

Date: August 21, 2025 (revised October 15, 2025)  
Project No.: 20985  
To: George Meservey  
From: Mike Giggey  
Subject: Orleans Nitrogen Management in Mill Pond Sub-Watershed  
On-Site Denitrification

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Ten options have been identified for reduction of nitrogen load in the Mill Pond sub-watershed. One of those options is the use of individual on-site denitrification (I/A) systems to reduce septic load. This option is described and evaluated in this memo.

Description

This option involves the installation of individual denitrification systems on some or all of the developed parcels in the sub-watershed. The I/A system would accept septic tank effluent, remove a portion of the nitrogen and discharge the effluent to the existing leaching field. In some cases, a pump would be required to feed the I/A system or the leach field, and some homeowners might choose to also install an emergency generator.

Ownership

We should expect that I/A systems in the Mill Pond sub-watershed would be privately owned and operated. The Town would establish a Responsible Managing Entity to oversee the project and to document the amount of nitrogen removal for eventual credits under a future watershed permit. Individual property owners would be responsible for cost and system performance.

Performance and Extent

There are many commercially-available wastewater treatment systems that could be used. There have been significant efforts to develop a reliable low-maintenance system that produces better effluent than the I/A systems in use on Cape Cod over the past few decades; however, the effluent quality to be expected is still uncertain, and this uncertainty makes it difficult to develop a definitive plan with predictable extent and results.

Average water use in the Mill Pond sub-watershed has been about 167 gallons per day. Using traditional nitrogen accounting (as per the Massachusetts Estuaries Project—MEP—with a groundwater impact of 26.25 mg/l from a Title 5 system), the average septic load is about 5.4 kg/yr per home. If the on-site denitrification systems could produce effluent of 10 mg/l, that would translate to a septic load removal of about 62%. The per-home septic load reduction would be as follows for a range of I/A system effluent nitrogen concentrations:

- 10 mg/l effluent      62% nitrogen removal      3.3 kg/yr removal per home
- 12 mg/l effluent      54% nitrogen removal      2.9 kg/yr removal per home

- 14 mg/l effluent      47% nitrogen removal      2.5 kg/yr removal per home
- 16 mg/l effluent      39% nitrogen removal      2.1 kg/yr removal per home

With a target septic load removal of 750 kg/yr, I/A systems would be needed on anywhere from 230 to 280 homes (80% to 100% of all homes in the sub-watershed). Note that I/A systems could achieve only 700 kg/yr septic removal at 14 mg/l and 590 kg/yr at 16 mg/l, even if installed at all 280 homes. If 750 kg/yr is the target, across-the-board I/A systems are only sufficient if they achieve 13 mg/l or better, on average. (The Orleans Health Department compiles operating data from I/A systems currently in use, and the average effluent concentration is well over 20 mg/l.)

In the upcoming comparison of alternatives, this option should be characterized as needing 260 I/A systems operating at 12 mg/l, with the recognition of a high degree of uncertainty. For comparison, a traditional municipal sewer extension would remove 100% of the septic load from each sewered home (5.4 kg/yr), requiring that 140 homes be sewered to achieve the 750 kg/yr target removal.

### Costs

Costs are difficult to estimate given the evolving technology and regulatory requirements. Compared with municipal sewerage, on a per-home basis, I/A systems may have a lower first cost, but considerably higher costs for operation and maintenance. Further, many more homes would be served by I/A systems than traditional sewerage, so the watershed-wide costs would be higher than for the sewerage option.

### Speed in Water Quality Improvement

The use of I/A systems would reduce septic loads at their source. For a home at the far reaches of this sub-watershed, prior septic system nitrogen discharges would continue traveling with the groundwater for many years before the reduced load would reach Mill Pond. A more rapid impact would occur for homes close to the pond. In general, the benefits of widespread I/A systems would not be achieved for 10 or more years after installation of the systems.

### Predictability of Performance

Despite claims by I/A system vendors, it is very hard to predict the performance of individual system due to many factors, including the level of operational oversight, the seasonality of the wastewater flow, the household practices of the residents, etc. The average effluent quality can be determined only after long-term operation of these systems, in this setting. A plan based on say 200 homes, might be found to be inadequate and an additional 20 homes might need to install these systems to reach a target aggregate nitrogen removal. If all 280 homes needed to install I/A systems, then it would not be possible to add more units the future.

### Reliability

Historically, I/A systems have been quite unreliable; that is, their performance varies considerably season-to-season or year-to-year. With advances in technology and with a Responsible Management Entity,

reliability should improve, but this nitrogen management option should be viewed as less reliable than sewerage.

### Need for Large Town Capital Expenditure

Orleans has committed to remove large amounts of nitrogen in the Pleasant Bay watershed under the 2018 watershed permit. The very high costs of that commitment mean that the Town has limited ability to undertake costly nitrogen removal projects in other watershed, like the Nauset Harbor system. Therefore, a plan based on I/A systems has the advantage that the costs would be largely borne by residents of this sub-watershed, with only a small Town expenditure to establish and operate the Responsible Management Entity.

### Regulatory Acceptability

Mass DEP has expanded its program to accommodate the use of I/A systems for nitrogen load reduction. The requirement for a Responsible Management Entity is one example of DEP's involvement. While gaining nitrogen removal credits under a watershed permit would be somewhat more cumbersome than with a sewer project, regulatory opposition is unlikely.

### Public Acceptability

The cost and impacts of this option would impact those property owners who install I/A systems, and impacts on the remainder of Orleans residents would be minimal. Acceptability will hinge on the outlook of the homeowners that would be required to install I/A systems and any cost sharing policies that the Town might put in place. A Town-funded incentive program is one way to encourage private investment in these systems; however, the success of such incentive programs on Cape Cod has been limited.

### Flexibility in Face of Unknown TMDL and Applicability to a Phased Approach

This option is very amenable to a phased approach. There would be no need to install all of the needed I/A system all at once. Properties with high occupancy that are located close to the pond could be fitted with I/A systems in an initial phase. Other parcels could have I/A systems in later phase, and/or other options could be implemented to supplement the first-phase I/A systems. Such a phased approach is an appropriate way to deal with the fact that the nitrogen removal goal is quite speculative, absent an updated MEP report and the setting of TMDLs.

### Environmental Impacts

Like any construction project, there will be impacts during construction and there will be the potential for long-term operational impacts. The Town has done a very good job managing impacts during the first two phases of the public sewer system and this option would have fewer impacts on the general public. Existing Town rules and regulations should be effective in addressing operational impacts, which might include noise and odor; if not, existing rules could be enhanced. In general, all impacts of this option are readily minimized.

### Impact on the Orleans WWTF

The existing Orleans wastewater treatment facility (WWTF) has a finite capacity to treat and dispose of municipal wastewater. It will need to be expanded to handle all of the wastewater that would be collected in the current 16-phase sewer master plan. The use of I/A systems would locally dispose of the wastewater volume that would otherwise go to the WWTF if this sub-watershed were served by a traditional sewer system, thus helping to defer the expected large capital expense of WWTF expansion.

### Ease of Implementation

The use of on-site systems should be relatively straightforward, once an RME has been established and selected homeowners have agreed to participate. However, there is limited experience with these two early steps, and they will require time and expense to complete.

### Summary of Advantages and Disadvantages

The use of on-site denitrification systems has these principal benefits:

- This could be a largely private solution that can be implemented with only a small impact on Town finances.
- It avoids the wastewater flow to the Orleans WWTF that would occur with sewerage.
- It is easily implemented in phases and/or combined with other alternatives.

The principal drawbacks include:

- Costs to the participating homeowners are higher than with sewers.
- The performance of the denitrifying systems varies from season to season and is hard to predict.
- Some degree of Town oversight would be needed.

The August 21, 2025 draft of this memo was reviewed by the WMAC at its August 28, 2025 meeting. This updated memo reflects comments made by the WMAC and Town staff at that meeting.