Can Title 5 protect coastal embayments?

An issue paper
by
J.E. Costa
Buzzards Bay Project, MCZM
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Introduction

The Department of Environmental Protection is considering amending Title 5 to limit septic system effluent dosage rates (gpd per system) in selected subwatersheds in the Commonwealth in order to protect coastal waters that may be sensitive to nitrogen inputs. The fundamental question has been posed, what allowable effluent dosage rates are adequately protective of these sensitive areas?

In the Buzzards Bay Comprehensive Conservation and Management Plan (CCMP), the Buzzards Bay Project recommends both a nitrogen management strategy (mass loading approach based on parcel level land use analysis) and recommended limits (a tiered system of embayment specific loading limits that depend on embayment volume, turnover time, bathymetry, and water quality classifications) to protect coastal waters. This approach has also been adopted by the Cape Cod Commission, in its regulatory decision making process.

While the Buzzards Bay Project recommends the use of a mass loading approach, rather than the establishment of groundwater concentration objectives, the recommended limits in the CCMP can be translated to groundwater concentration goals, if certain information about the embayment and its subwatershed (subbasin) is known, namely total maximum annual load of nitrogen allowed (embayment volume, turnover time, and bathymetry must be known) and watershed area and recharge.

The Buzzards Bay Project has already collected most of the above mentioned data for most Buzzards Bay embayments. Below is a summary of both the theoretical groundwater nitrogen concentrations for a given subwatershed under different Title 5 dosage and occupancy rates and a summary of groundwater concentration limits that should not be exceeded in the subwatersheds around Buzzards Bay embayments based on Buzzards Bay Project recommended limits.

Title 5 and groundwater N concentrations

The relationship between different levels of development and groundwater nitrogen concentration within a hydrologic unit (well recharge area, etc.) has been well established. It is generally accepted that nitrogen from septic systems in a recharge area, when mixed with groundwater recharge (precipitation on a subwatershed) will eventually reach certain equilibrium concentrations in the groundwater. Environmental planners routinely consider these groundwater impacts when reviewing projects or establishing zoning, especially in the recharge areas of public wells. Planners may assume either worst case or typical loading conditions.

In Tables 1 and 2 below, expected theoretical mean groundwater N concentrations are shown for Title 5 systems under various dosage, occupancy, and parcel size scenarios. Table 1 shows groundwater nitrogen concentrations expected based on system design limits (2 persons per bedroom), Table 2 shows N concentrations based on typical mean regional occupancy (1 person per bedroom, typical when unit vacancies are included). The expected groundwater concentrations were based on two key assumptions: a per capita nitrogen loading of 5.9 lb annually (55 gpd x 35 ppm N effluent reaching groundwater per capita; values adopted by the Buzzards Bay Project and Cape Cod Commission), and the recharge rate of 20" per year for vegetated surface (Cape Cod Commission--Cape area average). It was also assumed that groundwater background N concentrations are zero and precipitation is not a source of N.

Table 1. Theoretical groundwater nitrogen concentrations at maximum occupancy (system design limits-2 persons per bedroom)[1].

Design limit flow (gpd)	bedrooms	occup.	Parcel (sq ft)	MEAN N FOR PARCEL septic only (ppm)	septic +lawns+imperv. (ppm)
440	4	8	40000	8.9	9.5
440	4	8	30000	10.9	11.7
440	4	8	20000	14.1	15.2
440	4	8	15000	16.6	17.9
440	4	8	10000	20.1	20.9
330	3	6	40000	6.6	7.3
330	3	6	30000	8.2	9.0
330	3	6	20000	10.6	11.7
330	3	6	15000	12.5	13.7
330	3	6	10000	15.1	15.8
220	2	4	40000	4.4	5.1
220	2	4	30000	5.4	6.3
220	2	4	20000	7.1	8.1
220	2	4	15000	8.3	9.6
220	2	4	10000	10.1	10.8

[1] Assumptions: 1) maximum occupancy (2 persons/bedroom, 55 gpd per capita), 2) recharge = 19 " (=Cape Cod average, < 50% annual 44" rainfall, 3) N-conc. reaching groundwater =35 ppm (BBP & Cape Cod Comm.), 4) background N concentration = 0 ppm, 5) lawn=5000 sq ft except 10 k lots =2000, impervious = roofs + roads (i.e. add 3.5 lb per unit, 1.7 lb for 10 k lot)

Table 2. Theoretical groundwater nitrogen concentrations at typical average occupancy (1 person per bedroom)[2].

Design limit flow (gpd)	bedrooms	REALISTIC occup.	Parcel (sq ft)	MEAN N FOR PARCEL septic only (ppm)	septic +lawns+imperv. (ppm)
440	4	4	40000	4.4	5.1
440	4	4	30000	5.4	6.3
440	4	4	20000	7.1	8.1
440	4	4	15000	8.3	9.6
440	4	4	10000	10.1	10.8
330	3	3	40000	3.3	4.0
330	3	3	30000	4.1	4.9
330	3	3	20000	5.3	6.4
330	3	3	15000	6.2	7.5
330	3	3	10000	7.6	8.3
220	2	2	40000	2.2	2.9
220	2	2	30000	2.7	3.5
220	2	2	20000	3.5	4.6
220	2	2	15000	4.2	5.4
220	2	2	10000	5.0	5.8

[2] Same assumptions as Table 1. Actual average occupancy rates for Buzzards Bay area (=census population divided by total units [occupied + unoccupied]) is around 3 persons/unit [typical range: 2.7-3.3]).

In both tables, nitrogen concentration increases due to septic systems alone, and septic systems together with other N sources such as lawns and paved surfaces are shown. The latter sources are generally used for land use planning, but as shown, 80-90% of nitrogen from development is due to septic systems.

It is apparent from Table 1 (worst case conditions), that to protect drinking water supplies (10 ppm limit), one acre lots are required for 4 bedroom units. More stringent groundwater limits were adopted by the Cape Cod Commission (5 ppm) to account for uncertainties in the calculations and to ensure that 10 ppm is never exceeded. Such a limit requires even larger lot size or fewer bedrooms.

Embayment specific nitrogen goals

Tables 1 and 2 can be referenced easily to a single drinking water concentration goal (e.g. 10 ppm), but how do the predicted concentrations compare to embayment specific limits? Table 3 shows how embayment specific N loading goals translate to groundwater concentrations.

As might be expected, because both the size of coastal subwatersheds and embayment specific N loading limits are variable, protective groundwater N concentrations for coastal waters are wide ranging. On the low end are 0.4 ppm for the Weweantic River subbasin, 0.6 ppm each for the Slocums and Wareham River subbasin, and 1.2 and 1.5 ppm for the West and East Branches of the Westport River subbasins. Each of these embayments are poorly flushed compared to other Buzzards Bay embayments and have very large surrounding drainage subbasins. At the opposite extreme groundwater protective concentrations of 60 ppm for the Quissett Harbor subbasin, 23 ppm for the Aucoot Cove subbasin, 43 ppm for the Brant Island Cove subbasin. These embayments are well flushed compared to other Buzzards Bay embayments and their surrounding drainage basins are quite small. The majority of Buzzards Bay embayments would be protected by groundwater concentrations between 2 and 14 ppm.

Table 3. Recommended N loading limits for selected Buzzards Bay embayments, and respective N concentration targets in groundwater. "BBP preliminary recommended actions" were based on whether or not N-loading from land use now exceed N limits or would do so in the future.

BUZZARDS BAY EMBAYMENT	WATER AREA(km2)	Basin land area(km2)	Recommd N limit	BBP preliminary Recommended action	loadlimit GrndWtr conc
Acushnet River (New Bedford inner	4.27	69.5	192000	Remediate/man growth	5.4
Allens Pond	0.77	9.1	12000	no action	2.6
Apponagansett Bay, inner harbor	1.54	19.9	36000	Remediate/man growth	3.6
Aucoot Cove	1.29	10.5	124000	no action	23.1
Brant Island Cove	0.34	1.7	34000	no action	40.3
Buttermilk Bay	2.17	26.0	50000	Manage future growth	3.8
Hen Cove	0.26	2.7	3900	Remediate/man growth	2.9
Little River	0.50	5.3	11700	Remediate/man grwth	4.3
Marks Cove	0.46	2.9	22000	no action	14.6
Mattapoisett upper+lower	4.32	80.2	86000	Manage future growth	2.1
Inner Nasketucket Bay	2.05	14.2	107000	no action	14.8
Onset Bay	2.39	12.6	37000	Manage future growth	5.8
Phinneys Harbor	2.17	9.8	127000	no action	25.3
Pocasset River	0.80	19.6	21000	Manage future growth	2.1
Quisset Harbor	0.47	1.3	40000	no action	60.4
Red Brook Harbor	0.61	6.3	19000	no action	5.9
Sippican Harbor upper harbor	1.70	6.1	26000	no action	8.3
Slocums River	1.97	95.7	30000	Remediate/man growth	0.6
Squeteague Harbor	0.30	9.5	31000	no action	6.4
Wareham River	2.49	114.4	37000	Remediate/man growth	0.6
West Falmouth Harbor	0.80	10.7	37000	Manage future growth	6.8
Westport River, East Branch	8.02	154.8	120000	Manage future growth	1.5
Westport River, West Branch	5.32	44.0	27000	Remediate/man growth	1.2
Weweantic River	2.38	217.3	48000	Remediate/man growth	0.4
Widows Cove	0.54	1.4	28000	no action	39.1
Wild Harbor	0.49	2.6	30000	no action	22.7
Wings Cove	0.88	3.3	28000	no action	16.5
Waquoit Bay	6.56		63000	no action	ERR

Discussion

Clearly no single groundwater concentration limit is appropriate for all embayments, and protective groundwater concentrations are too wide ranging for any single standard. Moreover, a comparison of Tables 1 and 2 to Table 3 shows that even the most stringent dosage limits will not adequately protect some embayments. In those embayments, other sewage disposal strategies need to be considered if it is desired that nitrogen be managed.

It should be pointed out that the concentrations in Tables 1 and 2 can be directly compared to the concentrations in Table 3 only if the subbasin is 100% developed by residential units. In practical terms only 50-75% of any subbasin may be buildable as single family dwellings--other land being unbuildable wetlands, open space, or other land uses. In land use planning, some of these other land uses need also be considered nitrogen sources (some kinds of agriculture and husbandry exceed the nitrogen loading rates of residential use land). Even if only 50% of the land was developable in a particular subbasin, however, the expected groundwater concentrations from Title 5 systems (1/2 of values in Tables 1 and 2) would in many instances still exceed the limits in Table 3.

By far, the most serious limitation of the preceding analysis is that existing development was ignored. Most of these coastal watersheds have considerable amounts of development in place, at densities and dosage rates that far exceed the new dosage limits being considered in for Title 5. Adoption of new Title 5 system standards will do little to affect existing degraded embayments, or expected future conditions in other embayments. Adoption of a dosage limit of say 330 gpd will protect some Buzzards Bay embayments, but in many others, embayment specific management strategies must be developed that may include changes in zoning, the use of n-removing systems for new development, the retrofit of existing systems with nitrogen removal sewage treatment technologies, procurement of open space procurement, implementation of agricultural BMPs, and other regulatory and non-regulatory tools.

Conclusion

Title 5 should include dosage limits for subbasins around sensitive coastal embayments, but it must be recognized that this may be just one tool in a more holistic program to manage nitrogen to coastal waters.