

Memorandum

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Subject **Town of Orleans, MA**
Water Quality and Wastewater Planning
Task Number 10.1.B.1 – NT Demonstration Projects
Draft Aquaculture Full-Scale Implementation Program

Project Number 60476644

From Thomas Parece, P.E., AECOM Project Manager

Date 07/07/17

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1. Purpose and Background

The Town of Orleans is undertaking wastewater planning projects that include both the installation of traditional infrastructure as well as demonstrations to verify the performance, permissibility, management and costs associated with non-traditional approaches such as shellfish, permeable reactive barriers and nitrogen-removing barrier onsite septic systems. Several AECOM Technical Memorandum have been prepared that describe the planning and initial results of shellfish demonstrations, including:

- Final Site Characterization and Evaluation for Shellfish Aquaculture/Shellfish Propagation (March 13, 2016);
- Shellfish Cultivation – Final Preliminary Engineering Design and Work Plan for Preferred Sites (May 4, 2016);
- Shellfish/Aquaculture - Draft Enhanced Aquaculture Technical Memorandum (January 29, 2017);
- Lonnie’s (Kescayo-Gansett) Pond Oyster Aquaculture Demonstration Project Year 1 Project Report – Draft (February 16, 2017); and
- Shellfish/Aquaculture – Final Town Cove Exploratory Mailing Summary Report (February 27, 2017).

This Technical Memorandum presents a planning-level overview of the species, quantities and growing paradigms for removing nitrogen loads from both Pleasant Bay and Town Cove using shellfish. The target nitrogen-removal goals were initially defined during the development of the Orleans Consensus Plan. Table 1 presents the species to be grown, growing methods and the nitrogen-removal targets suggested in the Orleans Consensus Plan and reviewed during the June 6, 2015 Shellfish Forum.

Table 2 shows revisions to the species grown, locations and area required based on the results of the 2016 demonstration projects and reflecting stakeholder feedback. The total nitrogen-removal targets per watershed have not been changed in the revised table.

The purpose of this Technical Memorandum is to provide a starting point for a broad discussion with the Shellfish and Waterways Committee and other appropriate town advisory committees, Board of Selectmen, Conservation Commission, local growers, commercial wild harvesters, the Division of Marine Fisheries (DMF), MA Department of Environmental Protection (MassDEP) and other stakeholders related to overall shellfish implementation strategies for Orleans.

2. Consensus Plan and Shellfish Forum Description

The Orleans Water Quality Advisory Panel (OWQAP) was convened to achieve consensus and build widespread community support for a customized, affordable water quality management plan for the Town of Orleans. The panel consists of stakeholder representatives (Orleans Selectmen and representatives of engaged citizen constituencies), and liaisons from key town boards and commissions, organizations, neighboring towns, and regional, state, and federal partners. The OWQAP met for twelve half-day meetings starting in July 2014, all of which were open to public attendance and comment.

Potential alternative planning scenarios to meet water quality standards were developed for the OWQAP and presented at meetings and workshops. Initially, a Hybrid Plan was designed that included specific sites for aquaculture and coastal habitat restoration (CHR), as well as permeable reactive barriers (PRB) and floating constructed wetlands (FCW). The number of acres of shellfish growing area (as well as linear feet of PRBs and square footage for FCW) were approximately quantified to achieve specific nitrogen-removal targets. This exercise was undertaken to ensure that the quantities of shellfish (and all other non-traditional technologies) proposed in the Consensus Plan were feasible to install. These specific locations became the basis for potential demonstration site locations for aquaculture and CHR, as well as FCWs and PRBs.

The Hybrid Plan was vetted through the OWQAP during three meetings, including a day-long workshop. This iterative process resulted in a draft Consensus Plan that included a combination of non-traditional and traditional technologies. Once the feasibility of using shellfish and other non-traditional technologies as part of the Town's nutrient management strategy was established, the OWQAP decided that the final Consensus Plan would not specify exact growing locations, but instead focus on the overall area of shellfish and other alternative technologies needed to remove the appropriate mass of nitrogen at the watershed level. A map, entitled Conceptual Approach to Meet Orleans Water Quality Goals (March 2015), was developed which illustrated the agreed upon water quality management plan. The March 2015 Conceptual Approach map included 5.5 acres of shellfish in the Nauset Harbor watershed and 9 acres of shellfish in Pleasant Bay. Neither coastal habitat restoration nor aquaculture was part of the plan for the Rock Harbor watershed. The 2015 Conceptual Approach map also specified acreages for other non-traditional technologies.

To review the shellfish component of the Consensus Plan, a Forum was convened on June 2, 2015. The purpose of the Forum was to provide a mechanism for experts from across Cape Cod to review the Conceptual Plan for Shellfish in a collaborative and interactive session, and help Orleans optimize the opportunity to successfully demonstrate the use of shellfish in water quality management. As part of the Forum, an Expert Panel consisting of professionals with substantial experience growing shellfish and implementing and monitoring projects for water quality and habitat restoration on Cape Cod was assembled. Several local aquaculture farmers who were not able to attend the Shellfish Forum were contacted and the specifics of the Consensus Plan were discussed. Input from these growers was sought specifically regarding the number of shellfish proposed and the preferred growing methods. Information on the species type, acreage proposed and nitrogen-removal goals for specific waterbodies, including a summary table (Table 1) was provided to the Expert Panel for review more than one month prior to the Forum.

Key outcomes of this Forum included:

- Review and recommendations for specific criteria regarding selection of demonstration project sites;
- Initial review of locations and type of shellfish demonstrations;
- Enumeration of key considerations for planning and implementing demonstrations; and
- Identification of experts who can serve as advisors for the next steps of planning and implementation.

A report entitled Orleans Shellfish Operations and Program Expansion Plan (June 2015) documents the results of the Shellfish Forum.

3. Planning Assumptions for Pleasant Bay and Town Cove Shellfish Scenarios

During the implementation of the 2016 demonstrations and concurrent meetings with the Shellfish Working Group (SWG) and other stakeholders, a variety of considerations related to growing methods and shellfish species have been identified, and nitrogen uptake data has been gathered. Specifically, the biomass increase and related nitrogen uptake of oysters over a single growing season and preliminary denitrification rates have been measured through the demonstration project at Lonnie's Pond. In addition, the feasibility of working with existing growers to enhance aquaculture within the existing aquaculture grant areas in Pleasant Bay has been assessed and the importance of quahogs to the local commercial shellfishing industry has been emphasized.

The species, quantity and area required to grow the shellfish needed to achieve the nitrogen-removal goals of the Consensus Plan can therefore be updated based on this current information. The 2017 growing season will provide additional data that will increase the certainty of the assumed values for nitrogen-uptake of oysters at different stocking and bag densities and help determine whether denitrification rates for oysters should be included in nitrogen-removal calculations. However, at this time it is possible to revise the initial planning level estimates from the 2015 Consensus Plan based on knowledge gained from the 2016 shellfish demonstrations and SWG feedback.

Planning for using shellfish for nitrogen-uptake is based on several building blocks:

- Selection of species to be grown;
- Selection of growing method;
- Annual and daily nitrogen-removal associated with the specific species to be grown and removed from the system via harvest;
- Area required to grow the selected species using the specified growing method; and
- Annual and daily nitrogen removal targets for the planning area (waterbody).

Table 1 - Summary of Information Reviewed at June 2, 2015 Shellfish Forum

Location	Method	kg N removed	Area	Number of Shellfish
Arey's	Aquaculture	136	~ 1 acre floating bags	0.5M oysters
Meetinghouse	Coastal Habitat Restoration	150	~ 0.5 acre reef with remote set/trays	0.5 M oysters
Pochet	Coastal Habitat Restoration	780	~ 3 acres of quahogs and oyster reef with remote set and trays initially, may lead to reef without trays	3M oysters & planted quahogs
Lower River	Coastal Habitat Restoration	530	~ 2 acres of quahogs and oyster reef with remote set and trays initially	2M oysters or planted quahogs
Little Pleasant Bay	Aquaculture	620	Program within existing grants	2.5M oysters or quahogs annually (total from all grants)
Little Pleasant Bay	Coastal Habitat Restoration	420	~ 2 acres of quahogs and oyster reef with remote set and trays initially, may lead to reef without trays	2M oysters or planted quahogs
Town Cove	Aquaculture	500	~3 - 5 acres of growing area, assumes some suitable bottom available	2M oyster singles
Town Cove	Coastal Habitat Restoration	600	~3 acres of quahogs/mussels/oyster reef with remote set and trays initially	3M quahogs/mussels/oyster reef
Mill Pond	Coastal Habitat Restoration	260	~ 1 acre quahogs or oyster reef with remote set and trays initially	1M oysters or quahogs

The two species under consideration in this analysis are oysters and quahogs. Oysters are grown either as singles or in oyster beds and mature relatively quickly, reaching harvestable size from small (2 to 3 mm) seed in approximately 18 months (two warm weather periods). The uptake of nitrogen is therefore rapid. In addition, oysters that are grown in gear or are placed on the bottom of an estuary are stationary, increasing the certainty of quantifying population numbers and growth.

Quahog growth is variable (Macfarlane 1998) and there is no recently published data for local growth rates (Reitsma 2017). Although there is a range, an estimate of the average time required for quahogs to reach harvestable size from first field-planting has been estimated as three years. This timeframe is based on information provided by the Chatham Shellfish Department and the Barnstable Department of Natural Resources in regard to their current and historic husbandry practices (Renee Gagne, Rachel Hutchinson and Tom Marcotti, pers. comm.). Both towns have well-established municipal propagation programs for quahogs. Unlike oysters, quahogs live in the bottom substrate and are motile, making direct measurements of populations less certain.

Table 2 presents the planning values for oysters and quahogs that were used to calculate the area required and number of shellfish grown by a full-scale implementation program discussed in Section 3 and shown in Table 3. As shown in Table 2, annual nitrogen uptake is based on initial and final harvest weights over a single oyster growing season, percent nitrogen content in the shellfish and the time required to grow-out to final harvestable size. Quahog cultivation is based on an estimated three years to reach harvestable size from first field-planting. Oyster values assume two years to harvest, from seed. The sections that follow explain the assumptions used to calculate the values provided in Table 2.

Table 2 - Planning Values for Shellfish Area Requirements and Nitrogen Removal

Type of Shellfish Grown and Method	Shellfish Initial Weight ¹	Shellfish Final Harvest Weight (HW) ¹	Increase in Weight ²	Nitrogen Content ¹	Grow-Out Time ¹	Shellfish Nitrogen Uptake ³	Density ⁴	Annual Nitrogen Uptake ⁵
	grams	grams	grams	% of HW	years	grams/year	shellfish/sq.ft.	kilograms/acre/year
Year 1 Oysters in Floating Bags (low density)	0.20	30	30	0.43%	1	0.13	16	90
Year 1 Oysters in Floating Bags (high density)	0.20	30	30	0.43%	1	0.13	62	350
Year 2 Oysters on Bottom (low density)	30	60	30	0.43%	1	0.13	10	56
Year 2 Oysters on Bottom (high density)	30	60	30	0.43%	1	0.13	45	250
Existing Growers Year 1 Oysters	0.20	20	20	0.49%	1	0.10	35	150
Existing Growers Year 2 Oysters (Harvestable)	20	60	40	0.49%	1	0.20	15	63
Quahogs Under Net per Year (Year 1, Year 2)	1.0	40	39	0.43%	2	0.084	50	180
Quahogs Broadcast (Year 3)	40	57	17	0.43%	1	0.073	5.0	16

Notes:

1. Data for “Shellfish Initial Weight”, “Shellfish Final Harvest Weight”, “Nitrogen Content” and “Grow-Out Time” are from Lonnie’s (Kescayo-Gansett) Pond Oyster Aquaculture Demonstration Project Year 1 Project Report – Draft (February 16, 2017) and Reitsma 2017.
2. “Increase in Weight” is calculated by subtracting “Shellfish Initial Weight” from “Shellfish Final Harvest Weight”.
3. “Shellfish Nitrogen Uptake” is calculated by multiplying “Increase in Weight” times “Nitrogen Content”.
4. “Density” is based on a variety of published sources and local grower practices, as described in the text.
5. “Annual Nitrogen Uptake” is calculated by multiplying “Shellfish Nitrogen Uptake” by “Density” and 43,560 square feet per acre.

A. Initial and Harvest Weights

Initial weights are based on measured values from Lonnie’s Pond and Reitsma 2017. Ending weights can vary depending on husbandry practices. For example, the starting weight for both the “Year 1 Oysters in Floating Bags” and “Existing Growers Year 1 Oysters” is 0.2 grams. However, the ending weights for these categories are different because existing growers in Orleans do not purchase early start seed; their seed is typically deployed in June. Starting seed as early as possible in the spring (when water temperatures reach 6°C for six consecutive days) increases the nitrogen uptake over the growing season. For the growing paradigm for the category “Year 1 Oysters in Floating Bags”, an early start is envisioned and the resulting ending weight is based on what was reported in the Lonnie’s Pond Year 1 report.

Table 3 - Refined Planning Values for Annual Full-Scale Implementation of Shellfish in Pleasant Bay and Town Cove

Location	Method	Annual Goal for Kg N removed	Waterbody Surface Area and Notes	Annual Number of Shellfish Harvested/Removed
Arey's	Year 1 Oyster Aquaculture in Floating Gear	136	0.4 acres with high stocking density	1,100,000
Meetinghouse	Year 1 Oyster Aquaculture in Floating Gear	150	0.4 acres with high stocking density	1,200,000
Lonnie's	Year 1 Oyster Aquaculture in Floating Gear	300	0.9 acres with high stocking density	2,400,000
Pochet	Oyster Bed	480	2 acres with high planting density	3,800,000
Pleasant Bay: Existing Aquaculture Grant Sites	Oyster Aquaculture in Floating Gear	620	5 acres within existing grant areas, includes equal numbers of Y1 and Y2 size classes growing	2,200,000
The River, Namequoit and Associated Areas	Quahog Propagation	530	13 acres (includes area under netting and final broadcast)	2,300,000
Pleasant Bay (Areas South of The River)	Quahog Propagation	420	10 acres (includes area under netting and final broadcast)	1,800,000
Town Cove/Mill Pond	Quahog Propagation	1360	31 acres (includes area under netting and final broadcast)	5,700,000
Total Harvested Quahogs				9,800,000
Year 1 Oysters				4,700,000
Total Harvested Oysters				6,000,000

B. Nitrogen Content

The nitrogen content of oysters (expressed as a percent of harvest weight) differs, depending on whether they are grown on or off the bottom and other growing conditions (Reitsma, Murphy and Franklin 2014). The nitrogen content of 0.49 percent of live weight used for the “Existing Growers” category in Table 3 is the reported value for oysters from Pleasant Bay grown off the bottom (Reitsma, Murphy and Franklin 2014, Appendix C).¹ The 0.49 percent of nitrogen contained in Pleasant Bay oysters grown on existing grants is higher than the average value for oysters grown off-bottom reported for

Cape Cod as a whole, which is 0.43 percent based on a more recent study (Reitsma, 2017). This value of 0.43 percent is more specific to oysters grown-off bottom and more recent, and therefore was the value used for the general category of “Year 1 Oysters in Floating Bags” in Table 3. This study also presented average values that were measured for oysters grown on the bottom as well as quahogs. These published values were used for the category “Year 2 Oysters on Bottom” as well as the “Quahog” categories in Table 3.

C. Oyster Density

The maximum number of oysters that can be harvested from a given unit area depends on whether gear is used, stocking densities, and husbandry practices. Both a high and a low growing density for oysters are given in Table 3. A range is presented for oysters grown in floating gear because growing conditions and husbandry practices differ amongst sites and growers. The high-density values are achievable with the gear and oyster stocking densities per bag as they have been shown to work in other areas and are also used in Lonnie’s Pond. The low-density values are based on information provided by growers in Orleans, using fewer bags per unit area and lower stocking densities. Documentation for these high and low densities for oyster aquaculture is contained in AECOM’s Technical Memorandum entitled Shellfish/Aquaculture - Draft Enhanced Aquaculture Technical Memorandum (January 29, 2017).

A range of densities is presented for oysters grown in beds or reefs because there is a wide array of published values for oyster densities in restored oyster reefs, varying between 4 (Sisson 2011) to 47 (Frankic 2015) oysters per square foot (Humphries 2016, Kellogg 2013, Grizzle 2003). Based on these reports, this Technical Memorandum considers a target density of 45 oysters per square foot to be a high-density reef and 10 oysters per square foot to be a low-density reef.

D. Quahog Densities

Quahogs can be tightly packed for intermediate grow-out and should be broadcast widely at very low density for final grow-out, therefore a range for the area required has not been provided. Quahogs are started in the spring from small (1.5 to 3 mm) seed and remain in either upwellers or fine-mesh bags until they reach a screen size of 12 to 15 mm. This typically takes one full growing season. According to the Shellfish Constable and Shellfish Propagation agent in Chatham, MA, once quahogs reach 12 to 15 mm, they can be bottom planted under netting for protection from predators during different times of year. Because it is assumed that quahogs will be purchased by Orleans after they have reached a size of 12 to 15 mm, the nursery stage does not contribute to the nitrogen-removal goals of this program. Once quahogs reach a size that they can be planted under netting, nitrogen-removal can be calculated based on the total increase in biomass of quahogs from the time they are field-planted to the time they are harvested.

¹ The total nitrogen percent reported in Appendix C is for dry weight. However, the percent nitrogen for oyster wet weight is more directly useful in field evaluations. By dividing the sum of the grams of nitrogen in the shell and soft tissue (0.22g and 0.07g respectively) by the total harvest weight of the oyster (59.56 grams), the percent of total nitrogen content as a percentage of harvest weight can be calculated.

There is a wide range of field-plant densities under netting. In Chatham, densities are as high as 400 quahogs per square foot, depending on water flow and whether thinning and replanting is planned. Planting densities under netting in Barnstable is between 25 to 50 quahogs per square foot. Quahogs must be maintained under netting until they reach 25 mm, which is considered large enough for broadcasting into the wild fishery for final grow-out and harvest (Macfarlane 1998). For planning purposes, a below-net density of 50 quahogs per sq. ft. has been selected because it is routinely demonstrated in Barnstable and by commercial growers in Wellfleet. In addition, it is assumed that these quahogs will grow under netting for two seasons before they reach 25 mm and can be broadcast into the wild fishery based on observations from the municipal propagation programs in Barnstable and Chatham. It is advisable to broadcast 25 mm quahogs in the fall after water temperatures have decreased to a maximum of 42°F. This allows quahogs to burrow with minimal risk of predation, and increases survival (Macfarlane 1998). The time from broadcast to harvest size also varies from one to two years, with the total growing time from seed to harvest for quahogs ranging from three to six years. Because of the food availability in Orleans's estuaries, the total time from field planting size to harvest size is estimated to be three years.

Final broadcast densities based on food availability for 25 mm quahogs is 20 per square foot, with higher values accepted when water flow is high (Belding 1931). However, without protective netting a final planting density of 20 quahogs per square foot over a large area may attract predators. Lower density propagation for final grow-out and harvest also results in more animals that spawn because they are harder to find and therefore not all harvested, which replenishes the fishery naturally. Therefore, final planting at much lower densities is the approach used in Chatham and other towns.

Another metric to consider is the final density for commercial harvesting. Based on conversations with several commercial harvesters, a reasonable haul is when 40 littlenecks (1-inch thick quahogs) can be collected with one 20-foot long pull of a rake that is approximately 24-inches wide. This equates to a harvestable quahog density of one quahog per square foot, over a large area. It should be noted that harvestable size quahogs are 1-inch thick, while length measurements are used for propagation planning purposes. For this Technical Memorandum, a broadcast density of five quahogs per square foot for final grow-out is used and it is assumed that these are removed from the system by harvesting. For the nitrogen removal attributable to quahogs, actual harvest numbers will be verified using the estuary-specific information on quahog landings submitted to the Division of Marine Fisheries by commercial harvesters.

4. 2017 Update of Shellfish Plan from the 2015 Shellfish Forum

Based on the results of the 2016 Demonstration Project and discussions with the Shellfish Working Group, the 2015 Consensus Plan (Table 1) regarding planning values for full-scale aquaculture implementation was updated (Table 3). The nitrogen-removal goals for shellfish have not been changed from the values presented at the Shellfish Forum (Table 1). The species, quantity and area required to grow these shellfish have been modified as shown in Table 3 based on the results of the 2016 demonstration projects and stakeholder feedback. The main considerations that have informed these modifications are:

- Maintaining the same overall values for total kilograms of nitrogen removed annually for Pleasant Bay and Town Cove that were expressed at the Shellfish Forum;
- Based on results of the Enhanced Aquaculture demonstration, it is believed that there is space on each of the 15 currently-approved shellfish grants to grow 150,000 more oysters to market size annually, which would collectively increase current oyster production by 2.25 million oysters per year and remove 659 kg of nitrogen per year in uptake alone;
- It is assumed that the known predation in Pleasant Bay could be overcome by either establishing oyster beds using cultch or remote set or by the intentional cultivation of the bottom to remove predators. Permitting will not fall under the Town's existing municipal propagation permit if cultch or remote set is used. This approach will require filing a Notice of Intent with the Conservation Commission as well as separate permit applications with DMF and the Army Corps of Engineers;

- Balancing the value of floating gear for protecting shellfish from predation with the stated concerns regarding the proliferation of floating gear with respect to aesthetics and introduction of plastics into the environment;
- Focusing on increased quahog propagation in both Pleasant Bay and Town Cove; and
- Denitrification is likely to occur, but is not included in this Full-Scale Implementation Plan analysis to provide a level of conservatism with respect to regulatory acceptance.

As shown in Table 3, the updated approach to the consensus plan full scale implementation scenario includes harvesting of approximately 9.8 million quahogs annually through this program (once the initial years' animals reach harvestable size), with 5.7 million in the Town Cove/Mill Pond system and 4.1 in Pleasant Bay. With respect to oysters, the plan includes 2.2 million additional oysters grown to harvestable size annually through gear-based aquaculture within the existing Aquaculture Grant Area in Pleasant Bay. In the Pochet area, the updated full scale implementation scenario includes growing and harvesting 3.8 million oysters from an oyster bed. The total number of harvested oysters in the Pleasant Bay system from the Pochet oyster bed and the existing grant areas is 6 million annually. In addition, the full scale implementation scenario includes growing 1.2, 1.1 and 2.4 million small seed oysters for one year in Meetinghouse Pond, Arey's Pond and Lonnie's Pond, respectively. After the first growing season these 4.7 million Year 1 oysters could be grown-out to marketable size in Pleasant Bay or used to enhance the oyster bed in the Pochet area. Other possible scenarios for Year 1 oysters are presented in the Lonnie's (Kescayo-Gansett) Pond Oyster Aquaculture Demonstration Project Year 1 Project Report – Draft (February 16, 2017).

The area required to grow these quantities of shellfish are presented in Table 3, and shown in Figure 1. Quahog propagation can occur throughout identified waterbodies based on local knowledge of preferred seeding locations.

For all categories, the number of shellfish harvested is calculated by dividing the “Annual Goal for Kg of Nitrogen Removed” target in Table 3 by the “Shellfish Nitrogen Uptake” column in Table 2 and rounding up to the nearest 100,000.

The areas required to grow the necessary numbers of shellfish in Arey's, Meetinghouse, Lonnie's and Pochet are derived by dividing the “Annual Goal for Kg of Nitrogen Removed” target shown in Table 3 by the relevant “Annual Nitrogen Uptake” column in Table 2 and rounding to one significant figure. The area required for Pleasant Bay: Existing Aquaculture Grant Sites is calculated using equal numbers of Year 1 and Year 2 oysters and the different stocking densities shown in Table 2 and rounding to one significant figure. The area required for Aquaculture Grant Sites is based on harvesting at Year 2 and assuming that the total nitrogen uptake is the sum of uptake in Year 1 and Year 2.

For quahog propagation, the area required to meet the nitrogen-removal target is based on three years of growth, with the first two years under netting at a higher density than the third year. The increase in biomass for the first two years is assumed to be equal, and higher than the third year when the quahogs are harvested. The total nitrogen in a harvested quahog is the sum of the three years of uptake (.24 grams per quahog). This was used to calculate the required number of three-year old individuals to be harvested annually. To achieve the required number of three-year old quahogs, the density of three-year olds was used to calculate the required acres for broadcast at year three. It was assumed that twice the number of required three-year olds must be grown under netting due to mortality, and the anticipated density of quahogs under netting was used to calculate the associated acreage for years one and two. The total area required for quahogs was calculated as the sum of the areas required for quahogs grown under netting for two years plus the area seeded at broadcast density.

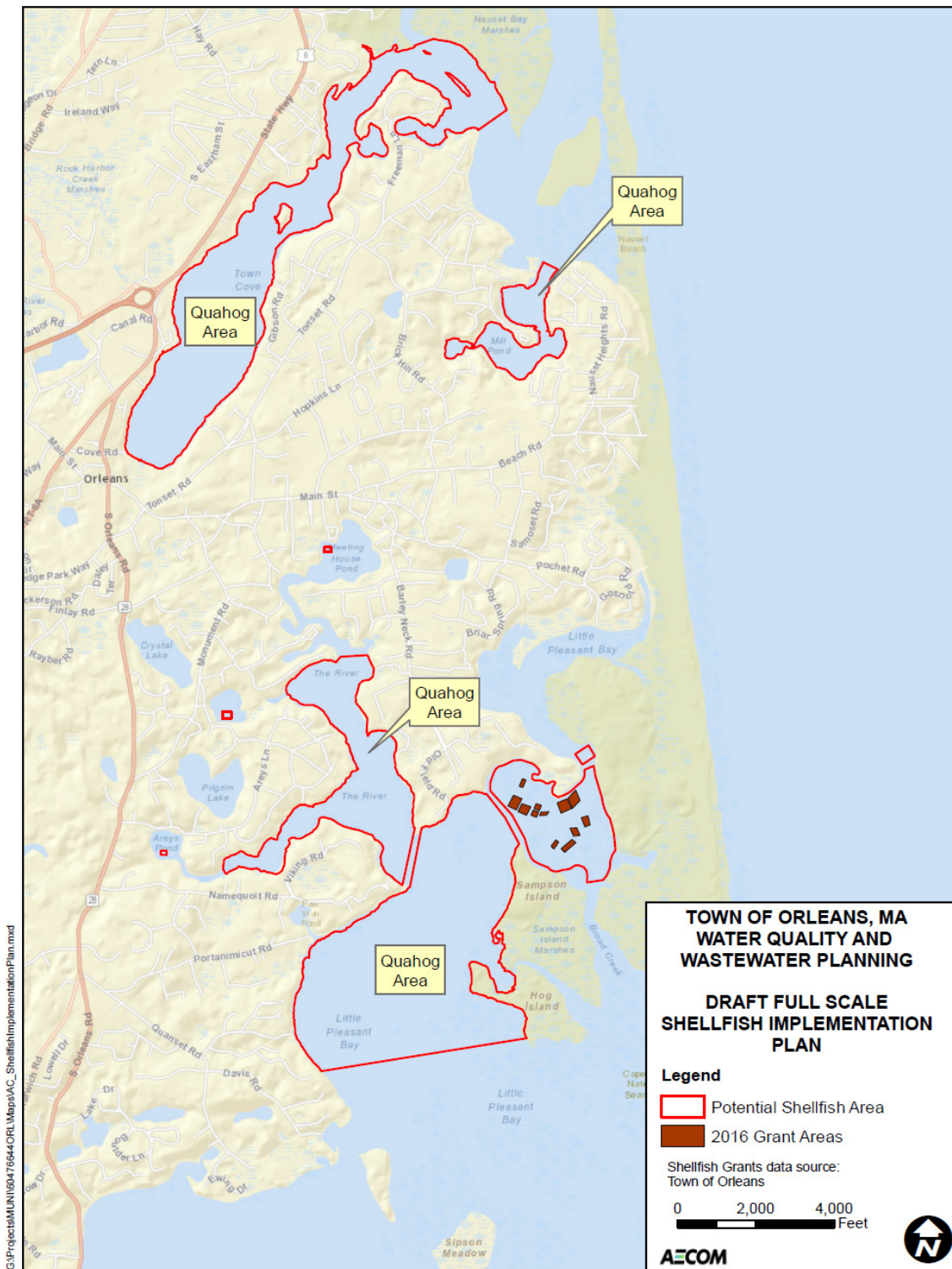


Figure 1 - Area required for the number of shellfish needed to meet the nitrogen-removal targets presented in Table 2 using the higher density values for oysters. The perimeters for oyster areas are sized according to the actual area that will be required for the numbers presented.

5. Next Steps

The values presented in this Technical Memorandum are intended to provide a range of planning-level estimates for a Full-Scale Implementation Program that meets the goals for removing nitrogen using shellfish that were presented in the Orleans Consensus Plan and 2015 Shellfish Forum. Initial species type and quantity, growing locations and growing methods are also presented as a starting point for discussion. This planning analysis should be viewed as part of a broader shellfish management and planning effort that is currently being initiated. The numbers of shellfish can be decreased if the Town chooses to combine shellfish propagation with other non-traditional technologies (PRBs, NRBs, etc.); or if discussions with regulatory agencies that are planned for 2017 determine that point source reduction will be required along with nitrogen removal within the waterbodies. A shellfish management plan is currently under preparation which will outline future activities in Lonnie's Pond. The full-scale implementation scenario outlined in this memo will be adjusted as needed based on the results of the three years of data collection at Lonnie's Pond as well as the final shellfish management plan currently under development.

6. References

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