Appendix D

Nitrogen-Loading Worksheets for Coastal Embayments

On the following pages are worksheets that describe how to implement a nitrogen management strategy for sensitive embayments around Buttermilk Bay. Because physical characteristics are different for each embayment, the critical nitrogen-loading limit will also be different. To calculate this critical nitrogen-loading limit for each embayment, a community fills out the first worksheet (Part 1). The next step (Part 2) is to inventory the existing and grandfathered anthropogenic nitrogen inputs in the drainage basin. The third step (Part 3) is to calculate what the expected future nitrogen-loading inputs will be from development expected to occur in the drainage area based on current zoning. The Total Nitrogen at Buildout is equal to the Existing Nitrogen Loading from Part 2 and the Additional Nitrogen Loading Expected from Part 3.

If the Total Nitrogen Load at Buildout [Item 23 in Part 3] is less than or equal to the Critical Loading Limit to the Embayment [Item 9c in Part 1], no changes are needed to the existing land-use program for that embayment drainage basin.

If the Total Existing Nitrogen Load [Item 17 in Part 2] or the Total Nitrogen Load at Buildout [Item 23 in Part 3] is greater than the Critical Loading Limit to the Embayment [Item 9c in Part 1], a nitrogen management strategy is needed for that embayment. The strategy must include changes in the expected future land use of the embayment's drainage basin to conform with established goals. Part of that strategy could be to require that proposed subdivisions meet loading limits per unit of land area developed (Part 4). If existing loading exceeds limits, a long term strategy to reduce existing inputs must be developed if the embayment is to be restored. Specific recommendations and nitrogen-management strategies are described in the action plan entitled Managing Nitrogen-Sensitive Embayments in Chapter 5. The technical basis of the nitrogen management strategy is contained in Costa et. al. 1991.

Part 1: Establishing Nitrogen-Loading Limits

1. Embayment: _____
2. Area of Bay:_____ hectares
3. Mean depth of bay at MLW:_____ m
4. Tidal prism volume: _____ cubic m
5. Volume at mid-tide: _____ cubic m[1]
6. Flushing time or residence period _____ days[2]
7. Flushing time or residence period ([item 6a] /365) _____ years
8. Critical loading rate for this embayment— (select 8a or 8b)[3]

   8a (volume-flushing adjusted limit):_____ mg/cu. m flushing during Vollenweider period

   8b (area adjusted limit): _____ mg/sq. m per year
9. Critical loading limit to embayment (use 9a or 9b based on criteria in Table 5.1):

   (METHOD 1, volume-flushing adjusted limit as in 8a)[4]

$$\frac{[\text{Item 8a}] \times [\text{Item 5}] \times (1+\text{sqrt}[\text{item7}]) \times 2.2}{[\text{item7}] \times 1{,}000{,}000} =$$

   9a. _____ lb N/year to the drainage basin

   (METHOD 2, area adjusted limit as in 8b)

   [Item 8b] x [Item 2] x 10 x 2.2 =

   9b. _____ lb N/year to the drainage basin

[1] Volumes of most major embayments are available from the Buzzards Bay Project. Volume at mid-tide can also be calculated by adding 1/2 the tidal prism to the volume of the bay at mean low water (MLW), or [Item 2] x [Item 3] + [Item 4]/2.. If mean depth is unknown, it will be necessary to calculate the area of each bathymetric contour on nautical charts to determine volume at MLW.

[2] Flushing should be calculated by a qualified hydrographer. The Buzzards Bay Project is developing criteria for the application of different flushing calculation methodologies. Preliminary flushing calculations for Buzzards Bay embayments are included in Table 5.2.

[3] Refer to Table 5.1 for the appropriate limits and method to use.

[4] The term (1+sqrt(flushing time in years) is an adjustment to the flushing period as described by Vollenweider (1976) and Costa et al., 1991, and referred to here as the Vollenweider term.

Part 2: Existing Anthropogenic Nitrogen Inputs

10. a. Number of existing residences in drainage basin: _____

    b. [Item 10a] x 17.7 lb/yr/residence[5] = _____ lb/year

11. [Item 10a] x 5000 sq ft/unit x 0.6 lbs N/1000 sq ft/yr[6] = _____ lb/year

12. a. Cranberry bog area in drainage basin: _____ acres

    b. [Item 12a] x 15.8 lb/ac/yr = _____ lb/year

13. a. Other agricultural area in drainage basin:

    b. Pounds and type of animal raised per year x _____ lb N/100 lb of animal/yr[7] =

    c. Acreage of various crops raised x _____lb N/ac/yr = _____ lb/year[7]

14. a. Area of existing paved surfaces in drainage basin: _____sq ft

    b. [Item 14a] x 0.31 lb N/1000 sq ft/year = _____ lb/year

15. a. Acreage of golf courses and cemeteries in drainage basin: _____

    b. [Item 15a] x _____lb N leached/1000 sq ft/yr = _____ lb/year

16. a. Significant non-residential land uses in drainage basin[7]: lb/year

Source	Flow	Units	Volume	N-Concentration	N Load
					lbs/yr
					lbs/yr
					lbs/yr
					lbs/yr

17. TOTAL EXISTING NITROGEN LOAD (add items 10 -16): _____ lb/year

[5] Presumes 3 people per residence, 5.9 lbs/person/year

[6] This assumes an application rate of 3 lbs N/1000 sq ft and a 20% combined leaching and runoff rate

[7] To calculate these inputs, use the methodology and assumptions outlined in "A Mass-Balance Nitrate Model for Predicting the Effects of Land Use on Groundwater Quality," USGS Open-File Report 88-493.

Part 3: Expected Additional Anthropogenic Nitrogen Inputs from Undeveloped Lands

18. a. # of additional residences in drainage basin: _____

    b. [Item 18a] x 17.7 lb/yr/residence[5] = _____ lb/year

19. [Item 18a] x 5000 sq ft/unit x 0.6 lb N/1000 sq ft/yr = _____ lb/year

20. a. Area of additional paved surfaces in drainage basin: _____ sq ft

    b. [Item 20a] x 0.31 lb N/1000 sq ft/year = _____ lb/year

21. Significant additional non-residential land uses in the drainage basin:[8]

Source	Flow	Units	Volume	N-Concentration	N Load
					lb/yr
					lb/yr
					lb/yr
					lb/yr

TOTAL non-residential: _____ lb/year

22. TOTAL ADDITIONAL ANTHROPOGENIC NITROGEN LOADS EXPECTED FROM UNDEVELOPED LANDS (add items 18 -21) _____ lb/year

23 TOTAL NITROGEN LOAD AT FULL BUILDOUT:

(Add Items 17 and 22)

If item 23 exceeds item 9c, nitrogen reduction strategies must be considered for the embayment.

If item 23 is less than item 9c, nitrogen-limiting strategies do not have to be considered for the embayment.

[8] Contributions from other types of proposed development should follow the methodology and loading assumptions outlined in "A Mass-Balance Nitrate Model for Predicting the Effects of Land Use on Groundwater Quality," USGS Open-File Report 88-493.

Part 4: Contributions from a Proposed Subdivision[9]:

Overlay District's permitted nitrogen loading limit to drainage basin: ____ lb/acre/yr

24 a. Number of units with 3 bedrooms or less: ____

b. [Item 24a] x 17.7 lb/yr/unit = ____ lb/yr

25 a. Total number of bedrooms from units with 4 bedrooms or more: ____

b. [Item 25a] x 5.9 lb/yr/bedroom = ____ lb/yr

26 a. Total number of units: ____

b. [Item 26a] x 5000 sq ft lawn/unit x 0.6 lb N/1000 sq ft/yr [10] =

_____lb/yr

27 a. Calculate the sq ft of paved or potentially paved surfaces in the subdivision:____

b. [Item 27a] x 0.31 lb N/1000 sq ft/year = _____ lb/1000 sqft/yr

28. a. TOTAL NITROGEN FROM SUBDIVISION (add items 24 - 27) ____ lb/yr

28. b. [Item 28a]/area of the subdivision in acres= ____ lb/acre/yr

If the per-unit-area contribution of nitrogen loading from the subdivision (Item 28b) is less than or equal to the permitted nitrogen-loading limit, and if the total nitrogen contribution from the subdivision (Item 28a) when added to Item 17 does not exceed embayment loading limits (Item 9c), no changes are needed to reduce nitrogen from the development.

If these conditions are not met, the proposed development must be changed to reduce the expected nitrogen loading to be less than or equal to the permitted nitrogen-loading limits.

The inputs from land left in its naturally vegetated condition should not be considered in this calculation.

[9] Contributions from other types of proposed development should follow the methodology and loading assumptions outlined in "A Mass-Balance Nitrate Model for Predicting the Effects of Land Use on Groundwater Quality," USGS Open-File Report 88-493.

[10] The average lawn size may be reduced if necessary provisions are included to guarantee the reduced size. As before, the assumed application rate is 3 lbs N/1000 sq ft and a 20% combined leaching and runoff rate.