Planning Board
and Board of Selectmen
59 Town Hall Square
Falmouth, MA 02540

October 9, 1997

Re: Update on Buzzards Bay Project assistance on West Falmouth Harbor Nitrogen Management Needs

Dear Honorable Board Members,

During the past several years, the Buzzards Bay Project[1] prepared for the Town of Falmouth several progress reports and evaluations on work undertaken by the Buzzards Bay Project, the Town, the Cape Cod Commission and others to document sources and impacts of nitrogen inputs in the West Falmouth Harbor watershed. The Buzzards Bay Project's objective in this endeavor is to provide technical, and where feasible, financial assistance to help the Town of Falmouth to develop a nitrogen management strategy for West Falmouth Harbor. Such a nitrogen management plan is not only a requirement by DEP for future upgrades of the town's wastewater plant, but is also essential for ensuring that the town protects the valuable coastal resources of West Falmouth Harbor.

Since our last report on the Wastewater Sewage Treatment Facility in May 1997, the Buzzards Bay Project has received and evaluated new data regarding the sewage treatment facility and other nitrogen sources in the watershed. Most importantly, a track record has been established as to the performance of the wastewater facility in light of recent upgrades.

Enclosed is an update of our May 1997 report on the performance of Falmouth's Wastewater Treatment Facility. This information and data on other nitrogen sources will be included in our draft nitrogen management report for West Falmouth Harbor this Fall. Two important findings in the enclosed report may be of interest to you:

- Combine inflow of sewage and septage into the facility increased substantially this summer, and total flow for 1997 is 17% above last year. This rate of increase is more than double the 8% annual increase in flow from the previous two years. If 1998 has a similar increase, the sewage treatment plant will exceed its 880,000 GPD discharge limit for the first time during the 1998 summer peak flow period. This and other aspects of the plant may result in DEP requiring the Town to prepare a new "Facility Plan" before the facility's 1999 permit renewal deadline. The evaluations of the Wastewater Facility performed by the Buzzards Bay Project during the past several years should help defray some of the town's costs in the preparation of a Facility

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*The **Buzzards Bay Project National Estuary Program** is a planning and technical assistance unit of Massachusetts Coastal Zone Management, and is jointly funded by the Commonwealth and the US EPA. The Project is sometimes confused with two non-profit organizations. One of these is the **Coalition for Buzzards Bay**, a not-for-profit education group, and the other is the **Buzzards Bay Action Committee**, a not-for-profit lobbying group composed of municipal officials.*

Plan.

- Improvements to the wastewater facility, such as upgrading of the aeration system, have been important in controlling odors and in improving the performance of the facility. However these upgrades have not increased the facility's ability to remove nitrogen, which remains a management concern. It is also important to recognize that the facility is not now violating nitrogen water quality limits established in its discharge permit. The Town's wastewater facility currently has a Class III groundwater discharge permit, the most lenient groundwater discharge standard, with a 50 ppm nitrogen discharge limit. Only three other Class III discharge permits remain in effect in the Commonwealth. Given increased concerns statewide about better protection of groundwater and surface water resources and the rapidly increasing flow to the facility, it is likely that DEP will consider more stringent discharge limits on the discharge. Such a decision would require capital improvements to the wastewater facility.

If you have any questions regarding this report, or if you would like a presentation, please do not hesitate to call me. The Buzzards Bay Project will soon reconvene the West Falmouth Harbor Nitrogen Management Workgroup to discuss these and other findings.

Sincerely,

Joseph E. Costa, Ph.D.
Executive Director

cc. West Falmouth Nitrogen Management Workgroup
Town of Falmouth Conservation Commission, Board of Health

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An updated Analysis of Wastewater Disposal at the Falmouth Wastewater Disposal Facility with respect to Nitrogen Loading in West Falmouth Harbor

by J. E. Costa

Buzzards Bay Project
National Estuary Program

October 9, 1997

Background

For the past several years, the Buzzards Bay Project National Estuary Program, a unit of Massachusetts Coastal Zone Management, has worked with the town of Falmouth and the Cape Cod Commission to document nitrogen sources in the West Falmouth Harbor watershed and their impacts on the harbor. The Buzzards Bay Project's objective in this endeavor is to provide technical and where feasible, financial assistance to help the Town of Falmouth to develop a nitrogen management strategy for West Falmouth Harbor. Such a nitrogen management plan is not only a requirement by Department of Environmental Protection (DEP) for the upgrade of the town's wastewater plant, but is also essential for ensuring that the town protects the valuable coastal resources of West Falmouth Harbor.

On May 17, 1997, the Buzzards Bay Project sent a preliminary evaluation of nitrogen loading to West Falmouth Harbor to the town. This report updates information contained in that report, and includes an evaluation of the Town's well monitoring conducted this past spring. This evaluation of nitrogen loading from the sewage treatment facility will be included in the West Falmouth Nitrogen Management Plan being developed by the Buzzards Bay Project. Other important sources of nitrogen in the watershed which will be included in this management plan include the Town landfill and residential and commercial development.

Sewage inflow to the wastewater plant

The Falmouth Wastewater treatment plant has a permit to discharge to groundwater 880,000 Gallons Per Day (GPD). This limit includes the total of both **sewage** conveyed by pipes from homes and businesses and **septage** (pumped cesspool and septic tank waste) hauled to the plant by trucks. Sewage intake by the plant is seasonal with flows highest in summer (with a peak in July) and lowest in winter. In 1996, the wintertime average intake of sewage was around 300,000 GPD and summertime flow averaged 500,000 GPD (Fig. 1).

In contrast to 1996, 1997 has shown a dramatic increase in the intake of sewage to the treatment facility, especially during July, which showed a 100,000 gallon or 19% increase in flow for that month compared with July of the previous year (see Fig.1). Both wintertime flows and summertime flows of sewage to

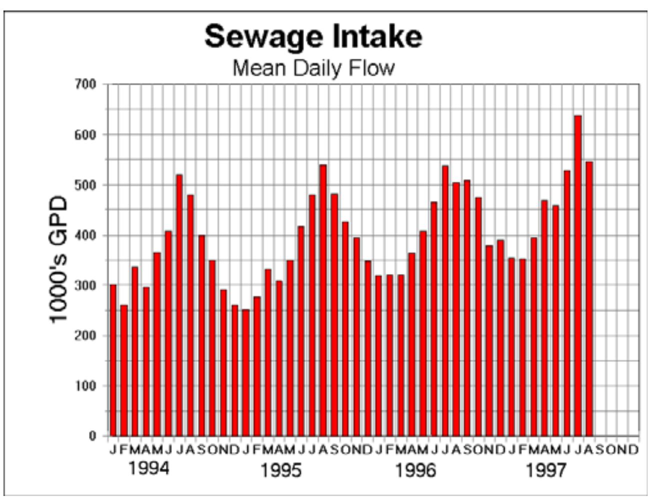

Figure 1. Mean daily sewage intake to wastewater facility in thousands of Gallons Per Day (GPD). The July 1997 average was 670,000 GPD. Data courtesy of Falmouth Wastewater Division.

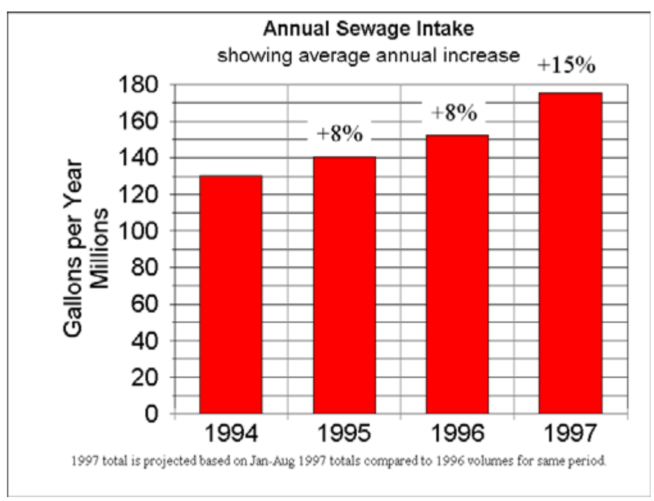

Figure 2. Annual intake of sewage to the Falmouth Wastewater Treatment Facility. Data for 1997 projected based on January to August flow.

the facility have been increasing. This is probably a result of several factors including new tie-ins, higher occupancy rates, and conversion of summer rentals into year round rentals. During the summer of 1997, two other factors may have also contributed to the increase reported. First, water from the Coonamessett drinking supply well was back flushed into the sewer system. Volumes often exceeded 20,000 gallons on many days over several months. This activity could have raised average monthly flows by 5,000 GPD or more. Another factor contributing to the apparent increase in volume was mechanical problems with a flow meter so that volumes of sewage on some dates were estimated, possibly incorrectly. Despite these problems in the summer data, the large increases in flow during other months and general observations by facility staff support the fact that inflow of sewage was much higher this year than in past years.

In Figure 2, total annual flows for each of the past four years are shown. Data for 1997 was projected using the total for January to August, and the rate of increase over the previous year for the remaining months. As shown, in 1995 and 1996, sewage flow to the facility increased by 8% whereas in 1997, the rate of increase nearly doubled to 15%.

Septage inflow to the wastewater plant

In Figure 3, monthly average daily intake of septage hauled to the plant by truck are shown. Like sewage flows, septage disposal at the plant shows a seasonal cycle, with wintertime lows around February and summertime highs in July or August. During the cleaning of the septage lagoons at the facility in the summer of 1995, septage was accepted by the town in a large receiving tank and was subsequently hauled off site. These flows were included in the graph (in a different color bar) to show long term trends. Similarly, the Town of Falmouth accepted septage from the Town of Oak Bluffs because of closure of the septage lagoons there, and these discharges are also shown in a light-colored portion of the monthly bar in the graph.

In 1996, septage delivery to the plant averaged 10,000 GPD in winter and 40,000 GPD in summer. Increases in summer septage intake during 1997 were not as dramatic as sewage flow, but overall, septage intake to the facility continues to increase (Fig. 3). In particular, septage intake during January and February 1997 averaged 80% higher than in 1996. Annually, septage intake increased 20% in 1997

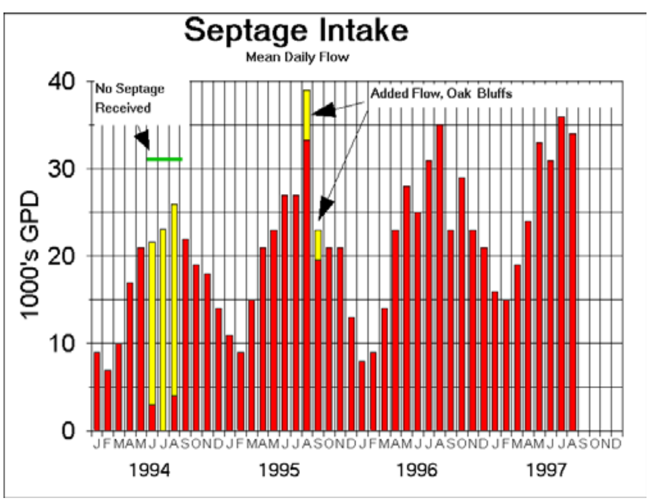

Figure 3. Septage intake to the Falmouth Wastewater Treatment facility. Data courtesy of Falmouth Wastewater Division.

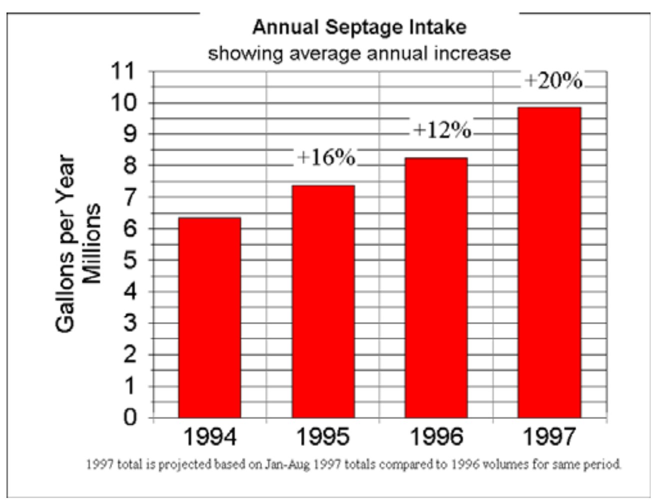

Figure 4. Total Annual Septage Flow between 1994 and 1997. Data for 1997 projected based on January to August totals.

(Fig.4), substantially higher than in previous years.

These trends may be the result of a variety of factors including new septic systems, increased occupancy rates, or better public awareness of septic system maintenance. However, new Title 5 inspection requirements at property transfer may be the most important reason for the increased volumes of septage during the past two years because pumping is required for these inspections.

Another factor contributing to increased septage volumes received in Falmouth may be the local pricing structure for accepting septage. For example, septage pumped in the Town of Mashpee is now supposed to be disposed of in the town of Barnstable since Mashpee's septage lagoons were closed three years ago. However, Barnstable charges $70.36 per 1000 gallons, whereas Falmouth charges only $41.00 per 1000 gallons. If a hauler with a 4000-gallon capacity truck pumps 2000 gallons from customers in Falmouth and 2000 gallons from customers in Mashpee, there is little incentive for the hauler to split disposal of the septage in his truck.

State law requires that septage haulers report the source of the septage they pump. In 1996 and 1997, a Buzzards Bay Project intern assisted the Falmouth Board of Health to enter septage hauler data in the Board of Health’s SepTrack septic system tracking software database. It was found that up to 30% of the record slips submitted by haulers either were illegible or could not be matched to an actual property in town.

Combined flows and nitrogen loadings

Combined monthly inflow of both sewage and septage to the facility are shown in Figure 5, and annual totals are shown in Figure 6. Sewage of course accounts for most of the flow at the facility. However, because the concentration of nitrogen in septage is much higher than sewage, septage accounts for a larger percentage of nitrogen loading from the wastewater facility than would be expected from flow alone. Literature values of septage nitrogen concentration suggest that concentrations of nitrogen above 600 ppm are typical, contrasting sharply with 30 ppm nitrogen typical of sewage. Actual concentrations of nitrogen in the wastewater facility’s sewage influent and septage holding tank are shown in Table 1. These samples were collected by the town and analyzed by Barnstable County Health Department. As

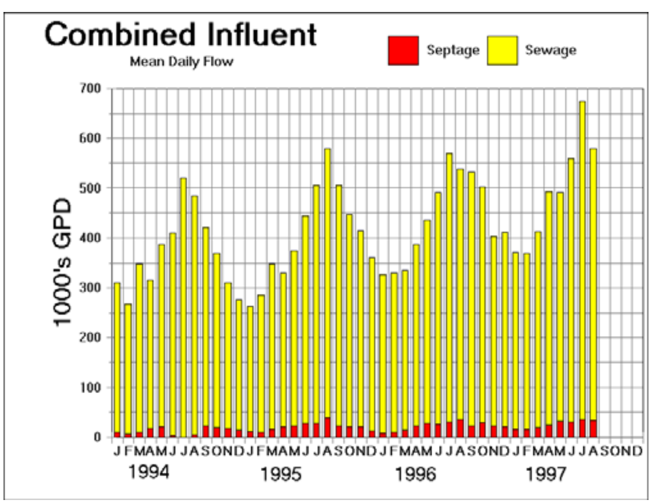

Figure 5. Sewage and septage intake to Falmouth’s Wastewater Treatment Facility. Note steady rise in off season flows. Data courtesy of Falmouth Wastewater Division.

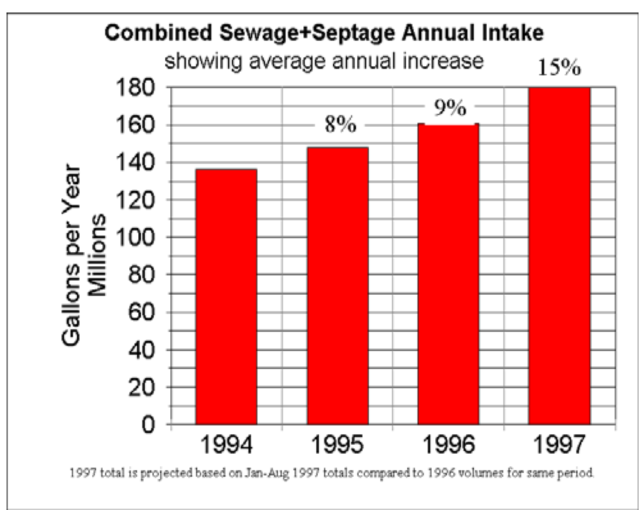

Figure 6. Combined annual total sewage and septage intake to the Falmouth wastewater treatment facility. Data for 1997 projected based on January to August totals.

Table 1. Nitrogen concentration (ppm) of septage and sewage on selected dates. Effluent Total N measurements in ppm. TKN is Total Kjeldahl Nitrogen which equals ammonia+ organic N.

Sewage	Nitrite+ Nitrate	TKN	Total N
1/22/96	0.15	25.6	25.8
01/17/96	0.15	20.2.	20.9
		Mean=	23.3
Septage			
12/02/96	0.65	170.7	171.4
12/04/96	0.16	120.2	120.4
12/12/96	0.39	148.0	148.4
12/18/96	0.21	85.2	85.4
		Mean=	131.4

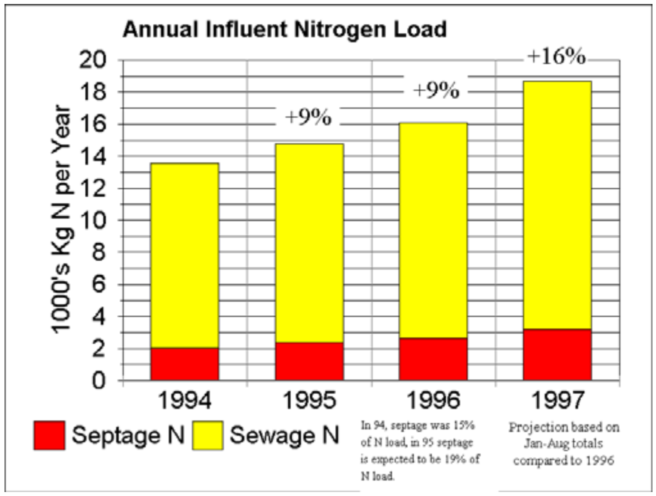

Figure 7. Nitrogen inputs to the wastewater facility. Note that because septage is more concentrated in nitrogen than sewage, it accounts for a greater proportion of the loading to the facility than would be expected from flow alone. Only 60% of this load is estimated to reach groundwater.

shown the mean concentration of 131 ppm observed on the four dates sampled are well below the values of 600 ppm expected. This lower-than-expected nitrogen concentration could be the result of mixing with non-septage effluent in the holding tanks, or possible settling of nitrogen in solids in the tank's sludge.

Using the nitrogen concentration in Table 1, septage accounts for 15-17% of total nitrogen load from the wastewater facility (Fig. 7). Like the rate of flow of both sewage and septage from the facility, total nitrogen input to the facility is also increasing each year, and the projected rate of increase for 1997 is much higher than previous years.

In Figure 8, nitrogen concentration in wastewater treatment plant effluent is shown. During the past few years approximately 75% of this effluent was discharged to the spray irrigation area, and 25% has been directed to sewage infiltration beds. The graph shows two main fractions of nitrogen in the wastewater. The first is known as Total Kjeldahl Nitrogen (TKN) which is the total of both organic nitrogen (particulate and dissolved) and ammonia. The second fraction is total nitrate + nitrite, shown as "NOx" on the graph. Nitrate+nitrate concentration is important because it shows how well the sewage lagoons are aerated. Well-aerated lagoons are less likely to release noxious gases like hydrogen sulfide, which is released when sewage is anaerobic (lacking oxygen). Also shown on the graph are major maintenance activities carried out at the wastewater facility.

Perhaps the most important conclusion that can be inferred from Figure 8 is that despite the improvements to the plant aeration system and resulting improved odor control, the aeration of the lagoons has not resulted in reduced total nitrogen concentrations in the effluent. Although changes in the various nitrogen fractions appear to coincide with maintenance activities, overall these improvements to the wastewater facility do not appear to have reduced nitrogen concentrations in the effluent in any appreciable way.

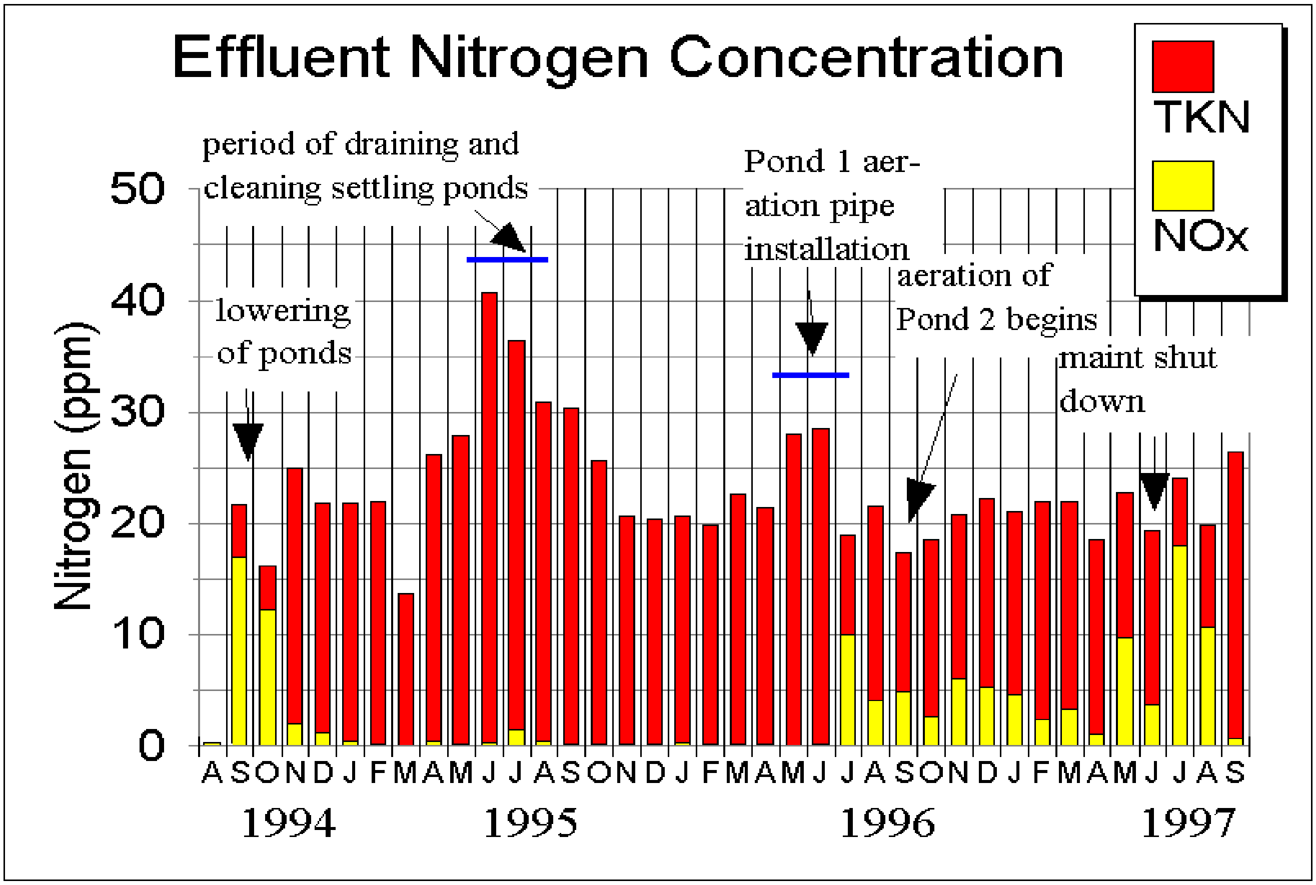

Figure 8. Concentration of different nitrogen fractions in the wastewater treatment plant effluent. TKN= Total Kjeldahl Nitrogen which is the sum of both ammonia and organic nitrogen. NOx equals the sum of nitrates+nitrites. Higher NOx values result from improved aeration of the sewage in the lagoons, which also improves sewage odor. Data courtesy of the Falmouth Wastewater Division.

Groundwater monitoring results and implications

More than 35 monitoring wells are sited in West Falmouth (Fig. 9), but few of these appear relevant for evaluating the wastewater treatment because most are not found within either the landfill or wastewater treatment facility plumes. Of these, Wells 15, 16, and 17 under the spray irrigation area and Wells 2 and 2A new the sewage infiltration basins are the most important in characterizing actual plant loadings to groundwater. Other wells such as the Long Pond "Early Warning System" wells have no relevance in evaluating the wastewater treatment plant plume.

In Figure 10, nitrate concentrations monitored in several wells are shown, including Wells 2, 15, 16, and 17 among others. The variability in well nitrate concentrations under the spray irrigation area (Wells 15, 16, and 17) is probably the result of intermittent seasonal use of the spray area and variability in rainfall recharge. The fact that Well 2, which is by the infiltration basins, has lower concentrations of nitrogen than the wells under the irrigation fields has two possible explanations. First, Well 2 may not be directly down gradient of the infiltration basins and reflects the diluted edge of the plume. Alternatively, biological processes could result in the denitrification of the effluent as it infiltrates through the bottom of the infiltration basins. Similarly under the spray irrigation areas, well 16 is clearly lower in nitrogen that either 15 or 17.

Figure 9. Position of groundwater monitoring wells sampled by the town for the wastewater treatment plant, landfill, and Long Pond drinking supply (so-called "Early Warning Well System"). Note that most wells are not along the path of the plumes of concern. Wells 18 and 18A, well 19, and well 11B are new wells installed earlier this year to better evaluate the plume.

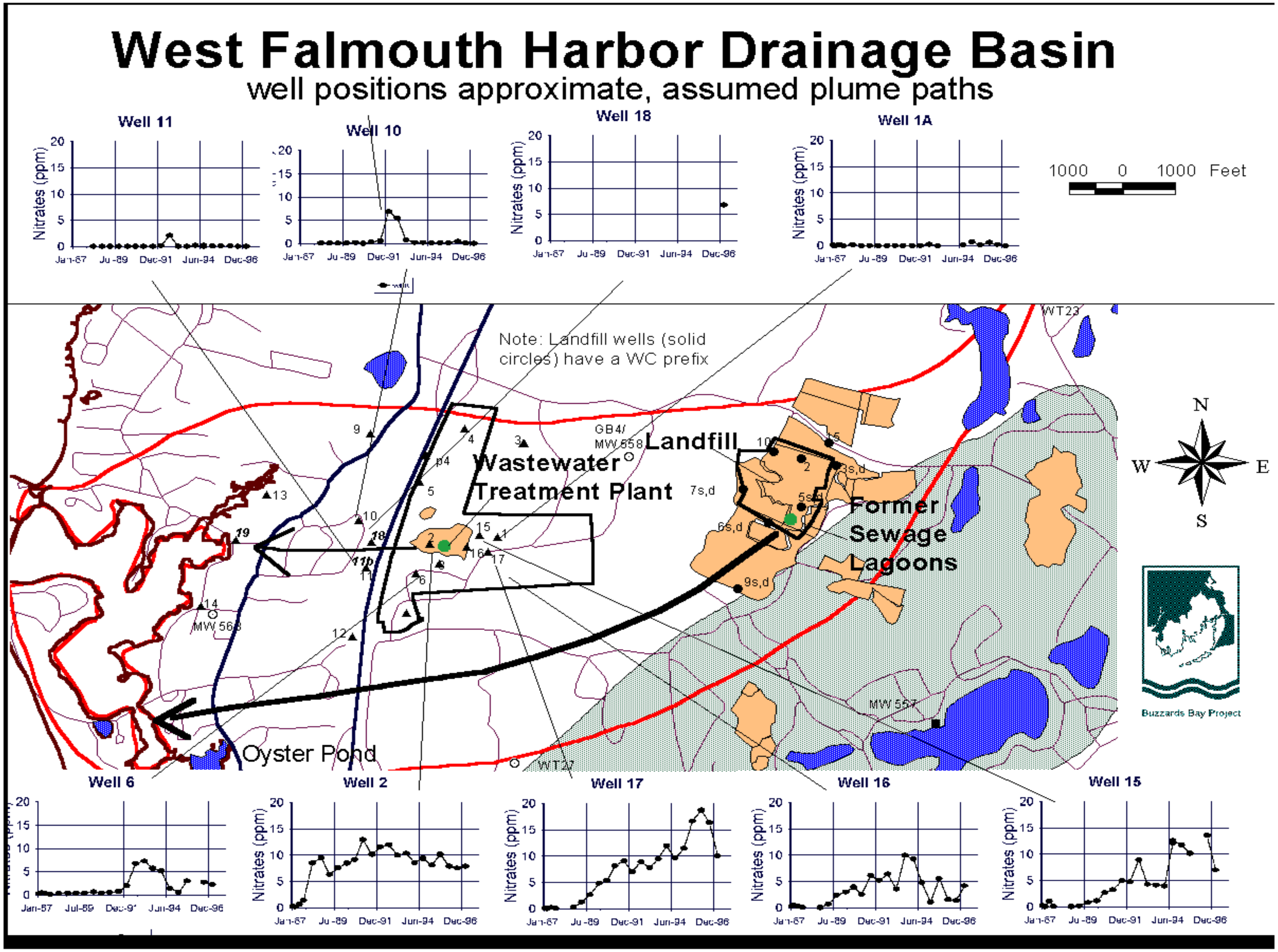

Figure 10. Nitrate concentrations in selected wells form near or within the plume of the wastewater plant. See text for explanation of variability.

These observations can be explained by examining sodium and chloride concentrations in the wells, and comparing these concentrations with sodium and chloride concentrations in the effluent. Both sodium and chlorides are not readily removed or attenuated as they move through groundwater and thus can be used as tracers to evaluate degree of dilution of the plume with groundwater or rainwater.

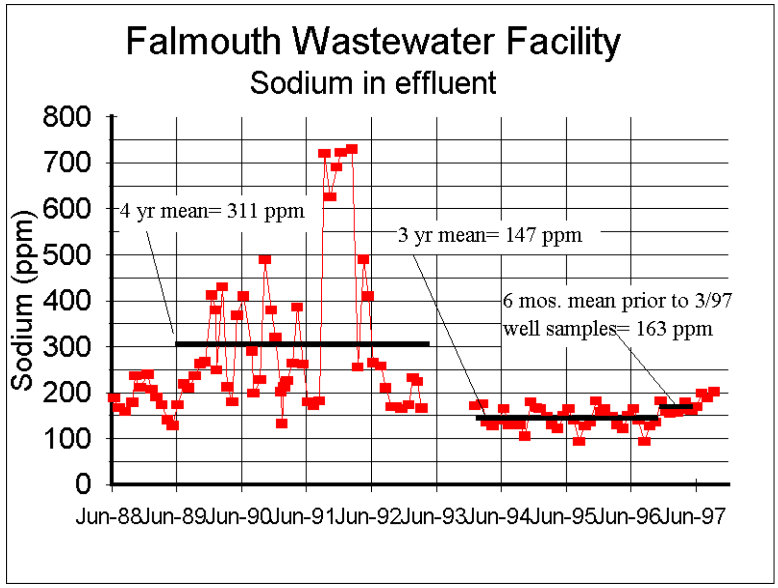

Figure 11. Sodium concentration in the Falmouth wastewater effluent since 1988. Recent discharge concentrations are relevant for evaluating data from wells immediately adjoining the plant. For wells downgradient, such as well 18 near Rt. 28, effluent sodium concentrations from the late 1980's need to be considered because of groundwater travel time.

As shown in Figure 11, sodium concentrations have been relatively steady during the past several years at around 147 ppm. For evaluating the March 1997 well data, the six month mean of 163 ppm is most relevant. For evaluating wells closer to West Falmouth Harbor such as well 18 along Rt. 28, effluent sodium concentrations from the 1980's need to be considered. Chloride levels have only been monitored in the effluent since fall 1996. Mean chloride concentration in Fall 1996 was 229 ppm.

Figure 11 also shows that seawater entry into the wastewater system was a severe problem in the late 1980's and early 1990's. This problem was apparently due to a cross connection with a Woods Hole laboratory seawater system that has since been rectified.

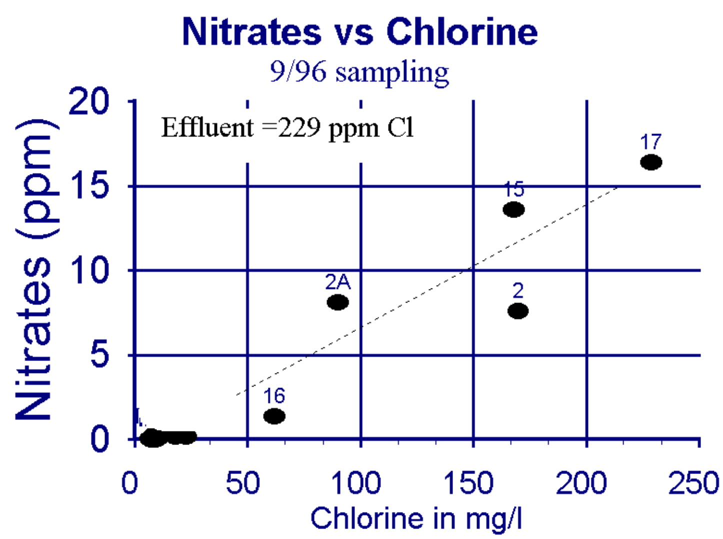

Figure 12. Nitrate in groundwater versus chlorine. Chlorine appears to be a good predictor of nitrate concentration suggesting that most of the differences in nitrate concentrations observed in the wells largely reflect degrees of plume dilution with groundwater or the placement of wells near plume centers. The somewhat lower than expected nitrate concentration at Well 2 may reflect denitrification under the sewage infiltration beds.

In Figure 12, chloride concentrations are compared to nitrate concentration for the Fall 1996 well monitoring. As shown, Well 2 and Well 16 have lower nitrate concentrations largely because the plume appears to have been diluted with either groundwater or rainwater. Only Well 17, with a chloride concentration most similar to the effluent had a nitrate concentration typical of actual effluent discharge.

Earlier this year the Town installed additional monitoring wells to document the wastewater plant plumes. The installation of these wells was initiated because of Buzzards Bay Project recommendations contained in a report on West Falmouth Harbor nitrogen management. The Cape Cod Commission gave technical guidance on the installation of the wells. Specifically, wells were installed at two new locations: Well 18, 18A and 18B representing a well cluster along Rt. 28 and Well 19 at Snug Harbor, and an additional well was installed at an existing well cluster but at a shallower depth (Well 11B).

In its past reports, the Buzzards Bay Project identified that Wells 10 and 11 were either poorly placed or at the wrong depth to evaluate the plume traveling to West Falmouth Harbor. The newly sited Well 18 apparently was sited effectively. On the last sampling round only Well 18 and Well 18 B were sampled in March 1997. The intermediate depth Well 18A was not sampled. Highest nitrate concentrations were observed in Well 18, at 6.8 ppm. Sodium levels were 210 ppm in this well, suggesting a good placement of the well within the plume. However, this well, placed 5,000 feet from the wastewater plant is actually sampling wastewater that originated from the late 1980's or early 1990s when sodium levels averaged around 310 ppm, with high concentrations exceeding 700 ppm. Thus, the plume reflects an expected degree of dilution during transit, but it may be impossible to estimate what original sodium, chloride or nitrate concentration contained in this portion of the plume when it was first discharged from the plant.

Surprisingly, Well 19, which was sited near Snug Harbor, did not capture the plume as demonstrated by the low nitrate, chloride, and sodium levels observed in the groundwater here (data not shown). The well was sited at 90 feet below the top of the water table and may have been sited too deeply. The Town's contractor may not have followed the Cape Cod Commission's guidelines for the installation of the well, and no detailed sampling logs have been provided by the contractor to help evaluate the placement depth of this well. Consequently, it is impossible to decide whether the lack of evidence of a plume at this site reflects the fact that a) the plume has not reached the bay, b) the plume is not entering the bay at this location, or c) the plume is entering the bay at a shallower depth than the screening of this well.

In Figure 10, several trends are apparent that may have significance in interpreting the loading of nitrogen from the plant. Well 2, which is closest to the infiltration basin, has shown declines in nitrogen concentrations during the past five years. In contrast, wells 15 and 17 under the spray area have shown a general increase. One possible explanation is that increasingly large percentages of the wastewater has been applied to the spray irrigation area, particularly near the wells. Other explanations are also possible, such as a slight southerly redirection of groundwater flow, as might be the result of drought conditions coupled with increased water draw downs in the Long Pond Zone of Contribution.

Conclusions and Recommendations

1) Though imperfect in nature, the monitoring wells in West Falmouth continue to help managers understand the loadings of nitrogen from the wastewater plant. In the next sampling round, all three wells in the Well 18 cluster should be monitored for nitrogen, chlorides, and sodium. Similarly, Wells 13, 14, and 14A, which have been infrequently monitored, should also be monitored on the next round of sampling. As a cost savings measure, the town could petition DEP to allow abandoning routine monitoring of certain wells that are far afield of the plume path, including Wells 4, p4, and 9. Well 3, which is north of the wastewater facility and has nearly always the lowest levels of sodium and chloride and conductivity should be kept as a background condition reference station. Well logs from 19 should be reviewed to determine what action is required at this site.

2) The rapidly expanding volume of sewage and septage inflow to the plant is quickly bringing the

facility to its permitted design capacity of 880,000 gallons per day. In July 1997, the plant exceeded 80% of this design capacity, often considered a trigger point for state review. If the current rate of increase continues, the plant will be above this 80% threshold throughout the summer of 1998. In light of this information, the town should consider initiating the "Facility Planning" process for an upgrade of the sewage treatment plant. Although such a Facility Plan has not yet been formally requested by the State, and because it could take several years to complete a new Facility Plan and implement design changes, such action by the town may be prudent, considering the rapid rate of increase in sewage and septage intake by the Town. The Town may also wish to carefully review the implications of new sewer extensions considering the fact that a large portion of the existing increases are the result of increased occupancy rates and alterations and expansions of existing sewer lines. In addition, better septage receipt records from the Facility and review of these records by the Board of Health with their septic tracking software will better identify both failing septic systems in town and septage hauled from out of town. These efforts and the facility planning are especially important if the Town wishes to initiate previously approved phases of sewer expansion.

3) Despite improvements in the operation of the facility, such as better aeration of the lagoons and the resulting improved odor control, these changes have not resulted in any apparent improved nitrogen removal capacity by the facility. The plant effluent remains at around 22 ppm total nitrogen, a concentration typically found in wastewater plants with only primary wastewater treatment.

4) Given trends around the state to upgrade sewage treatment plants to more stringent levels of protection, it is unlikely that the town will be allowed to continue to have a Class III groundwater discharge permit limit of 50 ppm nitrogen. Discharge limits of 10 ppm or below have become the norm, and tertiary treatment of nitrogen has already been required for several plants with groundwater discharge permits in Massachusetts. For example, in Edgartown, the wastewater plant was upgraded in 1996 with tertiary treatment and total nitrogen concentrations in the discharge are now typically below 3 ppm. Similarly, a new tertiary wastewater treatment plant was built at Otis in 1995, and this plant typically discharges 1 to 2 ppm total nitrogen with concentrations often below 1 ppm. It is worth noting that the Town of Falmouth was in the forefront in urging this level of treatment for the Otis facility because of the town's concerns for the protection of its groundwater and surface waters. The Town of Falmouth should begin to explore cost-effective approaches and options toward achieving tertiary treatment and advanced nitrogen removal for this facility.