* | *0.210* | *-14.2%* |
| Quanset Pond | WMO-01 | 0.191 | 0.172 | -20.1% |
| *Round Cove* | *PBA-09* | *0.241* | *0.221* | *-13.5%* |
| Muddy Creek - upper | PBA-05a | 0.674 | 0.644 | -5.2% |
| *Muddy Creek - lower* | *PBA-05* | *0.286* | *0.264* | *-11.6%* |
| Pleasant Bay - head | PBA-08 | 0.149 | 0.133 | -30.2% |
| Pleasant Bay - off Quanset Pond | WMO-02 | 0.160 | 0.140 | -30.2% |
| Pleasant Bay- upper Strong Island | PBA-19 | 0.117 | 0.111 | -29.5% |
| Pleasant Bay - mid west basin | PBA-07 | 0.168 | 0.147 | -28.2% |
| Pleasant Bay - off Muddy Creek | PBA-06 | 0.192 | 0.171 | -21.3% |
| Pleasant Bay - Strong Island channel | PBA-20 | 0.124 | 0.113 | -37.1% |
| **Ryders Cove - upper** | **PBA-03** | **0.250** | **0.231** | **-12.7%** |
| **Ryders Cove - lower** | **CM-13** | **0.158** | **0.148** | **-16.8%** |
| Frost Fish - lower | CM-14 | 0.243 | 0.240 | -2.5% |
| Crows Pond | PBA-04 | 0.162 | 0.150 | -18.6% |
| Bassing Harbor | PBA-02 | 0.127 | 0.117 | -29.6% |