ALTERNATIVES FOR THE FUTURE OF CARLISLE'S CRANBERRY BOG

Prepared by the

Cranberry Bog Alternatives Committee
Carlisle, Massachusetts

April 2017

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Cranberry Bog Alternatives Committee – 2016-2017

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ACKNOWLEDGMENTS

The Cranberry Bog Alternatives Committee acknowledges the significant help provided by the following.

Sylvia Willard, Carlisle Conservation Administrator
Mark Duffy, President of Carlisle Cranberries, Inc.
Mary Zoll, Carlisle, editor

The following also provided valuable information for this report.

- Dwight DeMay, Carlisle landscape architect
- Alex Hackman, Massachusetts Department of Fish and Game, Division of Ecological Restoration
- Chris Hart, Carlisle builder
- Dan Lenthall, District Conservationist, Natural Resources Conservation Service, US Department of Agriculture
- Brigitte Senkler, Carlisle realtor
- Brian Wick, Executive Director, Cape Cod Cranberry Growers Association

Front cover art by Susan Provenzano.
Front cover photos courtesy of Deborah Geltner and Susan Provenzano

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ALTERNATIVES FOR THE FUTURE OF CARLISLE'S CRANBERRY BOG

OVERVIEW

Carlisle purchased the 151-acre Cranberry Bog Conservation Land in 1986 for $1.8 million, and simultaneously Chelmsford purchased its portion (159 acres for $1.78 million) of the former Lowell Cranberry Company lands yielding 310 contiguous acres of forest, wetlands, stream, ponds, dams, open space, and – in the Carlisle portion – an operating cranberry bog now 110 years old. By 1987, Carlisle reinvigorated the operations of the Cranberry Bog through the significant efforts of local farmers, considerable investments by US Department of Agriculture (in 1990), and the water flow provided by the watershed and contiguous ponds in Carlisle and Chelmsford.

For the first fifteen years following Mark Duffy's initial lease of the bogs in 1989, the operations of the Cranberry Bog were profitable, and the land was maintained and improved by the farmer at no additional cost to the town. Since 2004, the cranberry market has changed dramatically as prices have dropped more than 50%, and nationwide cranberry production has almost doubled. The Carlisle Cranberry Bog, like many in Massachusetts, is no longer a viable cranberry agricultural operation; currently the fields are left fallow, and the bog is slowly deteriorating.

The question faced by the Town of Carlisle today is how to preserve and maintain the bog's conservation and recreation values, landscape, and water rights that are part of this unique and popular parcel of conservation land. The Cranberry Bog Alternatives Committee (CBAC) was formed in 2016 to assist the Conservation Commission and the Town to decide the future for the bog in the absence of cranberry growing. The CBAC identified and evaluated ten alternatives using several criteria. The committee proposes two options.

- The CBAC recommends preserving the conservation, passive recreation, and agricultural values of the land as well as a significant portion of the registered water rights. Specifically, the bogs would be converted to enable growth of other agricultural crops, essentially keeping the bog in active agricultural use as it has been for the last 112 years.

- If the non-cranberry agricultural alternative is not supported by the Conservation Commission or the Town, the CBAC recommends restoration of the bogs to a natural habitat (using an engineered approach) or the conversion of a portion of the bog to a passive recreation area.

Each of these alternatives has a cost – direct and indirect – that is explained in greater detail in the main report. The investment and conversion of the Cranberry Bog to another crop involves significant upfront costs (roughly $500,000) but maintains the agriculture use, the recreational values, and about half of our registered water rights. On the other hand, the ongoing maintenance and restoration of the bogs to natural habitat with loss of water rights may have comparable direct and indirect costs in the long run.

The CBAC feels that doing nothing – letting the bogs deteriorate – is not an option. Like all conservation land, it must be maintained and managed. Doing nothing means that the open fields would fill in with bushes, trees, and invasive weeds, the water ways would become clogged, the pathways would become grown over, dams fail and the passive recreational use would be diminished. The CBAC recommends that the town choose one of the two options described in detail in this report so that the town preserves the conservation, recreation, and agricultural values, the vistas, and the water rights of the Carlisle Cranberry Bog.

Summary Descriptions of the Ten Alternatives Evaluated

1. No Action: Carlisle abandons the bogs and the Bog House. It remains conservation land, but the Town will do no maintenance. Trails will not be mowed or cleared. If a dike breaks, it will not be repaired, the trail will be lost, and the pond the dike created will be gone.
   Pros: Lowest initial costs.
   Cons: Loss of water rights, loss of agricultural land, eventual loss of current uses of the conservation area.

2. Subsidy to Farmer: Provide temporary monetary aid to the farmer of the bog while the farmer tends to the new cranberry vines or alternative crop until it matures.
   Pros: Support of agriculture; maintain some or all water rights; entices farmer to maintain bog.
   Cons: Annual costs for life of subsidy.

3. Town Performs Maintenance: The Town handles basic maintenance of the bog and the Bog House, which includes mowing and maintaining dikes and trails and maintaining the Bog House's structure and utilities. This alternative does NOT include anything on the bog interiors, so trees and bushes would grow unhindered.
   Pros: Maintains conservation and recreation values.
   Cons: Annual costs. Potential loss of agricultural land.

4. Cranberry Bog Renovation**:** Renovate the 20-acre Irrigated Bog that has been in recent cranberry production to obtain higher cranberry yields. Involves stripping all material off the bog surface, redoing the drainage and irrigation, and planting new high-yielding vines.
   Pros: Bog continues as it has for 112 years in cranberry production; maintains all water rights; maintains vistas and trails; Bog House used and maintained.
   Cons: High cost with no guarantee of profits due to issues in the cranberry industry; still need to plan for other areas; hard to find an interested and qualified farmer. Some public use disrupted during renovation.

5. Convert to Other Agricultural Use: All 40 acres of the bog are renovated to allow growth of a different crop with the Town paying for the renovation. Agreement with farmer assumed to include use of Bog House for agricultural support.
   Pros: Maintains agricultural heritage; all areas of bog maintained; keeps some (about 50%) of registered water rights; maintains current public use of bog; Bog House used and maintained.
   Cons: High conversion cost; some public use disrupted during renovation.

6. Create Passive Recreation Area: Convert the Sand-Covered Bog area for passive recreational use by the public. Can likely incorporate handicapped access.
   Pros: Gives public a larger open area to play in and enjoy.
   Cons: Significant cost to design and convert; only one section of the bog converted. The area is known to flood.

7. Engineered Restoration to Natural Habitat: Convert all areas of the bog to a natural-

wetland wildlife habitat similar to what existed before the cranberry bogs were built. This alternative requires site engineering work (e.g., soil movement and possibly alteration of dams or water-control structures) and reintroduction of flora and fauna appropriate for the site.

Pros: Maintains vistas and adds habitats for wildlife.

Cons: High cost; no maintenance for trails and dikes; loss of water rights.

8. Passive Restoration to Natural Habitat: Essentially the same as the No Action alternative. The bogs are abandoned with no effort being made to maintain water-control structures, vistas, or invasive plants.

   Pros: Lowest initial costs.

   Cons: Loss of water rights, eventual loss of use of the bogs; loss of vistas across bogs.

9. Install Solar Array for Income: Install an array of solar panels in Sand Pit. The objective is to generate income to support one of the other bog alternatives.

   Pros: Green energy income (technically net metering credits) for conservation support.

   Cons: Potential high initial capital cost; major hurdle and dangerous precedent of Article 97 (converting conservation land to another use); difficult to get generated energy to grid; doesn't address bog itself. There are other potential legal hurdles.

10. Upgrade Bog House for Rental: Renovate the interior of the Bog House to upgrade the current two apartments or carry out a major renovation to convert to two town houses. Although there are significant initial costs for the renovation, there would be rental income to pay off the initial cost and then provide future income to support bog operation and maintenance.

    Pros: Maintain the historical aspect of the Bog House; generate income.

    Cons: High initial cost; doesn't address the rest of the bog. Possible legal issues involved, e.g., Article 97 of the Massachusetts constitution ("change in use").

The Cranberry Bog Alternatives Committee (CBAC) strongly recommends the choice of Conversion to Other Agricultural Use (Alternative 5) because it is the only option that accomplishes the following.

- Preserves the bog as close as possible to its current state
- Preserves local agricultural and the bog's agricultural heritage
- Preserves the vistas across the bog and the openness of the bog area
- Addresses all areas of the bog
- Addresses bog maintenance (assumes farmer involvement)
- Addresses the Bog House maintenance (assumes farmer involvement)
- Preserves about half of our registered water rights
- Preserves current aquatic habitats for wildlife (reservoirs, brook)
- Maintains current public use of one of the most popular Carlisle conservation lands and passive-recreation areas
- Covers all of the bog, unlike other alternatives, at a cost similar to that of other pro-active alternatives.

EXECUTIVE SUMMARY

Description of the Problem

In late 2015, Carlisle's cranberry farmer, Mark Duffy (operating as Carlisle Cranberries, Inc.), informed the Town that, for economic reasons, he was not interested in renewing his lease to grow cranberries on Carlisle's Cranberry Bog Conservation Land, at least not without a subsidy. Specifically, due to the chronically low prices paid to cranberry farmers for their crop (due to overproduction in the US and other countries) and to diminishing yields of Carlisle's cranberry bogs, it was no longer possible to make a profit. Although Mr. Duffy offered to continue cranberry growing for one more year (2016), adverse weather conditions in early 2016 resulted in no berry production on the vines and thus no harvest. Absent (1) a major and very expensive bog renovation (which would involve planting higher-yielding vines), (2) a recovery of cranberry prices (not anticipated anytime soon), and (3) the appearance of a willing and knowledgeable cranberry farmer (with infrastructure support), cranberry growing at Carlisle's bog will permanently cease. The fundamental problem for the Town is, therefore, to decide what to do with our 40-acre bog and the recently restored Cranberry Bog House, which is on the Cranberry Bog Conservation Land and which has, for the bog's 112-year history, been an essential component of the cranberry growing activity at this site.

The Cranberry Bog Alternatives Committee

Because of the high value of the Cranberry Bog in terms of local agriculture, opportunities for passive recreation, and a variety of wildlife habitats, the Conservation Commission (ConsCom) appointed a select group of interested Town citizens to a Cranberry Bog Alternatives Committee (CBAC) to study the problem and present to ConsCom and the Town alternatives for the future of the bog. The CBAC consisted of five regular Members, two Associate Members, and the Town's Conservation Administrator. The CBAC started its work in early July 2016.

The CBAC identified 10 alternatives for the future of the three bog areas, a sand pit, and the Cranberry Bog House. (See Figure 1 in Section 1 for the location of these areas. See Table 1 in Section 2 for the list of alternatives.) The CBAC also identified 13 evaluation criteria it felt were important. (See Table 2 in Section 2 for a list of the criteria.) Over the course of the next seven months, committee members undertook to describe and evaluate each of the 10 alternatives. The reports on each alternative are presented following Section 6: Conclusions and Recommendations.

In addition to the 10 alternatives, the CBAC investigated five important factors: (1) the economics of growing and selling cranberries in the US, (2) water rights, (3) agricultural dams, (4) considerations of present value costs, and (5) and the continuing problem with beavers and muskrats. The report on cranberry economics is provided in Section 4, and the reports on topics 2 through 5 are provided in Section 5. As part of its evaluation of alternatives, CBAC members reached out to a number of professionals to obtain factual

information and insights. On two occasions, the CBAC reached out to Town Counsel (Miyares and Harrington, LLP) on questions relating to (1) the placement of solar panels on conservation land, (2) the potential need to remove water-control structures, and (3) potential changes in our registered water rights following either a change in crop or a cessation of all agriculture. The questions to and answers from Town Counsel are provided in **Appendices B and C** to this report.

Two other notable CBAC activities included (1) the conduct of a cranberry bog car and visitor count for a 17-day period in September 2016 (see **Appendix A**) and (2) the collection of soil data, from field sampling, for all three bog areas (see **Appendix D**). The former was undertaken to see how popular the bog was to visitors; the second was undertaken to provide a more scientific basis for the evaluation of Alternative 5.

Conclusions and Recommendations

The major CBAC conclusion is that, for the three bog areas, the bogs should be modified to allow the growth of other agricultural crops. (In this report, this alternative is called Alternative 5.) As with other agricultural lands on Town-owned conservation lands, the new fields would be offered, via a public process, to local farmers who would be asked to submit proposals. Mark Duffy, the recent cranberry bog farmer and the farmer at the nearby Great Brook Farm State Park dairy operation, has said he would be interested in using the fields under a lease/management agreement with the Town. Alternative 4, which would have involved continued cranberry growing at the bog following an expensive bog renovation, was considered too expensive, too much of a financial risk, and impractical.

The conversion of the bog's 36 acres of bogs (40 acres including dams and service roads) to fields suitable to growing other crops is technically complex and expensive; a very rough estimate puts the conversion costs at around $500,000 excluding an initial consultant/engineering study, which would provide the Town with detailed conversion plans and a more reliable cost estimate. Yet, the CBAC feels this conversion is, by far, the best alternative for the long term future of the bog and the Town.

The major benefits of implementing Alternative 5 are as follows.

- The preservation of 36 acres (40 acres including service roads and dams/dikes) of agricultural land on a property with a significant cultural heritage of agriculture. (Note that agricultural preservation is a specific goal/objective of the Town's 2013 Open Space and Recreation Plan as well as in previous Plans.)
- The preservation of a significant fraction (about 50%) of the registered water rights Carlisle has for the Bog property. Absent this preservation, the Town can expect a renewed effort by the Chelmsford Water District to install a municipal well field abutting the Chelmsford Cranberry Reservation that could extract a significant amount of water from the River Meadow Brook watershed, with resulting adverse impacts on downstream wildlife habitats, private wells, and potentially to agricultural operations in drought years.

- The preservation of open vistas across the agricultural fields, considered a significant benefit to the public using the bog for passive recreation. (Without agriculture, or without any engineered restoration that would minimize tree and bush growth, the vistas would eventually be lost due to tree and bush growth.)
- Potential for continued beneficial use of the Cranberry Bog House to support agriculture by providing equipment storage space and housing (two apartments) for agricultural workers. Although the CBAC is recommending a new well and septic system for the Bog House regardless of which alternative is chosen, having the building be part of an agricultural lease to the chosen farmer avoids the necessity of a major Bog House renovation (described in Alternative 10) such as would be needed for rental of the apartments to the public.
- The preservation of the upper and lower bog reservoirs as these water bodies would likely be part of the irrigation system for the new agricultural fields. The reservoirs provide important aquatic habitat as well as pleasing vistas.

If the Town chooses not to pursue Alternative 5: Conversion to Other Agricultural Use for the three bog areas, then the recommendation is to do the following.

- Consider restoring the bogs to a natural habitat either through an engineered restoration (Alternative 7) or a passive restoration (Alternative 8). The engineered restoration would be expensive but create a much better wildlife habitat while also retaining most of the vistas.
- Consider converting the Sand-Covered bog to a passive recreation area (Alternative 6).
- Consider the value of Alternative 10: Bog House Upgrade for Rental Use as there would be no agricultural workers using the Bog House apartments.

For the sand pit on the south side of Curve Street, the CBAC considered either no action (Alternative 1), conversion to other agricultural use (Alternative 5), passive restoration to a natural habitat (Alternative 7), or the installation of a solar array (Alternative 9) – to produce income to support bog operations – as acceptable. There is no rush for a decision on the Sand Pit area.

The CBAC cannot present a strong recommendation for the upgrading of the two Bog House apartments to rental status (Alternative 10), especially if Alternative 5 is to be implemented as, in that case, the farmer would likely wish to include the Bog House in the lease/management agreement for the bog property. However, the CBAC does recommend that a new domestic water supply well and septic system for the Bog House be installed as the current systems are inadequate.

The CBAC recommends that the Town take over maintenance of the bog areas and the Cranberry Bog House while decisions on the future of the bog are made and the chosen alternative(s) are implemented. In the past, while cranberry operations were ongoing, this maintenance was provided by the cranberry farmer. In the future, depending on the agricultural lease/management agreement the Town will negotiate with the chosen farmer, some of the maintenance could be taken over by the farmer as in-kind payments

for the use of the land. The costs of the maintenance (detailed in Alternative 3) are likely to be around $25,000 per year but could be significantly lower or higher.

The Next Steps

The CBAC recommends that the Conservation Commission (ConsCom) do the following.

1. Carefully review this report and decide whether it agrees with the conclusions and recommendations of the CBAC or whether it wishes to modify the preferred alternative(s) for any bog area.
2. As part of the above, involve other boards and committees, other stakeholders, and the public in a review of this report and its recommendations.
3. Assuming there are no major delays or obstacles to moving ahead, proceed to request funding, at the 2017 Annual Town Meeting, to cover the maintenance of the cranberry bog (roughly $25,000 per year). During 2017, ConsCom should also seek additional technical and economic information related to the implementation of Alternative 5. By the 2018 Annual Town Meeting, ConsCom should be ready to request sufficient funds, roughly estimated at $30,000, to pay for a consultant/engineering study that would provide detailed plans for the implementation of Alternative 5.
4. Take any necessary steps to insure that the Town retains, for the bogs, its Agricultural Exemption under the Massachusetts Wetlands Protection Act and its regulations while the conversion to growing other agricultural crops is ongoing.
5. Obtain cost estimates and proposed plans for the installation of a new well and septic system for the Bog House.
6. Work with the CBAC to identify potential sources of grant funds that could be used to offset part of the Alternative 5 implementation costs.

1. INTRODUCTION

Background

This report presents and evaluates alternatives for the cranberry bogs, Cranberry Bog House, and related areas within Carlisle's Cranberry Bog Conservation Land located on Curve Street in the northwest corner of Carlisle and bordering on Chelmsford's Cranberry Bog Reservation. Both Carlisle's Cranberry Bog Land and Chelmsford's Cranberry Bog Reservation were part of the Lowell Cranberry Company's holdings, which were sold to the two towns in 1986. Both parcels are conservation lands. They are managed separately by the Conservation Commissions in the two towns. Both parcels are within the River Meadow Brook watershed, which has its headwaters just inside Route 495 (in Westford) and, locally, flows east into Heart Pond (mostly in Chelmsford), then south into Chelmsford's Cranberry Bog Reservation, then through Carlisle's Cranberry Bog Conservation Land, then into Great Brook Farm State Park, and eventually to the Concord River.

Figure 1 presents an aerial view of the area. The blue line shows the watershed boundary upstream of the State Park, and the red lines outline the conservation lands in Carlisle and Chelmsford. The red diagonal line is the town line separating the two conservation lands. In this image, north is roughly to the right, and one inch equals roughly 2,000 feet.

In late 2015, Carlisle's cranberry farmer, Mark Duffy (operating as Carlisle Cranberries, Inc.), informed the Town that, for economic reasons, he was not interested in renewing his lease to grow cranberries on Carlisle's Cranberry Bog Conservation Land. Mr. Duffy had been growing cranberries at the bog since 1989, most recently under a long-term (20-year) lease, which expired in 2015. In recent years, due to increased production of cranberries in the US and other countries, the prices paid to farmers for cranberries have declined dramatically. Simultaneously, the yields of cranberries from Carlisle's bogs have been lower than normal due to a combination of adverse weather (frost and freeze damage) and aging plants. Therefore, making a profit growing cranberries in Carlisle's bogs is no longer possible. Many other cranberry farmers have renovated their bogs, which involves removing the old vines, planting new and higher-yielding plants, and installing better drainage and irrigation. This undertaking is very expensive, with no assurance that future cranberry prices will rebound enough to allow a return on the investment.

As a result of the cessation of cranberry farming at Carlisle's bog, which has been on-going since 1904, the Town is now faced with (1) the possible abandonment of some 36 acres of agricultural land (40 acres if dikes and service roads are included); (2) the responsibility of maintaining or removing associated dams and water-control structures; (3) the responsibility of maintaining the service roads and trails around the bog areas; and (4) the responsibility for maintaining and using the Cranberry Bog House located at the bog. The loss of agriculture will also result in the loss of registered water rights that are associated with cranberry growing and issued under the authority of the Massachusetts Water Management Act of 1985. The loss of agriculture will also result in loss of the

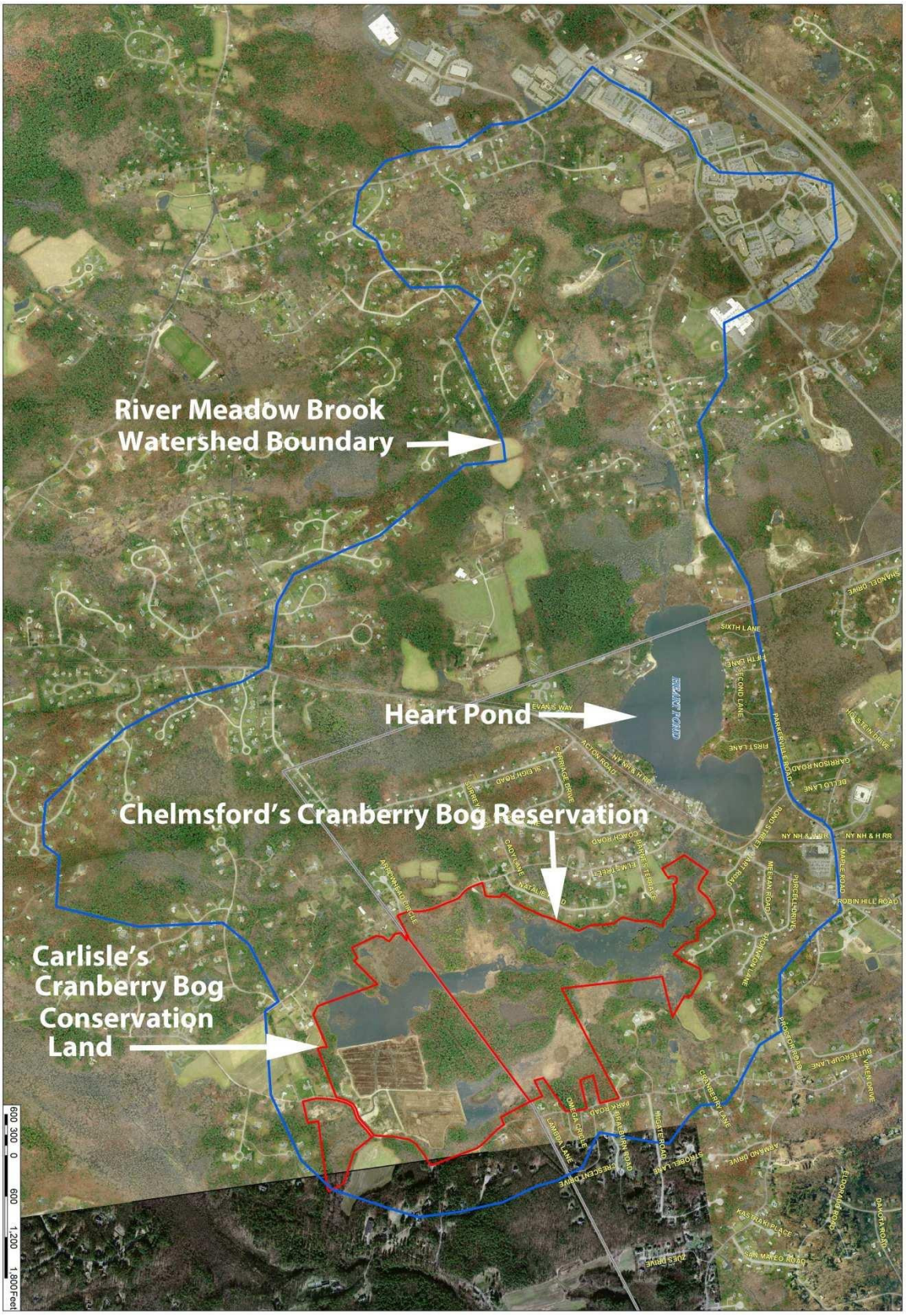

Figure 1. Aerial Photo of Watershed Around the Cranberry Bog Conservation Lands

Source: Town of Chelmsford, Community Development Department (based on 2008 aerial photo)

Agricultural Exemption for many activities regulated by the Wetlands Protection Act; without this exemption, many maintenance activities, such as mowing on the dams and dam repair, would require a public hearing and the issuance of Orders of Conditions by the Conservation Commission, which would likely restrict the maintenance work and result in added costs to the Town.

To address these problems, the Carlisle Conservation Commission established, in June 2016, the Cranberry Bog Alternatives Committee (CBAC). Five members and three associate members were appointed to the CBAC, with the Conservation Administrator, Sylvia Willard, as an unofficial, non-voting member. The CBAC held its first meeting on July 1, 2016, and generally met every two to four weeks in the ensuing months.

In this report, the CBAC presents information and recommendations on alternatives for the future use of five important areas of Carlisle's Cranberry Bog Conservation Land. The areas are as follows.

- The Irrigated Bog (18 acres), where cranberries are currently grown
- The Bog In Renovation (13.5 acres), which is a bog in renovation
- The Sand-Covered Bog (4.5 acres), which is also a bog in renovation
- The Sand Pit (1.9 acres), formerly used as a composting area and a sand pit
- The Cranberry Bog House

The locations of these areas are shown in **Figure 2**, and photographs of the three bog areas and one pit are shown in **Figures 3a – 3d**. The two in-renovation bogs are areas where cranberries were grown in the past, but they are not currently used for cranberry growing because of distressed economic conditions in the cranberry industry. Specifically, the prices cranberry farmers are receiving today are too low – even for established bogs – for many farmers to make a profit. In addition, the costs to bring these bogs back into production are prohibitive, e.g., $30,000 - $50,000 per acre (see Section 4).

The ten alternatives evaluated for the bog or pit areas listed above are identified in Section 2 below. The Committee's recommendations are presented in Section 6. The detailed evaluations for each alternative are presented following Section 6. It is expected that this report and its recommendations will be reviewed by the Conservation Commission and will be discussed with the Board of Selectmen, the Finance Committee, and with other interested groups and individuals. It is further expected that the Conservation Commission, after such reviews and discussions, will make a recommendation to the Town as to which alternative or alternatives it deems best for the Cranberry Bog. Approval by Town Meeting is required for any action that involves significant costs to the Town.

Non-Agricultural Value of the Cranberry Bog and Visitor Survey

Carlisle's Cranberry Bog Conservation Land is a favorite visiting spot for walkers, including those with dogs, from Carlisle and surrounding towns. Bike riders, horseback riders, cross-country skiers, and fishermen also are frequent visitors. The open areas

Figure 2. Aerial View of Carlisle's Cranberry Bog with Named Areas of Interest

Figure 3a. View of Irrigated Bog – September 2013 (Photo by D. Geltner**)**

Figure 3b. View of Bog in Renovation – August 2016 (Photo by D. Geltner**)**

Figure 3c. View of Sand-Covered Bog – May 2012 (Photo by D. Geltner**)**

Figure 3d. View of Sand Pit – August 2016 (Photo by D. Geltner**)**

around the bogs provide easy walking, breezes to keep bugs away, and eye-pleasing vistas. The woodland trails allow for longer walks connecting with Chelmsford's Cranberry Bog Reservation. The property provides a number of diverse habitats for wildlife; these include forested upland, wetland, and aquatic habitats. The aquatic habitats include two reservoirs, River Meadow Brook, and vernal pools. Further information on the attributes of the property can be found in the "Baseline Assessment for the Cranberry Bog" (June 2007) prepared by the Land Stewardship Committee, which is available on the Town's web site:
http://www.carlislema.gov/Pages/CarlisleMA_Steward/LSC%20activities.

Visitor Survey

To document the use of the Cranberry Bog by the public, the CBAC undertook a survey during a 17-day period in September 2016 (Sept. 10-26, 2016). During this period, various CBAC members went to the bog at random times during the day and counted the number of cars and visitors seen. In total, 32 observations were made in the 17-day period between 7 AM and 7 PM. Full details on the survey are provided in **Appendix A** to this report.

From the survey data, an average of approximately 290 people visited the bog each day during the study period. An average of approximately 160 dogs visited each day. The average ratio of people to cars was 1.5. These data substantiate the significant value of the bog to the public.

Committee Meetings, Outreach, and Public Involvement

Committee Meetings

Between July 2016 and April 2017, the Cranberry Bog Alternatives Committee (CBAC) held 14 meetings, all having the necessary quorum of members. Typically, the meetings were held every two to four weeks.

Outreach and Public Involvement

The CBAC took steps to insure that its ongoing work and deliberations were open to the public. In addition to posting meeting agendas and welcoming guests at meetings, the CBAC did the following.

- It gave updates to the Conservation Commission on July 28, 2016, and January 26, 2017.
- It led a discussion at a Conservation Coffee, hosted by Sylvia Willard, on November 15, 2016.
- It maintained a publically accessible web site on which were posted the latest drafts of reports on alternatives being evaluated and other report sections.
- It posted minutes from the CBAC meetings on a separate web site for public reading.
- It discussed its ongoing work and progress with representatives of the Chelmsford Conservation Commission at the semi-annual Cranberry Bog Subcommittee

meetings at which Carlisle and Chelmsford share information on the combined cranberry bog conservation land in the two towns.

Carlisle Mosquito Articles

The CBAC was fortunate to have coverage of several of our meetings or outreach activities by the *Carlisle Mosquito*. These articles provide a good description of the Committee's work at various times. The articles (dates and titles), which may be found on the Mosquito's web site (www.carlislemosqito.org), are listed below.

- August 12, 2016: "What next for the Cranberry Bog?"
- September 16, 2016: "Future of Carlisle's Cranberry Bog on the table"
- September 30, 2016: "Farm subsidies among options eyed for Cranberry Bog"
- October 21, 2016: "Cranberry bog alternatives take shape"
- November 25, 2016: "The Cranberry Bog's future: it's all about water"
- February 3, 2017: Editorial – "A bog for all seasons"
- March 24, 2017: "CBAC makes recommendations for Cranberry Bog's future"
- March 31, 2017: "CBAC: convert Cranberry Bog to other agricultural use"

2. ALTERNATIVES CONSIDERED

The ten alternatives considered for the five Cranberry Bog areas identified in Section 1 are listed in **Table 1** with a brief definition.

Table 1. Names and Descriptions of Alternatives

No.	Alternative Name	Description
1	No Action	Take no action for bog segments, sand pit, or Bog House.
2	Subsidy to farmer	Pay the farmer an annual subsidy that considers that year's yield, cranberry prices, and other factors.
3	Bog maintenance by DPW or paid for by Town	Delegate to DPW or Town-hired contractor all bog maintenance, such as mowing and maintaining the dike(s) and culvert(s).
4	Bog Renovation – Cranberry growing	Remove old vines, level the bog, and plant new, high-yielding cranberry vines. Reinstall irrigation system.
5	Conversion to other agricultural use	As necessary, clear bog area of vegetative growth, amend soils to suit other crops, and make the bog available for lease to area farmers.
6	Creation of passive recreation area	Clear bog area, amend soils to support a ground cover (grass), add other amenities if desired, and have DPW maintain as a recreational park.
7	Engineered restoration to natural habitat	Using professional help and with public input on key features, design and construct a natural habitat on the bog area. Possibly alter existing water features.
8	Passive restoration to natural habitat	Let time and natural forces alter the bog area. Eventually, possibly add some edge maintenance and removal of trees and invasive plants.
9	Installation of solar array for income generation	Install a solar-electric array that will generate electricity for sale to the local public grid. The proceeds (net metering credits) would be used to pay for some of the design and construction work, with residual income used to support cranberry bog operations.
10	Upgrade of two Bog House apartments for rental use	Upgrade the two Bog House apartments (total of 4 bedrooms), which will likely require a new well and septic system, central heating, and other interior improvements. Rental income from apartments to be used to support cranberry bog operations.

The detailed reports on each Alternative are located after Section 6 of the Main Report. Although Alternatives 2 and 10 do not apply to any of the three bog areas or the sand pit, all of the other alternatives could, in theory, be applied to any or all of the three bog areas or sand pit. The CBAC did not stipulate that just one alternative should be applied to all bog areas; a combination of alternatives could be chosen. In this report, a specific combination of alternatives is referred to as a Plan.

For example, one plan might be to select Alternative 4 for the Irrigated Bog, Alternative 5 for the Bog in Renovation, Alternative 6 for the Sand-Covered Bog, Alternative 9 for the Sand Pit, and Alternative 10 for the Bog House. The principal evaluation factors that should be used in deciding which alternative to use for which bog area, or which combination of alternatives to use in a plan, are described in Section 3 below. These evaluation criteria were considered by the CBAC before making the recommendations given in Section 5.

Of the ten alternatives, only Alternative 4: Bog Renovation would lead to a long-term continuation of cranberry farming in Carlisle. Alternative 2: Subsidy to Farmer is only intended to be a temporary support to help the farmer while the Irrigated Bog, or another bog area, is being renovated, or while a bog area is transformed (as in Alternative 5) in order to grow other crops. If cranberry prices remain depressed, the subsidy might have to continue for many years. If agriculture is not chosen for a bog's future, then the bog area could be transformed (1) in a purposeful manner (Alternative 7) to a natural wetland and wildlife habitat, or (2) by abandonment (Alternative 8), allowing it to restore itself slowly to a wildlife habitat. In the latter case (abandonment), the habitat would include more bushes and trees than are currently there, and these bushes and trees would mostly eliminate the vistas across the bogs.

Another alternative for non-agricultural use would be to convert a bog area into a passive recreation area to be used by the public (Alternative 6). Alternatives 9: Install Solar Array and 10: Upgrade Bog House Apartments have a primary purpose of generating long-term income to support agricultural operations at the bog, but these alternatives also have other benefits. Alternative 3: Bog Maintenance by DPW will help reduce the farmer's bog maintenance costs and reduce the need for a subsidy. Finally, the Town always has the option, on a temporary or permanent basis, of doing nothing (Alternative 1: No Action). This alternative entails, however, significant consequences.

The alternatives, except for 1: No Action and 8: Passive Restoration, will have significant implementation costs and continuing maintenance costs. Even Alternatives 1 and 8 are expected to have future maintenance costs and other impacts on the Town. In some cases, grant monies may be available to offset the Town's costs. Regulatory requirements (or even barriers) will also be a significant burden for the implementation of many alternatives.

The detailed alternative reports are intended to provide sufficient information for the Conservation Commission and the Town to make the initial decision on which alternative should be selected for each bog area. Because of limitations on time and resources for report preparation, and because the Committee members are not experts on the alternatives discussed, the amount and detail of information that is provided and perhaps its reliability is necessarily limited. These limitations hold especially for estimates of costs, regulatory requirements, and implementation times. Once the initial decisions have been made, further engineering, design, and cost studies will be required to obtain the design and cost details desired. Such information might come, for example, through a consulting contract with a qualified engineering firm.

3. SUMMARY EVALUATION OF ALTERNATIVES

Evaluation Criteria

To help in the evaluation of the ten Alternatives, a set of positive and negative evaluation criteria were developed (**Table 2**). The reasons for the inclusion of each criterion are briefly described. In addition to these criteria, the Cranberry Bog Alternative Committee (CBAC) used other criteria for some of the Alternatives. The order of listing of the criteria in Table 2 does not indicate greater or lesser importance for individual criteria. Initially the CBAC considered ascribing numeric weights to each criterion and giving each Alternative a numeric score for each pertinent criterion. This scheme was abandoned because it was deemed too confusing and inflexible.

Many of these criteria were used by the Carlisle's Cranberry Bog Agricultural Agreement Committee, which worked from 2013 to 2015 to evaluate future options for agriculture at our bog and to develop a new Management Agreement that would allow Mr. Duffy to continue growing cranberries at the bog. Other criteria were added by the CBAC.

Use of Evaluation Criteria in Alternative Reports

Although each Alternative report does not have a specific discussion with regard to pertinent evaluation criteria, it does provide a list of pros and cons, which touch on the most pertinent criteria. Because of unique aspects of some Alternatives, some reports use criteria not listed in Table 2.

Qualitative Evaluations Compared for the Ten Alternatives

Figure 4 presents a qualitative assessment of the extent to which different evaluation criteria appear to apply, positively or negatively, to each of the ten Alternatives. A darker color in a cell indicates the criterion is more strongly applicable to that Alternative. The assessment of these qualitative evaluation criteria can be quite subjective, and reasonable people can disagree on the nature and extent of how each criterion applies to any Alternative.

Estimated Costs of the Alternatives

A more quantitative estimate of the costs of each Alternative is provided in **Table 3**. Estimates of both capital and annual costs are shown. Two different options are provided for Alternatives 6 and 10. These estimates are very preliminary and would be revised, through a contract with a consulting engineer, before being presented to Town Meeting with a funding request.

Table 2. Evaluation Criteria for Alternatives

Positive Criteria	Reasons for Inclusion
1. Preservation of cranberry farming	The cultural heritage is valued. The vistas are pleasing, especially at harvest time
2. Preservation of agriculture	Preserving local agriculture is an important State and local goal.
3. Preservation or enhancement of conservation values (e.g., wildlife habitat including. impoundments)	Conserving open space, especially wildlife habitat, is an important goal for Carlisle.
4. Preservation of water rights	Water rights are needed to support agriculture, protect wildlife habitats, and protect well water.
5. Preservation or enhancement of recreational values (e.g., trails, fishing, vistas, new park land)	Preserving recreational values is also a key goal for Carlisle.
6. Preservation of Bog House	The Bog House supports agriculture at the bog, provides two apartments, and is an historical building.
7. Gain of Town revenue	Additional income supports conservation and recreation values in town.
8. Sustainability	The alternative chosen must be sustainable with a combination of human and financial resources and public support, now and in the future.
Potential Negative Criteria	**Reasons for Inclusion**
9. Town capital investments	This cost adds to the tax burden.
10. Town operation and maintenance costs	These costs add to the tax burden.
11. Regulatory constraints and other risks	Constraints add to the cost, implementation time, and risk of failures.
12. Extended time needed for implementation	Longer time adds to costs, including possible payment of subsidy to farmer for several years.
13. Effect on dam classification and related costs	Reclassified dams may have to be modified or removed, at substantial cost.

Figure 4. Summary Qualitative Evaluation of the Ten Alternatives

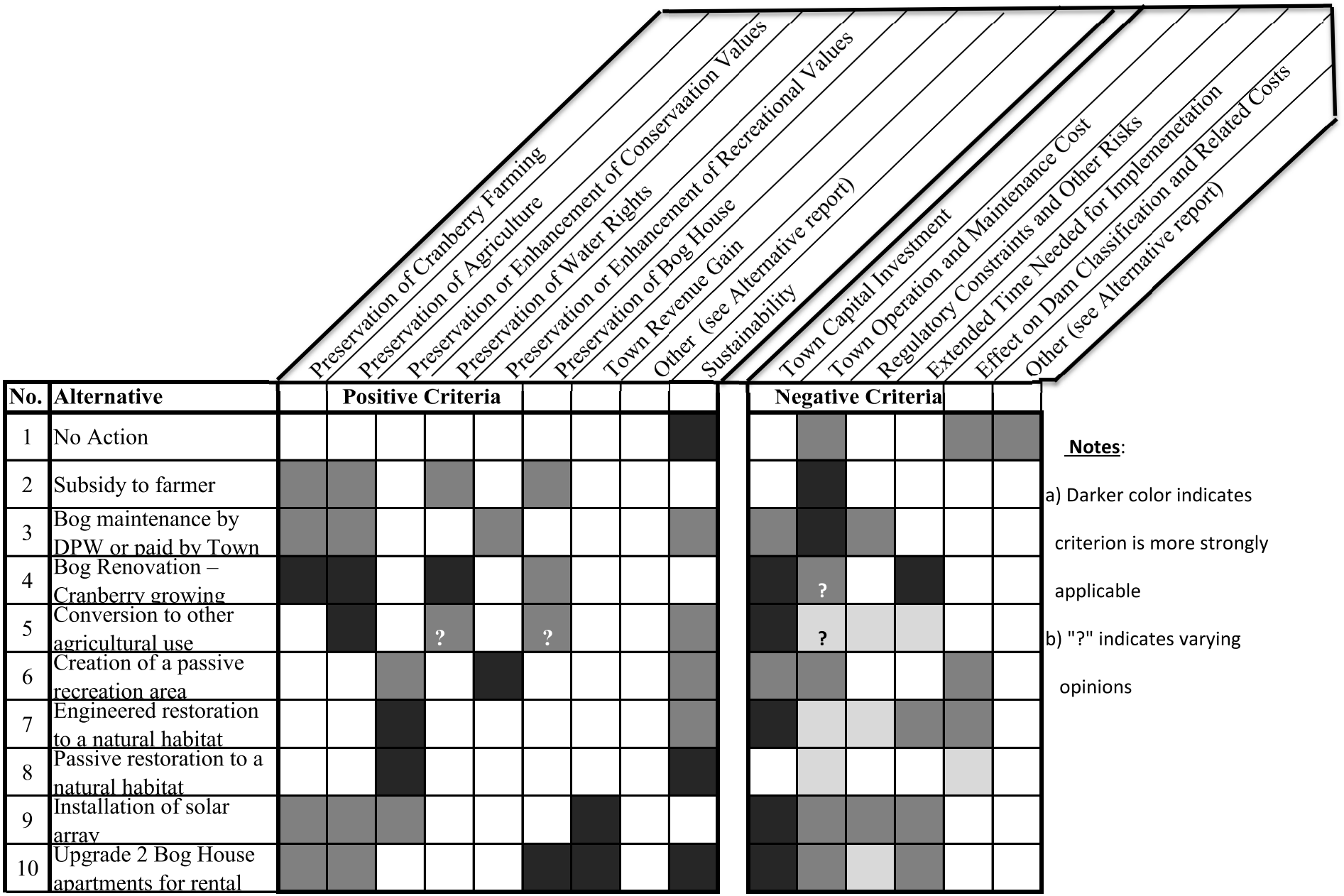

Table 3. Summary of Estimated Costs for Alternatives Evaluated

No.	Alternative	Location	Acres	Capital Cost[a] ($)	Annual Costs ($)
1	No Action	Whole bog	40	0	>10,000
2	Subsidy to Farmer	Any bog with farming	N/A	0	< 30,000[b]
3	Town Performs Routine Maintenance	Whole bog	40	0	25,000[c] (7,000 – 87,000)[d]
4	Cranberry Bog Renovation	Irrigated Bog only	20	700,000[e]	Allocated to farmer
5	Convert to Other Agricultural Use	All three bogs	36	500,000[f]	Allocated to farmer
6	Create Passive Recreation Area	Sand-Covered Bog A) Fill added B) No fill	4.5	A: 380,000[g] B: 88,000	2,000[h]
7	Engineered Restoration to Natural Habitat	All three bogs	36	500,000[i]	Not estimated. See Alt. #3
8	Passive Restoration to Natural Habitat	All three bogs	36	0	Not estimated. See Alt. #3
9	Install Solar Array for Income Generation	Sand Pit	1.9	Not estimated (see report)	Not estimated (see report)
10	Upgrade Bog House for Rental	Cranberry Bog House	N/A	A: 370,000[j] B: 860,000[k]	A: 2,000[l] B: 4,800[l]

a Except as noted, capital costs do not include the cost of an initial engineering or consultant study, or both, which would be needed for any alternative with a major capital expenditure. For planning purposes, a study cost of about $30,000 can be assumed.

b Subsidy would be reduced when yields are high or prices are high.

c Likely annual cost.

d Range of possible annual costs including, at high end, major dam repairs.

e Based on an estimate of $33,000 per acre.

f Capital cost includes an irrigation system. Without an irrigation system, the cost per acre is estimated to be $10,000.

g Includes raising the height of the central field by 2 feet with clean fill (1.5 feet) and topsoil (0.5 foot). Plan B would not use any fill except for planting new bushes.

h Covers DPW labor only at $30 per hour. Equipment costs are not evaluated.

i Based on estimate provided by a representative of the Massachusetts Department of Fish and Game, Division of Ecological Restoration. May need up to $100,000 for initial engineering study. Excludes any work on the Curve Street dam.

j Assumes the current layout of two apartments; includes $33,500 design and architectural fee.

k Assumes construction of two town homes in the Bog House; includes $60,000 design and architectural fee.

l Estimated net monthly income to Town from rental of units. Includes subtraction maintenance costs and realtor commission.

4. CRANBERRY ECONOMICS

The current operation of the Carlisle Cranberry Bog is not profitable. With substantial investment and a healthy market price for cranberries, however, the bog can become more productive and profitable. To become profitable, the Carlisle Cranberry bog must produce more quality cranberries (increase its yield), which must be sold at close to average market prices – a price comparable to the Ocean Spray A pool, or more than $30 per barrel. This increase in production and selling price would allow Carlisle, and its cranberry grower, to receive the normal revenue per barrel minus the average cost per barrel and, thereby, to make a reasonable profit margin, or economic return. If Carlisle cannot increase its yield (the production of cranberries per acre) and sell them at a competitive market price, it cannot operate a profitable cranberry bog.

Changes in the Cranberry Market

With a high-yielding and well-maintained cranberry bog and reasonable market conditions, well-run and efficient cranberry bogs can make money. Unfortunately, this has not been the situation over the past 10 years. The changes in the cranberry business, both in crop productivity and in farming improvements, have caused a collapse in cranberry prices. Therefore, unprofitable and inefficient growers have been gradually squeezed out of the business as larger and more efficient Ocean Spray Cooperative members have survived.

The factors affecting the cranberry market are listed below.

- Yields, or productivity per acre, have more than doubled from 1973 to 2012 due to improved higher-yield vines and more efficient agricultural practices (**Figure 5**).

- Costs per acre have remained stable or dropped as producers have become more mechanized and efficient in their cultivation of cranberries, particularly in the higher-yield fields in Wisconsin and New Jersey.

- Older fields and older growers have underinvested and fallen behind in upgrading fields with higher-yield bushes and refurbishing existing fields. At current market prices, these fields are unprofitable because of lower productivity.

- Cranberry supply has more than doubled over the past two decades with new acreage especially in Wisconsin and Canada and increased productivity of new plants. The increased supply of berries has out-stripped demand, which has dramatically affected prices.

- Production of cranberries has shifted away from Massachusetts and traditional growers to Wisconsin and newer, more efficient, low-cost producers in Canada, that have become part of the Ocean Spray Cooperative (**Figure 6**). The less efficient growers, including Carlisle's cranberry farmer, are being squeezed out of the oversupplied market.

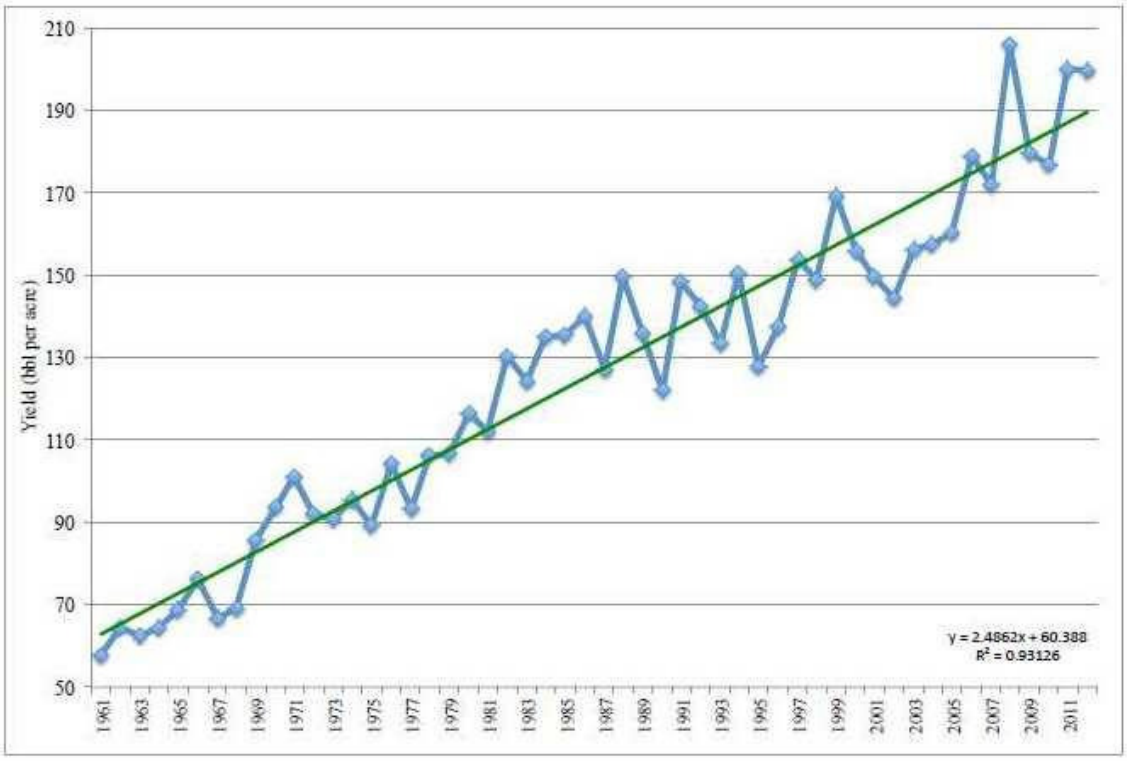

Figure 5. U.S. Cranberry Yield (barrels per acre), 1961 – 2012

Source: Economic Impact of the North American Cranberry Industry, by J.M. Alston, J. Medellin-Azuara, and T.L. Saitone, 2014. (©Copyright, 2014 by J.M. Alston, J. Medellin-Azuara, and T.L. Saitone.)

- Average prices have collapsed from $70 to 80 per barrel in the late 1990s to $20 to 30 per barrel in the current market (**Figures 7 and 8**), particularly for non-Ocean Spray B-pool berries, which cost considerably less than the A-pool berries.

- The oversupply of cranberries has resulted in a large inventory surplus that continues to depress prices. The Cranberry Marketing Committee (headquartered in Wareham, Mass.), a Congressionally authorized organization authorized to oversee the US cranberry market, has worked hard to expand its marketing efforts to increase the demand for cranberries (exports, Craisins®, etc.) to bring the cranberry market back into equilibrium and profitability.

The current market price, inventory surplus, and slow growth in demand mean that the unprofitable growers with lower yielding, higher cost, non-Ocean Spray fields are losing money and being forced to close their operations or find other means of support.

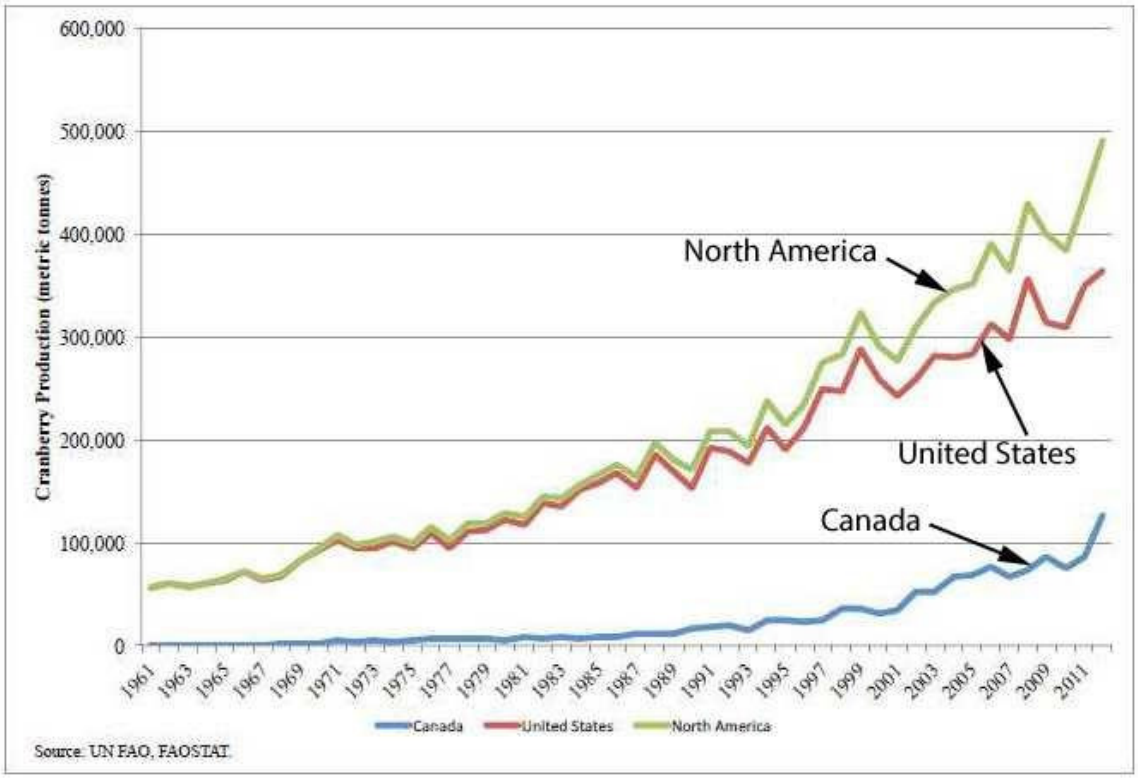

Figure 6. North American Cranberry Production, 1961 – 2012

Source: Economic Impact of the North American Cranberry Industry, by J.M. Alston, J. Medellin-Azuara, and T.L. Saitone, 2014. (©Copyright, 2014 by J.M. Alston, J. Medellin-Azuara, and T.L. Saitone.)

Ocean Spray and The Two-Tiered Market

The cranberry market is dominated by the Ocean Spray Cooperative, which some estimate controls about 50% of the market. Ocean spray growers (co-op members) receive preferential contracts, that is, a higher price for their berries (the A pool) and equally important distribution of their produce through the Ocean Spray supply chain. Non-Ocean Spray independent growers are the last supplier (marginal supplier) selling at auction to an over-supplied cranberry market. In other words, non-Ocean Spray growers receive a significantly lower price for their cranberries (the B pool). Currently, there is an outstanding lawsuit challenging this favorable pricing arrangement and "monopolistic" market structure. (See Cranberry Industry and Ocean Spray Cooperative in sources; note also, preliminary rulings on lawsuit favor Ocean Spray.)

Cranberry price data reflect the average price of berries and NOT the price differences between berries in the A pool and B pool, which are significant (for example, in 2013 the price for A-pool berries was $50 per barrel, compared to less than $20 per barrel for B-pool berries). The average cost has been relatively stable at approximately $20 to 25 per barrel. Given these price and cost averages, the A-pool cranberry grower makes

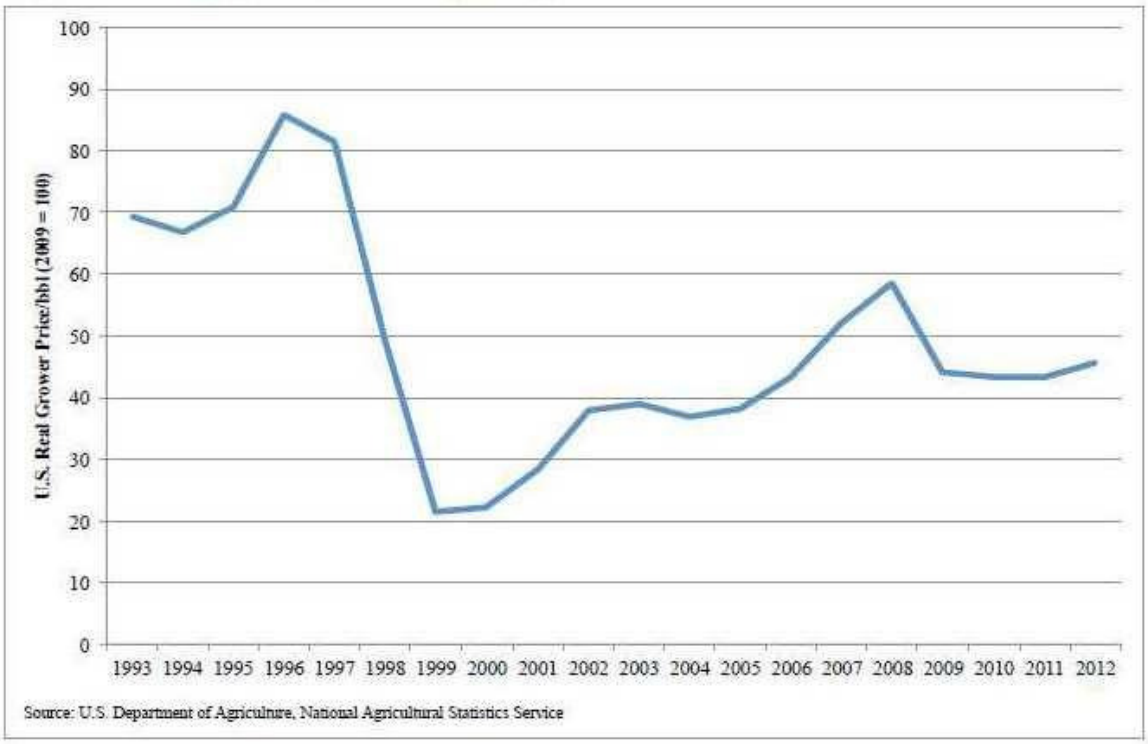

Figure 7. U.S. Real Grower Prices for Cranberries, 1993 – 2012

Source: Economic Impact of the North American Cranberry Industry, by J.M. Alston, J. Medellin-Azuara, and T.L. Saitone, 2014. (©Copyright, 2014 by J.M. Alston, J. Medellin-Azuara, and T.L. Saitone.)

money even in depressed markets ($35 revenue per barrel - $25 cost = $10 operating profit), whereas the independent B-pool grower loses money ($20 revenue per barrel - $25 cost = ($5) loss per barrel).

In the United States, the cranberry market has two tiers, with the Ocean Spray Cooperative members in the upper tier upgrading and investing in their fields as they sell their products into a separate primary market with more stable and managed prices, as alleged by the law suit. The other, non-Ocean Spray, or independent growers sell into a secondary auction market at whatever price the market accepts. Because the non-Ocean Spray growers do not have the same access to the Ocean Spray supply chain as the Ocean Spray Cooperative members do, they are essentially selling an excess supply of cranberries into an oversupplied market and thus receiving a lower price. (Note, we have NO trend data for the A- and B-pool cranberry prices; only the average does exist.)

Like for most agricultural products, the supply and demand for cranberries will reach an equilibrium in time – sometimes because the government buys up and holds the excess supply in inventory. Stabilization of the market means that growers with a high cost and

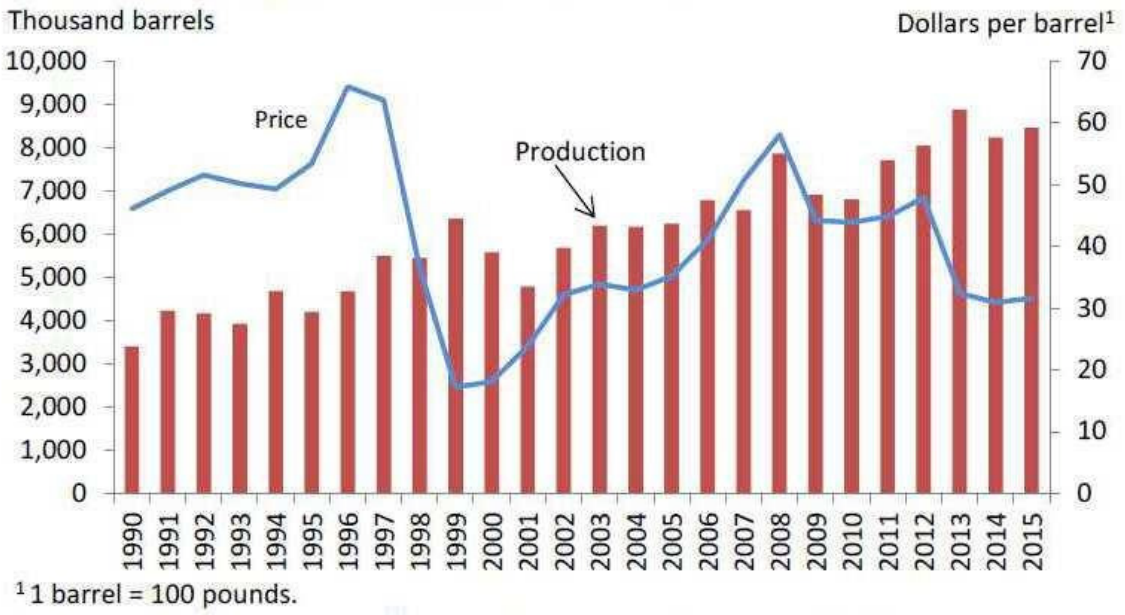

Figure 8. U.S. Utilized Cranberry Production and Average Grower Price

Source: USDA, National Agricultural Statistics, *Noncitrus Fruits and Nuts Summary*, various issues.

low yield drop out, thus allowing prices to rebound to a point at which the most productive growers make money.

The Carlisle Cranberry Bog

Carlisle's cranberry bog began producing cranberries in the early 1900s. The bog was dormant in the 1970s; production was restarted when the town purchased the bog (1986) and later leased it to Farmer Duffy when cranberry prices were high (over $70 per barrel). In the early 1990s, the cranberry farmer invested significant effort in improving the bog: new berries, irrigation equipment, trenches, cultivation, and pesticides. The Carlisle Cranberry Bog generated significant revenues for the farmer and strong economic returns. This situation changed dramatically with the collapse in cranberry prices in 1999 to 2002 as high-yield cranberry fields came onto the market. Carlisle and non-Ocean Spray growers were at a significant disadvantage.

- Yields were considerably less for non-Ocean Spray growers like Carlisle compared to the more efficient growers after 2002 (100 barrels versus 200 barrels per acre)
- Prices for B-pool growers (non-Ocean Spray) were 50% or more below the average market price. (The B-pool auction data is not collected by the Department of Agriculture; the price data is anecdotal and reported in court documents.)
- Cranberry growers were financially strapped and often operated at a loss, so they choose not to invest in their existing bogs or make the necessary capital improvements to compete in the changing markets.

Carlisle now has an unprofitable cranberry bog. The town and the farmer have not made the necessary investments and improvements to compete in the new, more productive

cranberry market. Nor is Carlisle in a position to be considered an efficient and modern Ocean Spray Cooperative member. The Cooperative is not accepting any new members at the moment, nor will it in an over-supplied market.

The economics of the independent and Ocean Spray grower are dramatic, as shown in the pro forma financial statements in **Table 4**. Average operating costs range from $3,500 to 5,000 per acre or $25 to 40 per barrel, depending upon cranberry bog yields.

Table 4. Pro-forma Profit (P) and Loss (L): Independent Grower vs. Ocean Spray

Parameter	Independent Grower		Ocean Spray	
	Number	Per acre P&L	Number	Per acre P&L
Yield per acre (barrels)	100	N/A	200	N/A
Cranberry Price ($ per barrel)	10 - 15	N/A	30 plus	N/A
Revenue ($) (price x yield)	N/A	1,000 - 1,500	N/A	6,000
Cost per barrel ($)	15 - 20	1,500	15 - 20	3,500
Profit (loss) ($ per barrel)	(5 - 10)	(500)	10 - 15	2,500

As is evident from the pro forma illustration, the current economics of the Carlisle Cranberry Bog differ dramatically from those of the Ocean Spray growers. The Carlisle cranberry farmer is losing $500 per acre and spending less than the Ocean Spray growers on maintaining the bog fields ($1,500 per acre or less), whereas the Ocean Spray grower is showing good profits and investing more than Carlisle's cranberry farmer in maintaining its fields ($2,500 per acre), thus maintaining a strong competitive position in the market.

Given the current cranberry market and weak competitive position, the Carlisle Cranberry farmer has been forced to cut costs and under-invest in the current operations, whereas the Ocean Spray growers improve their fields and maintain their dominant market position with high-yielding, efficient farms selling berries into the higher priced A-pool markets.

How To Compete in the New Cranberry Market

To compete in a cranberry market dominated by Ocean Spray, a market that is experiencing over supply and low prices, a grower must be efficient, with high-yielding fields that produce premium cranberries for the market. A competitive, independent grower might even be invited into the Cooperative when the cranberry market stabilizes, but, at the moment, the Cooperative is closed to new members. Therefore, to compete in this market, Carlisle must invest in high-yield, desirable cranberry plants that are in demand so that it is well positioned for a more attractive and higher priced cranberry market.

The investment required to refurbish and rebuild Carlisle's Cranberry Bog is substantial. Cost estimates vary depending on the extent of refurbishment and subcontracting work: $500,000 to $700,000 for the current 19 acres. More detailed cost estimates, bids, and financing would be required if Carlisle decided to refurbish the bog.

In addition to an investment of capital upfront, an investment of time is required: 3 to 4 years for the bog to reach full productivity. During this time, ongoing care and maintenance of approximately $30,000 per year is also required.

In 4 to 5 years, the Carlisle Cranberry Bog could be fully competitive, producing berries that could be sold at the average market price. As an independent producer, Carlisle would be on par with Ocean Spray or might be invited to join the Cooperative. Again, the pro forma statements shown above illustrate how a refurbished cranberry bog can be profitable with considerable time, effort, and significant upfront capital investment. The pro forma statements show different price scenarios ($20 to 40 per barrel) for the bog operations; a breakeven price of approximately $25 per barrel and a $40,000 to 50,000 profit at $40 per barrel.

The economics of agriculture, including the economics of cranberries, depends greatly on price, cost, and yield. In agriculture, conditions are always changing, particularly given the dominant role of Ocean Spray in the market. If Carlisle chooses to invest in the bog to achieve a competitive cranberry bog, it could compete in the market and make an economic profit.

Conclusion

The current cranberry market is oversupplied, so only the most efficient and productive growers can break even or make a profit. The Carlisle Cranberry Bog is presently unprofitable given the low price of cranberries. The current market conditions favor the protected Ocean Spray growers. Of course, agricultural markets change, moving through the normal cycles from oversupply to balance, to undersupply and higher prices. IF Carlisle chooses to invest ($500,000 to 800,000) over the next five years in the Cranberry Bog, the bog could become a competitive cranberry bog that could make a profit well into the future.

Such a commitment of time, effort, and funds requires further study and careful review of all the facts, estimates of a refurbished cranberry bog, and an assessment of the market participants. The continuing role and dominance of Ocean Spray (A- and B-pool growers) and the commitment of the Massachusetts Cranberry Growers Association and the Massachusetts Department of Agriculture (manifest as the availability of grants and loans) to a vital industry are critical.

If Carlisle chooses to invest in a more productive cranberry operation with the assumption of an improved cranberry market with healthy prices, it would also have to find a farmer willing to commit to the time and effort to renovate the bog. The current cranberry farmer (farmer Mark Duffy) is not currently willing to make such a commitment to a refurbished Carlisle Cranberry Bog. When requested in 2014, other cranberry growers were not interested in bidding on the Cranberry Bog license agreement.

The cranberry-farmer market has spoken.

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5. SPECIAL TOPICS

This section contains reports on four special topics of concern for the Cranberry Bog and its future.

Water rights
Dikes, dams, and water control
Beavers and muskrats
Present value cost of alternatives

Water Rights

For the Cranberry Bog, Carlisle has both deeded water rights and, separately, water rights that are registered with the State under the authority the State's Water Management Act of 1985 (M.G.L. 21G). The registered rights are specifically associated with the growing of cranberries at the bog. Both the deeded and registered water rights are further described below; they are also described and evaluated in letters from Carlisle's Town Counsel, which are contained in **Appendices B and C** of this report. The Town is extremely interested in maintaining as much of our water rights as possible. Although the deeded water rights would seem to be immune from any change in land use at the bog, the registered water rights are not immune. Town Counsel's opinions on the extent to which our registered water rights would be reduced if cranberries are no longer grown at the bog, if we switched to other agricultural crops, or if agriculture was abandoned altogether are provided in a subsection below.

The reasons for wanting to preserve our water rights include the following.

- The water will be needed if, as recommended, Carlisle continues with agriculture at the bog site. The new crops will require significant irrigation.
- The water rights help preserve and protect the diversity of wildlife habitats at the bog, including streams (River Meadow Brook), ponds, wetlands, and vernal pools.
- The water rights help preserve the groundwater in the River Meadow Brook watershed for the wells providing domestic water to numerous homes near the bog in Carlisle.
- The water rights also help preserve the visually pleasing surface-water features (streams and ponds) not only in the bog but also downstream in the Great Brook Farm State Park.
- There is a significant threat that loss of the registered water rights could encourage an upstream withdrawal of water by a privately owned company that supplies public water in Chelmsford. (See below for further discussion.)

<u>Deeded Water Rights</u>

Around 1903, when the Nickles brothers purchased all the land that was to become the Cranberry Bog, including land in both Carlisle and Chelmsford, they also purchased the

water rights to the water flowing into the bog ponds from Chelmsford's Hart Pond. They incorporated the water rights into the deed for the acquired lands, which was assigned to the Nickles Cranberry Company. In 1922, the Nickles Cranberry Company sold its holdings to the Lowell Cranberry Company. Included in the deeded conveyance of the cranberry bog land to the Lowell Cranberry Company was "all water power, water privileges and flowage rights from Hart's Pond."

When Carlisle and Chelmsford purchased, in 1986, the portions of the bog in their respective Towns, the words relating to deeded water rights were not carried over into the new deeds. Nevertheless, this omission did not eliminate the deeded rights. Based on a review by Special Town Counsel Francis A. DiLuna in April 2000 (see Appendix B of this report), Carlisle is unaware of any instrument that has terminated these deeded rights. Mr. DiLuna indicated he was not able to determine if others (e.g., Chelmsford) also held such rights, which would make our rights non-exclusive.

Registered Water Rights

Shortly after Carlisle acquired its portion of the bog and re-instituted its Cranberry operation, it registered its water-use rights with the State Department of Environmental Protection (DEP) as allowed by the State's Water Management Act (WMA) of 1985 (M.G.L. 21G). The WMA authorizes the DEP to regulate the amount of water withdrawn from the Commonwealth's groundwater and surface-water supplies. Carlisle's registration is for an average use of 357,000 gallons per day (GPD), with water being withdrawn from a single un-metered location. The registration letter from the State indicates that "this registration is for cranberry cultivation only; any change in use is subject to Department review and may require a permit application."

The registration, which is calculated based on Carlisle's 40 acres of cranberry bogs, is a 10-year renewable right assuming that Carlisle continues active agricultural use for the harvesting of cranberries. The current registration is valid through January 1, 2018; a request for a renewal of this registration must be submitted in 2017. The DEP's calculations of the allowable draw of water from the neighboring ponds or reservoirs is based upon best practices of cranberry farming; however, during drought years and harvest time, there is no question that the Carlisle cranberry farmer has had to rely upon the deeded water rights attached to the property.

Chelmsford Residential Water Use

Over the past 17 years, the Chelmsford Water District (one of three privately held public-water suppliers in Chelmsford) has expressed a strong interest in constructing a well field (the Barnes Terrace Well Field) near the upper pond in Chelmsford to draw water from the surficial aquifer for residential use. The proposed water withdrawal rate was 360,000 gallons per minute. Attempts to initiate such a project were made both in 1999 to 2000 and in 2011; in both cases, Carlisle, with input from Special Town Counsel, strongly objected to the proposed project based primarily on our legal water rights and ongoing cranberry production, which needed the water. In 2012, the Chelmsford Water District notified the Chelmsford Conservation Commission that it had temporarily suspended its efforts to develop the Barnes Terrace Well Field. However, it indicated the

suspension was temporary. To date (March 2017), no further development plans have been proposed by the District. Chelmsford continues to be interested in developing alternative water sources for its use in west Chelmsford for residential use; however, it also recognizes (and has discussed) the water rights that have been established by Carlisle.

A particular technical and legal problem with the proposed Chelmsford withdrawal is that the extracted water, coming out of the Concord River basin, would be discharged – after residential use – to a different river basin. State regulations look very unfavorably on such inter-basin transfers because they rob the donor basin, which may have multiple needs, of water.

FutureWater Rights with Continued Cranberry Growing

Although not recommended in this report, if Carlisle did decide to continue growing cranberries at the bog, the current registered water rights would not be lost as long as the Town continued to renew its registration every 10 years. It would also have to maintain the In-Renovation Bog and the Sand-Covered Bog in an in-renovation state.

Future Water Rights with Agricultural Abandonment

If Carlisle decided to discontinue all agriculture at the bog, it would lose its registered water rights but not the deeded water rights.

Changing Water Rights with New Agricultural Uses

If, as recommended in this report, Carlisle does convert the bog areas for other agricultural use, then a portion of our registered water rights could be retained. Because of the complexity of the rules regarding this case, the three-part information on water rights retention below is quoted directly from the January 18, 2017, letter from Town Counsel (see Appendix C). (GPD is gallons per day.)

> *(1) Activities that do not require more than the 100,000 GPD "threshold volume" of water.*
>
> If the Town's new farming activities will not require more than the 100,000 GPD threshold volume of water, … the Town should maintain its current registration statement and continue to file its annual cranberry registration reports to preserve the registration volume and allow the Town to switch back to cranberries if necessary. The annual reports would show zero GPD for cranberry cultivation, but that would be sufficient to preserve the full volume of 360,000 GPD under the current registration statement if there were ever a need or desire for a reversion to cranberry cultivation. Under this scenario, the Town could conduct a multi-year trial run for other crops to see if the change in commodity was more profitable, safe in the knowledge that the cranberry volume was still available if those crops did not produce the desired results. Under this approach, the Town would not be required to apply for a modification to its registration or a permit unless the new crop required a volume of water that would trigger either of these requirements.

(2) Activities that require more than the 100,000 GPD "threshold volume" but less than 181,001 GPD of water.

If a new crop required a volume of water exceeding the 100,000 GPD threshold volume, … the DEP's standard operating procedure is to require a modification of the registration statement. Because water use for cranberry growing is mostly non-consumptive only a fraction of the registered volume can be converted to another consumptive use, such as irrigating another crop. Therefore, if a modification of the registration is required, the Town could seek approval to modify the registration statement due to a change in commodity. DEP's practice is to assume that 22.5% of the volume of water allowed in the cranberry registration statement is consumptive and may be converted to other uses. Therefore, if Carlisle sought to modify its registration statement, DEP would allow such a modification by reducing the registered volume to 81,000 GPD (22.5% of the 360,000 GPD registered volume) and allowing this volume of water to be used on activities other than cranberry growing. The Town could then use this volume of water in addition to the 100,000 GPD threshold volume for a total of 181,000 GPD.

(3) Activities that require more than 181,000 GPD of water.

If the new crop requires water withdrawals in excess of 181,000 GPD then Carlisle will have to apply for a permit. 310 CMR 36.16(1)(b).

If the new agricultural crops did not require more than 181,000 GPD, and if this value became the new permitted amount for agriculture on the three bog segments, then our registered water rights will essentially be reduced to 50% of the current amount (181/357 = 0.507 = 50% [rounded]).

Value of Water Rights

The value of the water rights is somewhat subjective. However, there are several market value estimates that help us establish a range.

- Market value of water: what other agricultural producers are willing to pay for water. The high value might come from California farms, where the state provides a subsidy to maintain farming in California. This value is obviously high, given that there is a scarcity of water in California and usually plenty of water in Massachusetts and New England. Market value of water to Boston is another way to estimate the potential value of the water to Carlisle. Of course, the town does not charge for water. Residents have private wells.
- Opportunity cost of Chelmsford building a well-field to provide a residential source of water to South Chelmsford. Several years ago, the estimate for drilling wells and providing access to a new well field ran close to $1 million.
- Lost water for residents in Carlisle. Because Carlisle relies on private wells, the loss of surface water and aquifer supply means that some residents on

Fiske Street, in Tall Pines, and on Curve Street may not have as strong flowing wells as they do now or may need to drill deeper wells. IF there is a 10% chance that 10 of the 100 wells in the bog area may underperform over the coming years, additional well costs could run from $10,000 to $30,000 per well. Again, we do not know how many wells might need additional service; nevertheless, 10 wells at $20,000 each leaves a potential residential exposure of $200,000 at some point in the future.

- Conservation values of the water, the land, vistas, and Cranberry Bog. The Cranberry Bog was originally purchased for $1.8 million back in 1986; if this purchase price is amortized over 20 years, conservation uses (vista, water, water fowl, fauna) cost $90,000 per year. That conservation value could be degraded with less water and less conservation use. How much degradation might occur with negligence and less water is hard to say. Again 10 to 20% loss in value, or a loss of $180,000 to $360,000, is conceivable.

Future Concerns Regarding Water Supply in Carlisle

Although the above discussions on water rights are focused on the surface and ground waters in the River Meadow Brook watershed within Carlisle, issues regarding water rights, water supply, and water quality, especially ground-water quality, arise frequently for other parts of Town as well. These issues are understandable because, except for some municipal buildings and a few residential enclaves, all residential water comes from private wells. When significant problems or controversies do arise, paying for professional studies to provide supporting technical information is common. Given this situation, the Town may wish to consider a Town-wide study of water supply and water quality issues by a highly qualified professional organization such as the US Geological Survey. Joint support by the Conservation Commission, Board of Health, and Planning Board would likely be necessary to fund such a study.

Dams, Dikes, and Water Control for the Carlisle Cranberry Bog

Cranberry agriculture by its nature requires large amounts of water and water-control structures in order to manage for irrigation, frost protection, fertilization and chemigation, and for the colorful harvest that is the hallmark of cranberry agriculture. The water requirements haven't changed for over 110 years for Carlisle's Cranberry Bog with dams, reservoirs, and a pond within a watershed extending from Carlisle into Chelmsford, our neighboring town to the north.

Within Carlisle, there are five constructed water-control structures: one is approximately 20 years old, and the remaining four were built more than 100 years ago. Two other water-control structures are located in the Town of Chelmsford. One is located at the outflow of Heart Pond and under the jurisdiction of the Massachusetts Office of Dam Safety. The other is just over the Carlisle-Chelmsford town line within the Chelmsford Cranberry Bog Reservation.

Two of the five structures in Carlisle are also regulated by the Massachusetts Office of Dam Safety (ODS), under MGL Ch 131 s.44 because they meet the regulatory definition of a Dam. (See the end of this section for that definition.) Under Massachusetts law, the owner of a regulated dam is responsible for its maintenance and repair; therefore for the purposes of this discussion, only the structures in Carlisle will be discussed in greater detail.

Two of the three non-regulated water-control structures are sometimes referred to as dikes. They do not conform, however, to the strict definition of a dike, so this term will not be used in this report; they will be called dams. The remaining water-control structure, the most recently constructed one, functions as a water conveyance and is incapable of withholding water. This structure will be referred to as a berm.

The Town of Carlisle through its purchase of the Cranberry bog land in Carlisle, including the entire working cranberry bog, acquired the deeded water rights up to and including Heart Pond in Chelmsford.

All four dams in Carlisle have been upgraded within the past 25 years with modern aluminum flumes, replacing the historic wooden flumes in existence for possibly 100 years. These flumes can be used to alter the depth and flow of the water they control by simply inserting one or more stoplogs in slots located in the structure on the upstream side.

In addition to controlling water, all the dams and the berm in the Carlisle Cranberry Bog provide very popular public walking trails, including access to and from trails in Chelmsford's Cranberry Bog Reservation. Water-control features are particularly susceptible to storm events and erosion, both external and internal. Occasionally, they can and have been overtopped and breeched. As with all manmade structures, maintaining them in safe condition is important and takes time, funding, and regular inspections to address maintenance issues before they become significant and lead to dam failure. Some critical maintenance is simple, such as removing beaver debris blocking the flumes.

One of the two dams in Carlisle under the jurisdiction of the Office of Dam Safety (ODS) is the Curve Street Dam, which also functions as the foundation for Curve Street itself. This dam leads from near the Cranberry Bog House northerly for approximately 375 feet. The ODS has classified this structure to be a Significant Hazard Dam and, as such, requires a Phase 1: visual inspection by a qualified dam engineer every 5 years. The other ODS-regulated dam, Cranberry Bog Dam #1 (CBD1), is located within the bog and separates the Lower Water Reservoir from the bog area that has been in-renovation for the past few years. This dam is classified as Low Hazard by the ODS and requires an inspection every 10 years. In 2011 this dam failed during a major northeast storm called the Halloween Storm, emptying its reservoir into the bog in-renovation and then under Curve Street. It took nearly a year to be repaired, and attempts to find outside funding for the repair were unsuccessful.

The ODS ordered an inspection of both dams, which was carried out in October 2015. A consultant, Weston and Sampson, was hired by the Town of Carlisle, and a detailed report was submitted to the Town and to the ODS in December 2015 for each dam. This was the CBD1's first inspection, and this 550-foot-long structure was found to be in Poor Condition. The report detailed many deficiencies and recommendations for repair and maintenance, with potential costs ranging up to $300,000. However, the report also recognized that the structure was created for agricultural purposes and had no other use. Due to the agricultural function of the dam, the report recommended the Town seek to have this structure reclassified as Non-Jurisdictional to the ODS.

The report submitted for the Curve Street Dam, the second inspection for this structure, found this dam to be in Fair Condition and repeated most of the recommendations made in its report five years earlier, with potential repair costs of up to $300,000. These recommendations included a comprehensive Hydrologic and Hydraulic Study for the watershed to determine the adequacy of the spillway and culvert under Curve Street, preparation of an Operations and Maintenance Plan, addressing areas of erosion, removal of trees and brush on the dam embankments, culvert repair, filling animal burrows, repairing the dam embankment, and performing other maintenance in order to bring the dam into a safer and more stable condition. The report did recommend repairs around the culvert under Curve Street be accomplished as soon as practicable.

More complete details about the recommendations for both dams can be found in the reports located in the Conservation Commission office. ODS could require a Phase 2 inspection of either of these dams at any time. A Phase 1 visual inspection that included both the Curve Street Dam and CBD #1 in 2015 cost $7,900. A Phase 2 inspection is considerably more involved and can be very costly.

Within the last dozen years, two unfortunate dam failures have occurred, one in Chelmsford's Cranberry Bog Reservation and one in Carlisle. Clearly, these failures can result in damage to wildlife habitat, wetland ponds, and structures on both sides of the town line. They also take months to resolve and are expensive to repair. Maintaining good communication between the Carlisle Conservation Commission, the Chelmsford Conservation Commission, and the Heart Pond Association will continue to be of great benefit to both towns in order for water-control structures on both sides of the town line to remain in good condition.

For the last few years, the Heart Pond Association has had a program of water release for the purpose of controlling aquatic invasive plants. Carlisle lately has been notified of these releases, and this practice should continue. Care should be taken to time these releases to avoid major storm events and to allow time for Carlisle to ensure that all flumes are free of debris and adjusted to handle the increased flow.

Many of the maintenance needs of water-control features used in agriculture have exemptions under the Wetlands Protection Act (M.G.L. chapter 131 s. 40) and its regulations (310 CMR 10.00) provided that the agricultural practices have a Conservation Plan prepared by the U.S. Department of Agriculture.

A question regarding the bog dams is whether they would need to be removed if cranberry farming stopped, and, if they were removed, if any upstream landowners who might be negatively affected by such removal would have any legal recourse. This question was put to Town Counsel (Miyares and Harrington LLP), and their August 2016 opinion letter is provided by Item 2 in Appendix B of this report. Because the answer is a "little complicated," the reader is referred to Appendix B.

The Massachusetts Definition of a Dam and a Dam Breach

Dam means any artificial barrier, including appurtenant works, which impounds or diverts water, and which:
(a) is 25 feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation; or
(b) has an impounding capacity at maximum water storage elevation of 50 acre feet or more. Any other artificial barrier, including appurtenant works, the breaching of which could endanger property or safety, may be designated by the Commissioner as a dam, and shall be subject to M.G.L. c. 253, §§ 44 through 48.

The word "dam" shall not mean any of the following.
(c) any appurtenant works which temporarily impounds or diverts water used on land in agricultural use as defined pursuant to M.G.L. c. 131, § 40;
(d) any barrier or appurtenant works which has a size classification of small or low hazard potential classification that is used on land in agricultural use as defined in M.G.L. c. 131, § 40; and
(e) any barrier which is not in excess of six feet in height, regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of 15 acre feet, regardless of height. The Commissioner shall make such determination by taking into consideration factors such as height, type of structure, condition of structure, volume of the impoundment, extent of development downstream, and other factors deemed appropriate by the Commissioner.

Dam Breach means an eroded opening through a dam which drains the impoundment. A controlled breach is a design and constructed opening. An uncontrolled breach is an unintentional opening which allows uncontrolled discharge from the impoundment, Dams, which are water control structures 10 or more feet in height are under the jurisdiction of the Massachusetts Office of Dam Safety (ODS) unless they are considered agricultural or unlikely to cause damage downstream if the structure fails.

Beaver and Muskrat Control

The Carlisle Cranberry Bog is part of the River Meadow Brook watershed. Both upstream of the bog in Chelmsford and Westford and downstream of the bog at the Great

Brook Farm State Park, beavers and muskrats have been a significant management problem for years. Beaver dams both above the bog and below it prevent the free flow of water, causing flooding, and make it difficult for the farmer to control the amount of water for his crops. Debris from both beavers and muskrats commonly clogs up culverts and water-control structures, which increases the risk of water overflowing and possibly washing out a cranberry bog dam or a public road. Muskrat burrows in the cranberry bog dams can undermine their integrity, possibly causing them to collapse or wash out.

Beavers and muskrats have been seen at the Carlisle Cranberry Bog since at least the mid nineties. In the past, Carlisle's cranberry farmer has spent a significant amount of time periodically cleaning the culverts and water-control structures, and our up- and down-stream neighbors have also taken measures to deal with beavers and muskrats. Regardless of the alternative(s) chosen for the future of the bog, some attention will need to be paid to problems that beavers and muskrats create because the bog dikes could become dangerous or impassable as time goes on. This section is intended to provide an overview of the best beaver and muskrat control measures currently available.

Beaver

The North American Beaver is a large nocturnal, semiaquatic rodent that builds dams to create deep still water, which serves to protect them against predators and to float food close to their lodge (home). A beaver family consists of an adult male and female in a monogamous pair and their kits (babies under a year old) and yearlings. They have one litter each year that consists of one to four kits. The young stay with the parents for two years. Beaver families can be as large as ten members with multiple lodges and can live 5 to 10 years in the wild. Based on this information, there could be over fifty beavers at the bog, but fortunately beavers rarely overpopulate an area because the two-year-olds will leave in the spring to find their own mates, and beavers will have fewer kits when their population reaches a certain level and food becomes scarce.

In 2015, eight beavers were trapped downstream from the bog, which most likely were a family that had moved on from the bog. In 2014, some were trapped farther downstream. Beavers are also living at Great Brook Farm State Park, which is downstream, so they may have come from the bog. Beavers mark their territory with mounds made of mud and debris and scent them to warn intruders. These piles are visible along the Otter Slide Trail now, indicating that some beavers are moving downstream again.

Currently, beavers and their attempts at water control are addressed by using various flow devices or trapping. The cranberry bog is a unique problem because the beaver problem is not just at the bog but starts at a large dam upstream in Westford. The Westford beaver dam restricts water to Heart Pond in Chelmsford, which, in turn, affects the water level downstream in the Carlisle Cranberry Bog. Beavers also have dams in the Cranberry

Bog both in Chelmsford and Carlisle sections. In addition, when relocating beavers was a legal option for beaver control, beavers were caught elsewhere and then released at the bog.

To properly assess the situation and design a humane and hopefully effective plan, the town should hire a beaver professional such as Beaver Solutions. A site assessment by Beaver Solutions would cost $250 and would include travel to the site, evaluation of the conflict site as well as the immediate upstream and downstream areas, data collection and analysis including topographical map assessment, and development of site-specific recommendations including written cost estimates.

There are three options for flow devices: the Flexible Leveler System, the Clemson Leveler, and the Beaver Deceiver. Both the Flexible Leveler System and the Clemson Leveler place pipes through the dam and extend the pipes upstream at least five feet where a wire fence is placed. The beavers will make a dam around the fence, but the water will flow through the pipe and maintain the pond levels. The Flexible Leveler uses a 12-inch-diameter corrugated polyethylene pipe, whereas the Clemson Leveler uses PVC pipe.

A Beaver Deceiver is either a rectangular fence that protects the upstream opening of a culvert or trapezoidal fence that is narrow at the culvert and widens upstream. Sizes and shapes vary, according to the site. The length of each side of the fence is normally at least twice the diameter of the culvert. Installing this device can be the best solution for a large flowage where the water flow is too great for a pipe system or smaller flowages where roads were built in floodplains. A floor of fencing is usually laid first to deter beaver burrowing. Mike Callahan of Beaver Solutions states "Most beaver problems can be solved with flow devices at a typical cost of $1,100 to $1,600 for all materials and labor, including installation. With minimal maintenance, flow devices can remain effective for many years. Our flow devices are so effective that we can guarantee them."[1]

The final option is trapping the beavers and removing them from the site. Beaver removals must be done by kill trappers in Massachusetts because it is illegal to relocate them. Unfortunately, traps cannot distinguish their prey and often kill other wildlife and pets, so this may not be an option for a public conservation area. Beaver removal is also often a temporary solution because other beavers will move into the abandoned area unless all beavers up stream are caught too, and removing beavers from an area can stimulate larger litters. The current cost for trapping is $150 per beaver.

Muskrat

The other Cranberry Bog rodent is the muskrat, which is a medium-sized, semiaquatic rodent that is native to North America. Since their natural wetland habitat has been reduced by human activity, their new habitat has been in canals and irrigation channels, such as those found at the Cranberry Bog. Muskrats live in groups that consist of a male and female and their young. Muskrats can have two or three litters a year of six to eight young each. Their population is cyclical over a six to ten years. They are an important

food resource for many animals including mink, fox, coyotes, owls, and hawks. Muskrats make nests of vegetation and mud that can be up to 3 feet in height and look a bit like small beaver lodges. They also will burrow into banks and make their homes in the bank. This type of house is a problem at the bog because it undermines the dikes and ditches causing them to collapse when people or machinery go on them.
Currently the only way to control muskrats is to trap them. A pest professional is the best option for trapping, but trapping would have to be done on an annual basis to keep the population under control. Trapping on pubic land is controversial because of animal-rights activists. Trapping might also be unsafe because other species, including pets, might be caught in a trap.

Conclusion

The problem of beavers and muskrats at the Carlisle Cranberry Bog must be addressed regardless of the alternative because of the damage they are doing and potentially can do. The first step in this process is to get input from a wildlife control/pest control expert for advice on addressing the problem of beavers and muskrats at the Cranberry Bog.

Footnotes

1. Email conversation with Mike Callahan on December 19, 2016.

Bibliography

http://www.beaversww.org/

http://www.beaversolutions.com

http://icwdm.org/handbook/rodents/Muskrats.asp

http://www.wildlifeanimalcontrol.com/muskrats.html

Present Value Costs of the Alternatives

One of the more convenient ways that economists compare costs across varying time periods with different uses and different risks is to estimate costs at one point in time, or discount them back to today's present value (PV) (**Table 5**). In this way, varying costs that occur at some point in the future are shown as though they happen today (discounted back to today's present value). A present value calculation is a way of comparing or ranking costs at one point in time.

For example, a cost of $300,000 today may be more than $400,000 six years from now, even though the face value (nominal) of $300,000 today is less than $400,000 six years from now. Or to put it differently, $400,000 cost six years from now is approximately $300,000 in today's dollars – they are equivalent.

How is this possible? In the above example, if $300,000 were reinvested at an interest rate of 5% every year for six years (which is a good market rate return), we would receive

Table 5. Present Value Costs for the Alternatives[a]

No.	Alternative	Assumptions	Concerns	Present Value ($)
1	No Action	Value of conservation and water rights. Possible loss of ground water.	Opportunity (potential) costs of lost resources	300,000
2	Subsidy to Farmer	Making small profit with B-pool cranberries, but degradation of bog	Price of B-pool berries varies, so subsidy varies. Bog less efficient.	400,000[b]
3	Town Performs Routine Maintenance	Mowing and preserving vistas and fields; degradation of bog	Insufficient maintenance and monitoring	250,000
4	Cranberry Bog Renovation	Upgrade productivity of 20 acres active bog. A-pool member of Ocean Spray	Need to invest in A-pool berries to be profitable	700,000
5	Convert to Other Agricultural Use	New agricultural crops on all three bogs, expert consultation	Draining bog for new crops. Market unpredictable.	500,000
6	Create Passive Recreation Area	Not all the bog, just sand-covered. Other alternatives for rest of bog.	Occasional flooding. Maintenance requirements could be significant.	300,000
7	Engineered Restoration to Natural Habitat	Assuming vista and fauna appropriate; not whole bog	Much design & consultation needed	500,000
8	Passive Restoration to Natural Habitat	What will be appropriate for all three bogs (36 acres)	Not designed; lots of maintenance work may be needed	Not estimated. See Alt. 3
9	Install Solar Array for Income Generation	Only possible in Sand Pit. Article 97 issues	Several. See Alternative 9	Not estimated
10	Upgrade Bog House for Rental	Housing that could be rented for residents, costs over $700k, rental $350k	Code cost in upgrading to code. Profit not guaranteed.	350,000

[a] The cost bases and other assumptions for the present values shown in this table were shown in Table 3 (Section 3).

[b] Assumes ongoing subsidy to farmer since B-pool berries are not profitable; annual costs of approximately $20-25,000, which results in long-term present value costs.

5% interest every year; or our money would be compounding at 5%. After six years that $300,000 would be $402,028, which means that $300,000 today is worth slightly more than $400,000 six years from now. In other words, discounting $400,000 cost back at 5% to today's dollars is slightly less than $300,000, or the present value of $400,000 occurring six years from now is $298,507.

Present value calculations are a useful way of comparing or ranking relative costs at one point in time. The calculations are very dependent upon assumptions of costs, discount rates and estimated values. The present value Table 5 is a useful way of looking at the various costs of each alternative relative to others; it should NOT be viewed as the actual cost in today's dollars.

There are a number of pitfalls with this approach, namely the underlying assumptions and the discount rate (or risk adjusted rate). The assumptions regarding estimated future costs need to be looked at very carefully – how much will it cost to renovate the bog house or refurbish the bog to a different crop – and the risk adjusted discount rate can also dramatically change the expected values or costs. (The 5% discounted cost of today's market is quite different from the 1% discount of last year's market, which was the interest rate that many were using during the very slow recovery from the Great Recession). In other words, the present value costs of a project depend greatly on the estimated costs of doing something in the future and the discount rate.

It is also important to note that some costs are explicit outflows of funds and other opportunity costs – or the lost value of not doing something. This is particularly the case with loss of conservation value or water rights that may not involve explicit upfront costs but will result in the loss of valuable resources in the future that have assumed values. One person's conservation land, or vista, is worth more than another. Or less potable water for the neighborhood is a loss for some number of houses, but not necessarily a loss to the whole population of Carlisle.

The present value table shows the comparable cost estimates of the various actions items being considered – they provide a ranking of the comparable costs. For example renovation of the bog is one of the highest present values, whereas maintenance is the lowest.

The present value estimates shown in the Table 5 are based on the range of calculations discussed in detail in different sections of the report – the table shows the potential cost comparisons of different alternatives, or relative ranking, of present value costs of the Cranberry Bog options, at one point in time. For consistency, a 5% discount rate (which is slightly more than Carlisle's Aa bond rating) was used for all the alternatives (with no risk adjustment). The cost estimates used a midpoint number rather than showing the range, e.g., $500,000 rather than $300,000 to $700,000. This lets us discount back one set of costs at 5% to today's present value rather than discounting a range of values.

For example, the range of Bog house renovations costs is estimated to fall between $370,000 and $860,000, generating income of $2,000 to $5,000; for present value

calculations, this has been simplified to $700,000 capital cost occurring in three years with an income stream of $3,000 per year after year 4. This renovation cost and income stream was then calculated to a **net** present value of $350,000 (700-350). Again, the costs to renovate the bog house have a wide range, so that in some instances present value of rental income might cover the costs (PV is positive). This has not been shown since it might be considered too optimistic; instead the table shows a negative Net present value cost of renovation.

The present value opportunity costs are very assumption driven, particularly since this does not involve an outflow of funds. However, the bog was purchased for $1,800,000, so a 20 percent loss of conservation value of the acreage (30 + acres / 150 acres) could be anywhere from 360,000 to 180,000 loss of value (10% to 20% loss depending on a person's perspective). The loss of water rights could mean that some neighboring wells are degraded or need additional work (2-5% of one of the 100 houses in the area might be affected – in other words, 3 houses with $30,000 well and water expenses in the future). Based on these assumptions, potential opportunity costs could range from less than $270,000 to 450,000 (360k + 90 = 450), or approximately $300,000.

Again, there are several simplifying assumptions being made for each option so that we can compare the relative costs of various alternatives. The present value Table 5 is way of comparing the options and costs in terms of today's dollars. The underlying assumptions have been listed along with some of the concerns that could change the comparisons of various options. For example, water rights are an opportunity cost of not having access to water in the future. They are not an explicit cash flow cost but something that Carlisle could lose if we do not have use of the Cranberry bog water rights that people living close to the bog might value quite differently from those who do not visit the bog (the opportunity cost, tied to loss of surrounding neighborhood wells and aquifer).

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The most important basic conclusion from the Cranberry Bog Alternatives Committee (CBAC) is that the Town of Carlisle should make a major effort to continue agriculture at the bog. Specifically, it should abandon any attempt to continue growing cranberries and modify the bogs to allow them to be used to grow other agricultural crops (Alternative 5). This Alternative was strongly favored over all other alternatives considered. The major reasons for this conclusion are provided later in this Section 6. The full details on the recommended Alternative 5 are provided in the Alternative 5 report.

The full scope of the CBAC's conclusions is shown by the point scores in **Table 6**. The table is the result of input (ballot scores) from each of the five regular members of the CBAC plus one CBAC Associate Member (JB) and the Conservation Administrator (SW); i.e., a total of seven individuals, all of whom had reviewed the reports on each Alternative and participated in CBAC meeting discussions. The instructions (to the CBAC members) for filling out their individual ballots are provided below the table. The point scores shown in Table 6 are the sum of scores from the seven voters. The higher the score in any cell, the more favored it was by the voters. The grey-shaded cells in Table 6 are the primary options for the four land areas (three bogs and the sand pit) while the unshaded areas relate to infrastructure and/or economic support. The scores in cells that are similarly shaded may be compared directly with each other. Comparison of scores having different shading is not appropriate, as should be evident from the different voting instructions.

The major CBAC conclusions indicated by Table 6 are as follows.

<u>For all three cranberry bog areas (Irrigated Bog, In-Renovation Bog, Sand-Covered Bog)</u>:

The order of preference by the CBAC is as follows (most preferred first).

1. Alternative 5: Conversion to other agricultural use (Avg. score = 20)
2. Alternative 7: Engineered restoration to a natural habitat (Avg. score = 7.7)
3. Alternative 6: Creation of passive recreation area (Avg. score = 5.7)
4. Alternative 8: Passive restoration to a natural habitat (Avg. score = 3)
5. Alternative 4: Bog renovation – cranberry growing (Avg. score = 2)
6. Alternative 1: No action (Avg. score = 1.3)

As indicated, Alternative 5 is preferred by a wide margin over Alternatives 7 and 6 (almost tied for second place), which, in turn, are preferred by a wide margin over Alternatives 8 and 4. Alternative 1: No Action is the least preferred. Note, however, that Alternatives 1 and 8 are essentially the same if considering only the internal bog areas.

Table 6. CBAC - Member's Recommendations[a]

Alternative	Total Score from Members' Ballots			
	Irrigated Bog	Sand-Covered Bog	Bog in Renova-tion	Sand Pit
1. No action	1	1	2	8
2. Subsidy to farmer	6	3	3	
3. Bog maintenance by DPW or paid for by Town[b]	18	18	18	4
4. Bog renovation - cranberry growing	3	1	2	
5. Conversion to other agricultural use	20	20	20	5
6. Creation of passive recreation area	5	7	5	3
7. Engineered restoration to natural habitat	8	7	8	1
8. Passive restoration to natural habitat	4	3	2	4
9. Installation of solar array	N/A	N/A	N/A	7
10. Upgrade 2 Bog House apartments for rental use	7	7	7	5

[a] Grey shaded areas are the primary options for the 4 land areas listed. Unshaded areas have scores for infrastructure or economic support.

[b] Maintenance is primarily for service roads, dams/dikes, water-control structures, and, if necessary, the Bog House. Not for bog interiors.

Instructions to Members for Filling Out Ballot

1. Within the grey shaded areas, and considering each bog area and sand pit separately, i.e., for each of the four shaded columns, insert: Insert "3" for 1st choice, "2" for 2nd choice, or "1" for 3rd choice. When done, you should have one "3," one "2," and one "1" in each of the 4 grey-shaded columns.
2. For Alternative 2 (Subsidy to Farmer), if you have given a 1, 2, or 3 score to Alternatives 4 or 5 for any bog area, then in the Alternative 2 row insert a 3 (means "yes") or 0 (means "no") in the column above where you provided a score for Alternatives 4 or 5.
3. For Alternative 3 (Bog Maintenance by DPW), provide a 3 (high), 2 (medium) or 1 (low) score. Do this for each of the 4 bog areas, understanding that if we have a farmer in the future, he/she may take responsibility for some or all of the maintenance after an agreement is in place. Note also, that Alternative 3 does not cover "maintenance" (e.g., mowing) within the bogs, just around them.
4. For Alternative 9 (Solar Array), in the Sand Pit column only, indicate your preference level by inserting a 3 (high), 2 (medium), 1 (low), or 0 (never).
5. For Alternative 10 (Bog House Upgrade for Rental Income), provide a 3 (high), 2 (medium), or 1 (low) score for each of the bog areas and sand pit. Note that, if we have a farmer (Alternative 4 or 5), he/she may wish to use the Bog House apartments leaving them just as they are today. In any case, assume the CBAC will recommend to ConsCom that the well and septic system be replaced.

Additional conclusions and comments are as follows.

1. Bog Maintenance by DPW: There is a significant amount of CBAC support for Alternative 3: Bog Maintenance by DPW or Paid for by Town (average score for the 3 bog areas is 18). As noted in Table 6, the maintenance is primarily for the service roads, dams and dikes, water-control structures, and possibly the Bog House. Interior areas of the bog and sand pit are not covered. This maintenance needs to start as soon as arrangements can be made with the DPW and the required funding – for labor and equipment – is authorized.
2. Sand Pit: For the Sand Pit, top scores (7-8) were given to Alternative 9: Installation of Solar Array and Alternative 1: No Action. Alternative 5: Conversion to Other Agricultural Use ranked third. The relatively low scores for the Sand Pit reflect the fact that not all members voted for the implementation of any alternative at this location; this reflects the Committee's opinion that the Sand Pit is low priority for action in the near future.
3. Bog House: For the Bog House, Table 6 shows there was modest Committee support for Alternative 10: Bog House Upgrade (average score = 7). Aside from the need for a new well and septic system, a decision on the upgrade of the apartments should probably be deferred until the Town has made a clear decision to proceed with Alternative 5: Conversion to Other Agricultural Use. Following such a decision, the Town will want to negotiate the potential use of the Bog House apartments with the selected farmer. The farmer may feel that apartment upgrades are not necessary. If the Town decides not to implement Alternative 5, then it should consider upgrading the Bog House apartments for rental income.
4. Subsidy to Farmer: There was relatively little support for Alternative 2: Subsidy to Farmer (average score = 4), and most of that support was associated with the low preference for a continuation of cranberry farming. Although not evident at the start of the CBAC's deliberations (July 2016), it did become clear at the end of our deliberations that Mark Duffy, the most likely person to continue any cranberry farming, was not interested in continuing cranberry farming at any realistic subsidy level.
5. Solar Array: For Alternative 9: Installation of Solar Array, there was relatively little support.

Although the Committee's conclusion is that all three bog areas should be converted to other agricultural use, there is no major obstacle to the Conservation Commission and the Town selecting different Alternatives for each bog. The Committee encourages consideration of such options. For example, after deliberation, the Town might decide to have one bog follow Alternative 5: Conversion to Other Agricultural Use, another bog to follow Alternative 6: DPW to Maintain as a Recreation Area, and the third bog to follow Alternative 7: Engineered Restoration to a Natural Habitat. The complexities and cost of such a mix of Alternatives could be mitigated by implementing them in stages over a number of years.

Why Not Continue to Grow Cranberries?

At the beginning of CBAC's deliberations (July 2016), the continuation of cranberry growing was a sentimental favorite. However, it was clear from the reports from Mark Duffy (our cranberry farmer) and from a variety of other sources that the U.S. cranberry industry was in serious trouble due primarily to low prices (due to a combination of over production and stagnant demand) paid by the processing facilities to which the cranberries were shipped. In addition, the yield of cranberries at Carlisle's bog had diminished in recent years due to a combination of causes including adverse weather, aging (and low-yielding) vines, and weed growth.

To help us understand the current state, and future potential, of the local cranberry growing industry, one CBAC member undertook a detailed study and provided us with his conclusions in Section 4 (Cranberry Economics). The conclusion is that (1) if Carlisle was willing to renovate our 20-acre Irrigated Bog (ignoring the other two bogs) at a cost of $500,000 to $700,000, and (2) if we were willing to assume an improved cranberry market with healthy prices in the foreseeable future, and (3) if we could be assured of an interested and qualified cranberry farmer with sufficient infrastructure support (e.g., equipment, technical advisors, and labor), then it would be possible to run the bog at a profit. Unfortunately, these three criteria are unlikely to be met, even for organic cranberry farming.

The CBAC concludes that the 112-year history of cranberry farming in Carlisle must, unfortunately, come to an end. The Committee did consider a switch to the growing of organic cranberries, but the obstacles (described in Alternative 4: Cranberry Bog Renovation) appear to be just as great as they are for traditional cranberry growing. Because Alternative 2: Subsidy to Farmer was considered primarily as a companion alternative to Alternative 4, the Committee sees a lesser possibility that it would be needed in conjunction with Alternative 5.

Key Steps to Implement Alternative 5: Conversion to Other Agricultural Use

Excluding Town deliberations and approvals, fund raising, and engineering studies, the major steps required to convert a cranberry bog (comprised of saturated muck soils topped with layers of sand) to a field suitable for other agricultural crops include the following.

- Removing existing vegetation and subsurface irrigation system
- Leveling the fields and potentially adding sand
- Installing a subsurface drainage system (to lower the water table about 1 to3 feet depending on the results of the engineering study)
- Clearing, contouring, and grading the existing drainage ditches
- Constructing a new overhead irrigation system for each bog
- Applying soil amendments
- Obtaining specialized equipment and support services

A variety of cash crops may be grown on properly amended muck soils (see Alternative 5), but it is most likely that hay or some other forage crop – for livestock feed – would be grown on Carlisle's bog fields. The Town may wish to implement this Alternative gradually over three or more years to spread out the costs and learn from experience.

At some point in the process, the Town would need to go through a formal, open process to select a farmer and to negotiate an agreement with the farmer for the use of the Town land and the Cranberry Bog House. Mark Duffy has informally informed the CBAC that he would be interested in growing forage crops on the converted bog lands.

Costs and Benefits of Alternative 5: Conversion to Other Agricultural Use

There are significant technical obstacles to converting our cranberry bogs to agricultural fields that will support the growth of other crops. A detailed description of the problems is provided in the Alternative 5 report. A very rough estimate of the conversion costs (total for all 3 bogs) is $500,000 some of which might be covered by grant funds. Once funding was obtained, conversion could take about two years. A consultant/engineering study would have to be undertaken first to evaluate geotechnical and hydrological factors, provide a detailed design for the conversion, evaluate regulatory issues, prepare bid documents, and provide a more accurate cost estimate. A preliminary budgetary estimate for the engineering study is $30,000.

Besides the conversion costs, there are a number of other concerns regarding this recommended alternative, including the following.

- The loss of wetlands and wildlife habitat, including some Priority Habitat, currently afforded by the two in-renovation bogs
- The potential loss of some of our registered water rights (see Section 5)
- Finding a farmer with the interest, expertise, and equipment to farm on (partially drained) muck soils
- Negotiations with the chosen farmer over in-kind services (or other compensation) to be provided for the use of the fields
- Negotiations with the chosen farmer over maintenance of the service roads, dikes and dams, and water-control structures within and around the agricultural areas
- Negotiations with the chosen farmer over use and maintenance of the Cranberry Bog House if such is requested
- Potential soil loss from wind or water erosion or muck oxidation, which leads to land subsidence
- Others described in the Alternative 5 report

The major benefits of implementing Alternative 5 are as follows.

- The preservation of 36 acres (40 acres including service roads and dams/dikes) of agricultural land on a property with a significant cultural heritage of agriculture. (Agricultural preservation is a specific goal/objective of the Town's 2013 Open Space and Recreation Plan.)

- The preservation of a significant portion (about 50%) of the registered water rights we have for the Bog property. (See Section 5 for details.) Absent this preservation, the Town can expect a renewed effort by the Chelmsford Water District to install a municipal well field abutting the Chelmsford bog property that could extract a significant amount of water from the River Meadow Brook watershed, with resulting adverse effects on downstream wildlife habitats, private wells, and potentially agricultural operations in drought years.
- The preservation of open vistas across the agricultural fields, considered a significant benefit to the public using the bog for passive recreation. (Without agriculture, or without any engineered restoration that would minimize tree and bush growth, the vistas would eventually be lost due to tree and bush growth.)
- Potential for continued beneficial use of the Cranberry Bog House to support agriculture by providing storage space for equipment and housing (two apartments) for agricultural workers. Although the CBAC is recommending a new well and septic system for the Bog House regardless of which alternative is chosen, having the building be part of an agricultural lease to the chosen farmer may avoid the necessity of a major Bog House renovation (described in Alternative 10) such as would be needed for rental of the apartments to the public.
- The preservation of the upper and lower bog reservoirs, as these water bodies would likely be part of the irrigation system for the new agricultural fields. The reservoirs provide important aquatic habitat as well as pleasing vistas.

The Need for Bog Maintenance

The Committee recognizes the importance of Alternative 3: Bog Maintenance by Town or Paid for By Town – primarily for the maintenance of the service roads, dams and dikes, and water-control structures – if the Town does not have an agreement, as it has in the past, for a farmer to do the maintenance as part of an in-kind service payment for use of the agricultural land. Absent such a farming agreement, as may happen on a temporary or permanent basis, the Town must take responsibility for the bog maintenance or suffer significant deterioration of the property and possible breach of dams if water-control structures are not kept clean (e.g., of beaver debris). At a minimum, it is expected that the Town will have to take responsibility for bog maintenance – at an annual cost of around $25,000 per year – for at least three years (starting in 2017) while the Town looks to implement Alternative 5: Conversion to Other Agricultural Use. Even after this interval, the Town may be responsible for some long-term maintenance.

Why Not Choose the Low-Cost Solution?

Alternative 1: No Action and Alternative 8: Passive Restoration to a Natural Habitat are essentially the same when applied to the three bog areas. For both, up-front capital costs are essentially zero. However, as mentioned in the reports on each of these Alternatives, there are eventual maintenance costs that will become more pressing as time goes on. In spite of the attractiveness of a low-cost solution, Alternatives 1 and 8 scored very low to low in the member's voting (see Table 6). One main reason is the Committee feels it

would be a major mistake to allow the Town's favorite, and most heavily used, conservation and passive recreation area to deteriorate to the point that the key attributes – easy walking, pleasing vistas, open field wildlife habitat, and breezes to keep the bugs away – were lost. Walking the bog would become more like walking through the woods around a 40-acre swamp. The Town paid $1,816,540 to purchase the Cranberry Bog in 1986, equivalent to paying about $4,000,000 today (December 2016) according to the CPI Inflation Calculator published by the Bureau of Labor Statistics (www.bls.gov/data/inflation_calculator.htm). This cost, in addition to the heavy recreational use of the property (see Appendix A), supports a view that the Bog is a very valuable conservation and passive recreational property that should be maintained close to its current state.

Other significant reasons for not choosing the low-cost alternative include (1) a strong desire to support local agriculture and preserve agricultural land for future generations; and (2) an equally strong desire to preserve our registered water rights for the future, which protect the local wildlife habitat and nearby private wells. Along with the preservation of agriculture comes support for the preservation of the Cranberry Bog House; without use and support (e.g., maintenance and utility-bill payments) by a local farmer, the Town would either have to invest $400 to $800 thousand (including architect fees) to upgrade the apartments to decent rental units or pay for the maintenance and security of an abandoned building.

Recommendations

Summary of Recommendations for Each Cranberry Bog Area

- Irrigated Bog: Alternative 5: Conversion to Other Agricultural Use
- In-Renovation Bog: Alternative 5: Conversion to Other Agricultural Use
- Sand-Covered Bog: Alternative 5: Conversion to Other Agricultural Use
- Sand Pit: Either Alternative 1: No Action, Alternative 9: Install Solar Array, Alternative 5: Conversion to Other Agricultural Use, Alternative 6: Creation of a Passive Recreation Area, or Alternative 8: Passive Restoration to a Natural Habitat. There is no pressure for an early decision.
- Cranberry Bog House: (1) If Alternative 5 is chosen for the three bog areas, negotiate a use and maintenance agreement with the farmer. Install a new well and septic system, but do not upgrade the apartments. (2) If Alternative 5 is not chosen, consider Alternative 10: Upgrade Bog House Apartments to Rental Units, which would also require installation of a new well and septic system.

If Alternative 5 is not chosen for the three bog areas, then ConsCom should consider their restoration to a natural habitat either via Alternative 7: Engineered Restoration or Alternative 8: Passive Restoration. The former has significant capital costs for the restoration activity but produces a more natural habitat with preservation of partial vistas. Optionally, select Alternative 6: Creation of a Passive Recreation Area, preferably just for the Sand-Covered Bog. In essentially all cases, the Town will have to assume full responsibility for bog maintenance at least temporarily (Alternative 3). If Alternative 5 is

successfully implemented, the negotiated agreement with the selected farmer may pass the responsibility for some or all of the bog maintenance to the farmer once he or she has started growing crops.

Town Review and Consensus Building

The Conservation Commission (ConsCom), with the help of the Cranberry Bog Alternatives Committee (CBAC), should undertake a review of the CBAC recommendations and, as appropriate, obtain input from public hearings and meetings with other Town boards, committees, and stakeholders. Discussions should also be held with the Chelmsford Conservation Commission through the existing Chelmsford-Carlisle Bog Subcommittee. The review should make sure that the Town's conservation goals and objectives are being followed and that major issues related to technical feasibility, regulatory hurdles, and costs have been considered. ConsCom is officially charged with management responsibility for the Cranberry Bog and, following its review, it must either accept the CBAC recommendations (detailed above) or suggest a different plan.

Actions for 2017

First, ConsCom should seek approval at Town Meeting for a maintenance budget for the Cranberry Bog of approximately $25,000. (See Table 1 in the Alternative 3 report for estimates of the range of maintenance costs that may be incurred.) Similar amounts may be required in future years. Second, ConsCom, the CBAC, or both should collect additional technical and financial information about Alternative 5 so that the committees are better prepared to seek approval at Town Meeting in 2018.

Actions for 2018

Seek approval at Town Meeting for a one-time consultant/engineering study to provide the necessary details for planning the implementation of Alternative 5: Conversion to Other Agricultural Use. A current budgetary estimate for this study is $30,000, but ConsCom should request formal proposals and cost estimates from qualified consulting/engineering companies before Town Meeting and for review by the Carlisle Finance Committee.

Maintain Agricultural Exemption in Interim

ConsCom should take the necessary steps to insure that our Cranberry Bog continues to receive the Agricultural Exemptions under the Massachusetts Wetlands Protection Act (WPA) and its regulations while it is working to change from cranberry growing to other agricultural crops. As noted below, a five-year exemption is normally allowed; longer periods of inactivity may be allowed under certain conditions.

According to the WPA, the exemption (clause 18 of Massachusetts General Laws Chapter 131, Section 40) exempts "work performed for the normal maintenance or improvement of land in agricultural or aquacultural use" from WPA regulations. According to the WPA regulations (310 CMR 10.04), "land in agricultural use may lie

inactive for up to five consecutive years unless it is under a United States Department of Agriculture (USDA) contract for a longer term pursuant to the Conservation Reserves Program (the Food Securities Act of 1985, as amended by the Food, Agriculture, Conservation and Trade Act of 1990; and 7 CFR 1410). . . . The issuing authority may require appropriate documentation, such as a USDA Farm Plan or aerial photography, to demonstrate agricultural use." If the Town does not maintain its agricultural exemption for this land, all proposed activities in the wetlands or the buffer zone, and all lands within the 100-year flood plain, would be regulated by WPA regulations.

Engage a Consultant/Engineer to Undertake an Evaluation of Alternative 5

If the 2018 Town Meeting approves the necessary funding, ConsCom should hire a qualified consulting/engineering firm to evaluate technical, regulatory, and cost factors associated with the implementation of Alternative 5. Specifically, the study should evaluate geotechnical and hydrological constraints and regulatory hurdles and present the Town with detailed construction plans, permit applications, reliable cost estimates, and bid specifications to be used in selecting contractors for the necessary construction and equipment.

If the report from the consultant/engineer is considered sufficient, then ConsCom should be prepared to request the necessary funding at a future Annual Town Meeting.

Engage a Second Consultant/Engineer for a New Well and Septic System at the Bog House

A second consultant/engineer should be hired to provide a proposed design and associated cost estimate for the installation of a new domestic water supply well and septic system to serve the two Bog House apartments. If Alternative 5 is not approved for the Cranberry Bog, then this action should be delayed until ConsCom and the Town have decided if the Bog House apartments are to be upgraded to rental units.

Identify Potential Sources of Grant Funds

ConsCom, with CBAC help, should undertake a significant search for potential sources of grant funds that could help pay for the implementation of Alternative 5, assuming it is approved by Town authorities. Contacts should be made for each potential source to obtain reliable information on the application requirements and restrictions, application dates, and the level of funding that might be obtained. According to one CBAC member, it is unlikely that Community Preservation Act funds would be approved for the implementation of Alternative 5.

ALTERNATIVE 1

NO ACTION

Description of Alternative 1

Of the ten alternatives being considered in this report, Alternative 1: No Action is the simplest and potentially the least expensive. "No Action" means literally that, once cranberry growing ceases at the bog, no action is taken to continue growing cranberries or to convert specified areas of the bog to other uses or habitat types. The No Action alternative could be applied to any or all of the three identified bog areas, the sand pit area, and the Bog House. The decision to choose this alternative could be considered temporary or permanent, depending on the wishes of the Conservation Commission (ConsCom) and the Town.

Loss of Agricultural Exemption[1]

The entire bog area (i.e., the active and in-renovation bogs and the adjacent dikes) is within the 100-year flood hazard zone and thus falls under the protection of the Wetlands Protection Act (WPA). Some bog areas are wetlands or within the 100-foot buffer zone for wetlands. The WPA includes an Agricultural Exemption, which allows activities that would otherwise be precluded. The language of the exemption (clause 18 of Massachusetts General Laws Chapter 131, Section 40) exempts "work performed for the normal maintenance or improvement of land in agricultural or aquacultural use" from WPA regulations.

Importantly, however, once agriculture at the bog ceases, even if the cessation is temporary, many activities historically carried out by the farmer at the site may no longer be covered by the Agriculture Exemption to the Wetlands Protection Act (WPA) and its regulations: 310 CMR 10.00. For any activities previously exempt because of on-going agriculture at the site, post-agriculture plans to engage in such activities would likely require the filing of a Notice of Intent, a public hearing, and the approval of the ConsCom (with restricting orders of condition) for any such work. Examples of such activities would include mowing, dam or culvert repair, the use of any water-control structure, and the use of herbicides or other methods of invasive-plant control.

Although the land must be "presently and primarily" in agricultural use, the definition allows it to be "inactive" for up to five consecutive years – or longer if the land is inactive as part of a USDA contract pursuant to the Conservation Reserves Program – without losing exempt status. If Carlisle intends to engage in new agricultural activities within five years of ending cranberry production, it will need to document the process in order to keep an agricultural exemption. Land under the jurisdiction of the WPA that has been out of production for longer than five years (without being under USDA contract) is considered new land. Farming activities proposed for such areas are not exempt and therefore require a permit (an Order of Conditions) under the WPA.

Whether or not the Town plans to continue agriculture in the future at the Cranberry Bog, many other important details of the Agricultural Exemption exist, which the Town must be cognizant of. See Reference 1 for more details.

Further Discussion

Although Alternative 1: No Action may be the least expensive one, actual costs will probably not be zero because of needed bog maintenance such as trail-side mowing, maintenance of dams (including frequent removal of beaver debris from culverts), and possible mowing of the bog areas to maintain vistas and maintain a non-forested wildlife habitat. If these maintenance activities are taken on by Carlisle's Department of Public Works, the additional work load would likely require the hiring of additional personnel and the purchase of additional equipment. Although no detailed estimate of such costs is provided here, they would likely exceed $10,000 per year. In fact, as described in Appendix 3 on Alternative 3: Bog Maintenance by DPW, a proactive maintenance program is likely to cost around $25,000 per year.

No regulatory hurdles are associated with this alternative except for compliance with the Wetlands Protection Act (WPA) for any activities proposed in WPA-regulated areas. Such costs would likely include engineering fees for the preparation of maintenance plans and Notice of Intent documents for submission to the Conservation Commission. Existing regulations would probably not require any proactive dam modifications or removals as a result of Alternative 1: No Action being chosen.

The cessation of agriculture implicit in the selection of this alternative would lead to the Town's loss of water rights registered under the authority of the Massachusetts Water Management Act of 1985. The current registration ends in 2017. Cessation of agriculture would likely also lead to loss of tenants in the Bog House because the current tenants are related to the current agricultural use. This loss of tenants could lead to increased maintenance costs for the Bog House.

Finally, the cessation of agriculture could affect the Chelmsford Cranberry Bog Reservation, which abuts Carlisle's Cranberry Bog Conservation Land. Not only might there be hydrologic impacts, but also Alternative 1: No Action would question the future need for, and maintenance of, the dam and reservoir – in Chelmsford – that is just upstream of Carlisle's bog (and downstream of Heart Pond). These issues would have to be discussed between the two towns.

Summary Evaluation

<u>Pro</u>

- No implementation costs
- No regulatory issues except for WPA-regulated activities

Con

- Loss of agricultural land
- Loss of Agricultural Exemption under the WPA unless a 5-year continuation is approved in conjunction with a planned conversion to other agricultural use
- Loss of water rights granted under the 1985 Water Management Act
- Potential degradation of dams and trails (requiring maintenance)
- Loss of vistas and non-forest wildlife habitat
- Increased bog maintenance costs, including engineering fees for WPA filings
- Possible increased maintenance costs for the Bog House

References

1. Most of the information in this subsection has been taken directly from the following. "Farming in Wetland Resource Areas: A Guide to Agriculture and the Massachusetts Wetlands Protection Act," issued by the Massachusetts Department of Environmental Management, Department of Environmental Protection, Department of Food and Agriculture, revised January 1996. Available at www.mass.gov/eea/docs/dep/water/laws/a-thru-h/farman.doc.

ALTERNATIVE 2

SUBSIDY TO CRANBERRY BOG FARMER

Description of Alternative 2

This alternative involves the payment of a subsidy, presumably temporary, from the Town to the farmer in cases when the costs of producing the crop exceed the revenue from sales of the crop (or the value of the crop if it is consumed internally).

Use of a Subsidy

The most likely use of a subsidy would be if the Town decides to continue cranberry farming at the bog. At present, because of low cranberry prices and the relatively low yields of cranberries at Carlisle's bog, production costs do exceed revenues. In this situation, a subsidy would be required for the farmer to continue to grow cranberries. Without an increase in cranberry prices or an increase in bog yields, the subsidy might have to be used for an extended time. In the worst case, the subsidy might be as high as $30,000 per year.

Another possible use of a subsidy would be if the Town decides to renovate the bog to obtain higher cranberry yields (Alternative 4: Bog Renovation). After any such renovation, a subsidy would probably have to be paid to the farmer to cover maintenance costs for up to 4 years until the new plants matured and yields rose.

Another possible use of a subsidy would be if the Town decides to convert to another, non-cranberry crop (Alternative 5: Convert to other agricultural use). Again, a subsidy would cover the costs of establishing the new agricultural crop. The details of what the subsidy covered would be decided between the Town and the farmer.

Sources of Subsidies

At the national level, subsidies are often provided by the federal government to help farmers cope with the variations in agricultural production and profitability from year to year. Although subsidies are available to all farmers for all crops, most of the subsidies go toward the five major commodities of corn, soybeans, wheat, cotton, and rice. In addition, most of the subsidies go to the largest farm operations and not the small farms nor the family farmers. The primary subsidy system includes the following elements, each of which is explained below.

- **Direct payments** are made at a set rate every year regardless of conditions.
- **Counter-cyclical payments** are made when market prices fall below a certain threshold.
- In a new **revenue assurance program,** payments are made, as necessary, to ensure overall profitability for a given crop.

- **Marketing loans** offer very favorable terms whereby farmers can realize tremendous gains through loan deficiency payments (LDPS) and commodity certificates.
- **Disaster payments** are made to cover large losses from natural phenomena. In addition, the government subsidizes crop insurance to insulate farmers further from risk.[1]

A subsidy for the farmer of the Carlisle Cranberry Bog would be under a revenue assurance program, in which a dollar amount is agreed upon by the farmer and Town that guarantees the farmer a fixed dollar amount of profit. The Town would pay the difference between what the farmer earns as gross and the fixed dollar amount. As crop production improves, therefore, the payments would decrease.

Because current low cranberry prices and declining yields at the bog have made farming cranberries at the bog economically unfeasible, the current farmer, Mark Duffy, declined in 2015 to renew his lease to farm the Cranberry Bog. During the meeting to renew the lease, Duffy and the Board of Selectmen discussed a subsidy. The annual subsidy mentioned by the Cranberry Bog Agricultural Committee (operating from March 2013 – May 2014) was $30,000. This dollar amount compares with the estimate from a member of the Land Stewardship Committee for wet harvesting of cranberries at the Carlisle cranberry bog for 1996 through 2012 of an average gross revenue of up to $32,700. This estimate is based on published data on the average, US-industry-wide prices paid for wet-harvested cranberries from 1996 through 2012; the prices paid to Carlisle Cranberries, Inc., may have been lower than the industry average.[2]

Renovating the Bog

If cranberry production is to continue at the bog, then renovation would be required to make farming the bog economically worthwhile. There are two options here. Option One: Hire a company to renovate the bog, and let the farmer use the subsidy to care for the vines until they mature and produce a crop. Option Two: If the farmer has the ability, machinery, and interest, the farmer renovates the bog, cares for the maturing vines, and uses the subsidy to cover costs during renovation while waiting for the vines to mature and produce a crop. In fact, if any agriculture is to occur at the bog, a subsidy will most likely be necessary to entice a farmer to take on the bog as a project.

As stated earlier, the subsidy and what it entailed would be part of the lease agreement between the Town and farmer. At the end of the year, the farmer would present his or her expenses and income from all sources including grants or other subsidies, and the Town would pay the difference between the gross and the subsidy amount. An option that might reduce the actual dollar amount of the subsidy is for the Town to take over some of the maintenance on the bog. These services would need to be discussed and agreed upon by the Town and the farmer.

The CBAC is not aware of any legal or regulatory hurdles or expenses to this Alternative 2: Subsidy to Farmer except for the involvement of Town counsel in writing

and reviewing the lease agreement that includes the subsidy between the Town and farmer.

Summary Evaluation

Relative to the general evaluation criteria listed in Section 3 of the Main Report and other considerations, the following pros and cons of this alternative follow.

Pro

- A subsidy would allow the bog to continue as it has for the previous years.
- A subsidy would not affect the public's use of the bog, but the renovation of the bog for cranberries or another crop might cause some disruption in the public's use.
- The successful renovation of the bog for cranberries or successful conversion to some other agricultural crop eventually would make the subsidy unnecessary.
- The successful renovation of the bog for cranberries or successful renovation to some other agricultural crop would improve the bog overall by maintaining vistas and paths.
- The successful renovation of the bog for cranberries would preserve all the existing water rights, and the successful conversion to some other agricultural crop would preserve some water rights.

Con

- The town would have to budget for the subsidy annually for the life of the lease.
- Subsidizing a private entity is setting a bad precedent.

References

1. E.G.'s Farm Subsidy Database, Subsidy Primer, https://farm.ewg.org/subsidyprimer.php, January 26, 2017.

2. Personal communication with Warren Lyman on September 27, 2016

Bibliography

Personal communications with Steve Hinton, CBAC member, on August 2, 2016, and August 3, 2016.

Grants: http://www.cranberries.org/growers/programs.html

Subsidies: http://www2.rma.usda.gov/fields/nc_rso/2016/2016macranberry.pdf

https://farm.ewg.org/crop_insurance_analysis.php

ALTERNATIVE 3

BOG MAINTENANCE BY THE DEPARTMENT OF PUBLIC WORKS OR PAID FOR BY TOWN

Description of Alternative 3

For this alternative, the Town of Carlisle assumes all responsibility for the upkeep and maintenance of the Cranberry Bog property. The Town would not maintain the interior of the bog areas (with or without crops), just the remainder of the property, including the possibility of maintaining the water-control structures. The Town may choose to do any, all, or none of these activities. This evaluation includes generalized costs for scenarios that are possible but not necessarily probable. Even though the probability is low, the Town needs to acknowledge the potential financial consequences.

A more specific listing of likely maintenance activities that would need to be undertaken is provided below; see **Figure 1** for the general location and extent (or number) of the work areas described.

- regular mowing of edges of service roads and trails in the bog area, including mowing around the Bog House
- occasional cleaning of the drainage ditches alongside the service roads and trails in the bog area
- occasional maintenance of the service roads (e.g., following erosion) and the two parking areas
- occasional cleaning of the six flow-control (or culvert) structures, which are commonly blocked by beaver debris
- regular inspection of the three dams and other earthen dikes for erosion or other problems. (The State's Office of Dam Safety recently ordered Carlisle to have a qualified engineer inspect the Curve St. Dam and Cranberry Bog Dam #1)
- occasional maintenance of the dams. (The State's Office of Dam Safety could order repairs to be undertaken.)
- routine maintenance work for the interior and exterior of the Bog House

The Department of Public Works (DPW) of the Town of Carlisle currently does not have all the equipment necessary to maintain the Cranberry Bog property. General maintenance includes mowing and maintenance of the main trails, which the DPW has currently contracted to an outside landscaping company. If this responsibility became permanent, the Town would need to evaluate the cost of either purchasing the necessary equipment or the long-term cost of renting the necessary equipment at regular points throughout the year.

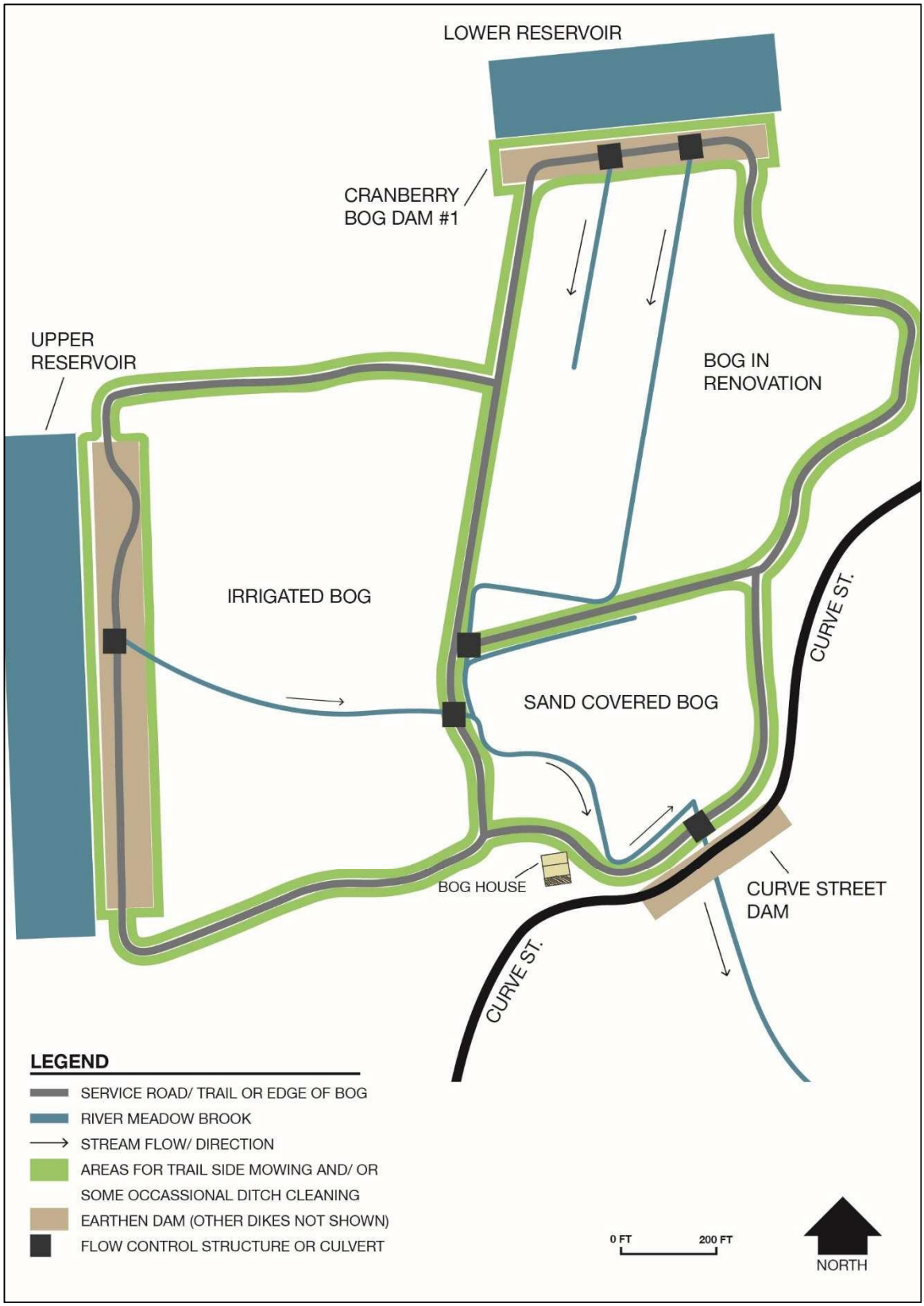

Figure 1. Schematic Diagram of Likely Maintenance Areas at Bog

Standard Annual Costs

The minimum cost to the town for the typical two mowings per year of the main trails would be approximately $3,000 ($75/ hour x 20 hours x 2 mowings). Typically, there is also an annual cutting of the bog edges using a large tractor with a side-arm mowing deck, which would cost approximately $2,500 per day for the equipment and the operator. The cost for cutting the edges might be slightly reduced if it happened when the Town regularly rents this type of equipment to trim road edges. Although cutting the edges would utilize DPW personnel instead of an outside contractor, the savings would not be significant.

The Town would also need to remove trees and invasive species that grow in the bog area. These removal activities would likely require permitting or approval (as described later in this section). Removal may only need to be done twice a year, but it should be included in ongoing maintenance costs. The DPW is equipped to remove trees and invasives, and the cost could potentially be incorporated into the current DPW budget. If removal were contracted out, it would cost about what the annual mowing costs and could be significantly higher in some years to due to the labor involved, especially if it were not an annual activity.

The Town would also need to assume all general clean up and maintenance responsibilities as they do with other town properties, including the removal of fallen trees and branches, plowing, fence repair, etc. How much additional time these activities would require is not known because it depends greatly on weather. A low estimate of the time required is for a four-person crew from the DPW to spend at least one day a year doing general cleanup, at a cost of $1,500 per day.

The Town could choose to maintain regularly only a portion of the property. Partial maintenance would reduce short-term costs but could lead to increased future costs if the Town ever decided to return the property to agricultural use. Any proposal to maintain a portion of the property would need to include an evaluation of the proposed usage of each specific area and meetings to collect community input. The individual maintenance costs for each section would also need to be assessed.

Additional Costs

If agricultural practices cease at the bog, the Town may or may not decide to maintain the water-control structures. The dams, dikes, and flumes at the bog all present the potential for significant liability in the event of a failure.

Minimal repairs and maintenance could be handled by the DPW but would require increasing the current DPW budget. Estimating the cost of general maintenance to prevent minor events is difficult, although it would likely cost around $5,000 per year. The cost could be adjusted as needed in future years as more accurate costs were determined.

Although catastrophic failure of a water-control structure is rare, the Town does not have the ability to repair a catastrophic failure, which has to be hired out. The most recent failure was in 2014 when water flowed over the top of a water-control structure and partially washed it out. The cranberry bog farmer performed the repairs as required per

the license agreement, but an estimated cost for this work would be in the range of $50,000.

Lastly, beaver activity and possibly beaver control must be considered. The DPW can remove beaver dams from the culvert under Curve Street, but it cannot be responsible for beaver control for the entire bog. If the Town decided to hire a company to monitor and mitigate beaver activity, it would cost about $5,000 per year. See Section 5 of the Main Report for more information on beaver- and muskrat-control techniques.

Cranberry Bog House

The Bog House would also likely come under the care of the DPW. Although the DPW could maintain the ground around the Bog House, it cannot maintain the structure itself. If the Town decides to maintain the structure, it would probably have to appoint a special subcommittee or hire a property manager to oversee the structure. In either case, the Town would probably not have tenants in the Bog House, so the building would be vacant for an extended period. The party responsible for the care and custody of the Bog House could be either the Conservation Commission or the Board of Selectmen, which oversees other town buildings.

Impact of Loss of Agricultural Crop

If the Town chooses to cease agricultural activities at the Cranberry Bog, the Town may lose the registered water rights associated with the bog. These water rights currently allow the farmer to withdraw up to 360,000 gallons per day for the cranberry operation. Whereas changing to another agricultural crop may affect the water rights, the town would probably not lose water rights altogether. If the Town ever chose to return the land to agricultural use, whether the Town could reacquire these water rights is not known. Town Counsel's opinions on this water rights question are provided in Appendix C.

When the land is removed from an agricultural classification, that property loses all agricultural exemptions and waivers from State and Town bylaws. The most significant of these exemptions is from the Massachusetts Wetland Protection Act (WPA). Although routine mowing would not fall under the pervue of the WPA, most of the other activities previously mentioned would and would, therefore, require a filing with the Conservation Commission. The Commission waves filing fees for Town entities, but projects that require a full Notice of Intent would result in the need to hire an engineering firm. These costs could range from less than $1,000 for a basic filing, which includes a basic plan and wetland delineation, to several thousand dollars for repairing a failed water-control structure.

Removal of the bog land from agriculture (thus necessarily re-classified as non-agricultural) would not automatically require any modifications or removal of the associated dams and water-control structures, although subsequent evaluations and orders by the State's Office of Dam Safety could require such. The subject, somewhat complicated, is addressed by Item 2 in an August 15, 2016 letter from Town Counsel (see Appendix B to this report).

Responsibility

The Cranberry Bog is land under Article 97 and is currently in the care and custody of the Conservation Commission. This care and custody would continue. The Commission is currently understaffed, however, and does not have the capacity in its annual budget to absorb the cost of the additional responsibilities that have traditionally been handled by the farmer. Most of the added responsibilities will have to be shared between the Conservation Commission and the DPW, and, to a lesser extent, by the Board of Selectmen and the Town Administrator.

Range of Costs

As with all Town properties, the decision and ability to do essential maintenance versus the ability to maintain fully a property comes down to cost. The Conservation Commission currently has an annual maintenance budget of $6,000 to maintain all the Town's conservation land not under an agricultural agreement. This limited budget has resulted in the loss of field edges, significant infiltration of invasive and non-native species, and a slow degradation of conservation lands over time. If the Town decides to take over the maintenance of the bog property (excluding farming activities), it will have to budget accordingly. The generalized cost ranges are shown in **Table 1**.

Table 1. Generalized Cost Ranges for the Town to Maintain the Cranberry Bog

Annual Activity	Minimum Annual Cost ($)	Likely Annual Cost ($)	Maximum Annual Cost ($)
Regular Mowing of Main Pathways	3,000	4,500	7,500
Mowing of Edges with Sidearm Mower	2,500	5,000	7,500
Tree and Invasive Plant Removal in Bog Ditches	0	3,000	5,000
General Upkeep (including basic dam maintenance)	1,500	4,000	6,000
Beaver Control	0	5,000	5,000
Failure of Major Water-Control Structure	0	0	50,000
Basic Maintenance of the Bog House	0	3,000	6,000
Totals	**7,000**	**24,500**	**87,000**

Summary Evaluation

Pro

- The property will continue to serve as a parcel allowing passive recreation. The Bog is currently one of the most popular properties in Carlisle.
- Although unlikely, this alternative would allow for cranberries or another agricultural crop to be farmed at a future time.

Con

- The Town would incur ongoing costs for edge maintenance and mowing in the main areas around the bog (e.g., mowing, tree removal, dam repair, and invasive-plant control etc.). Maintenance within the bog would likely fall under the Massachusetts Wetland Protection Act, which limits permissible activities to a small number of activities. Maintenance and costs associated with the water-control structures could be significant.
- Regulatory constraints may exist, the most significant being whether the Town could maintain the water-control structures or whether they would have to be removed. If the land is no longer used for agriculture, the classification of dams may change.
- If no agriculture is continued in the three bog areas, then the Town will lose its registered water rights. If some form of agriculture is continued, then a fraction of the registered water rights can be retained. Details are provided in Section 5(a) of the main report and in Appendix C.

ALTERNATIVE 4

BOG RENOVATION FOR CRANBERRY GROWING

Description of Alternative 4

This alternative involves the renovation of the 18-acre Irrigated Bog area to obtain higher cranberry yields. The current low cranberry yield – due to old vines, weeds, and adverse weather – has made farming the bog uneconomical, so the farmer declined to renew the lease.

Renovating a cranberry bog starts with removing the old vines, weeds, and surface organic material. Next, each of the fields is leveled, and the drainage ditches are cleared. Then, the irrigation system is updated, and the organic material is tested and adjusted for optimal growth. The renovation ends with the planting of new, high-yielding vines. If each step occurs on schedule, the renovation process can be completed in a year, but another three or four years are needed for the vines to mature and produce a crop. The cost of renovation ranges from $30,000 to $50,000 per acre depending on variables such as access to sand, machinery, and labor and unforeseen issues.

When deciding to renovate, considering whether the renovated bog would yield a profit is important. The economic analysis in Section 4: Cranberry Economics says that Carlisle's Cranberry Bog needs to get $30 per barrel or significantly increase the number of barrels produced per acre in order to turn a profit. Brian Wick of the Cape Cod Cranberry Association said, "There are some hard economic considerations, as the Return On Investment (ROI) can be 10 years or more and really will depend on the market price for the fruit among other factors." [1]

The cranberry industry has two levels of prices: the A Pool, which gets the top price from Ocean Spray, and the B Pool, which gets prices about half of the A Pool's prices. Some independent growers are in the next tier below the B Pool but get B Pool's prices. The Ocean Spray prices are elevated (from the sale of Ocean Spray products), whereas the B-pool prices and independent prices reflect wholesale prices.

Renovation Steps

In the first step, all the old vines and other plants are stripped off the bog surface using a bulldozer (**Figures 1 and 2**). Though unlikely, some of the old organic material could be screened, cleared of weeds and insects, and reused as organic liners. If the bog cannot support the machinery needed to level the bog, special machinery would be brought in, at additional cost.

Figure 1. Scraping the old bog

Figure 2. Leveling the new bog

In the next step, the irrigation and drainage systems are examined and upgraded. This step includes clearing and shaping the ditches around each bog. The irrigation system could be upgraded to pop-up heads (**Figures 3 and 4**), which conserve water because there is no leaking due to the wear and tear of removing the sprinkler heads for the winter and then reinstalling them in the spring. This system can also be programmed to turn on automatically when the bog needs frost protection, which eliminates human error in predicting frosty nights, which freeze the buds and kill the crop.

Figure 3. Pop-up irrigation system

Figure 4. Close-up of pop-up head

Then, the bog surface is leveled by laser to within two-inch tolerance, which conserves water when flooding for the harvest because extra water isn't needed to cover the high areas.

The next step is to add 6 to 8 inches of coarse sand for proper drainage and aeration so the cranberry vines can establish roots and grow. The irrigation system is placed during the laying of the sand, so it is not too far below the surface. Covering 18 acres of bog with a layer 6 to 8 inches thick requires about 1,000 truckloads of sand. **Figure 5**

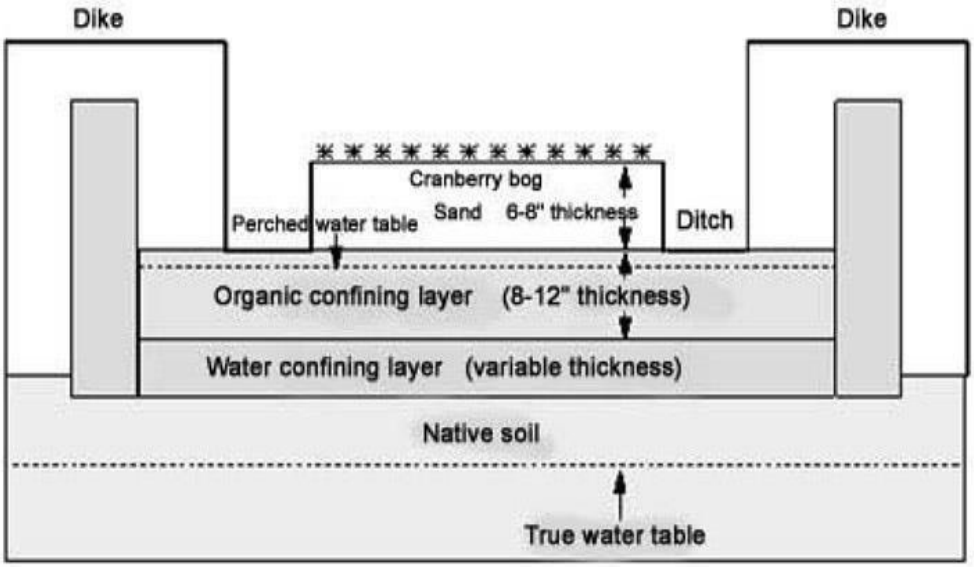

Figure 5. Cross-section showing construction of cranberry bog with location of organic and water confining layers in system using perched water table design.

shows a cross section of an ideal cranberry bog. The Carlisle Cranberry Bog's layers are probably different because of the bog's age. A study of its exact makeup would help in knowing what renovation involves.

In the last step, new vines are planted. The minimum recommended planting density is 1 plant per square foot or 43,560 plants per acre. Two options are available for new cranberry plants. One option is vine cuttings from specific species. The cuttings are laid on the sand and lightly harrowed into the sand to encourage the vines to take root (**Figure 6**). These cuttings are called stolon bundles and can cost $3,000 to $5,000 per acre depending upon the type of vine.

Figure 6. Cranberry vines being spread

The other option is plugs, which are cranberry vines that already have a small root system and must be individually planted (**Figure 7**). The plugs have a much higher success rate, because they already have a root system, but they are much more expensive: from $9,000 to $11,000 per acre. Although the vines themselves are cheaper, they often leave bare spots, so more vines have to be used.

Figure 7. New cranberry plugs

A list of advantages of plugs follows (taken from Evergreen Nursery[2]).

- Starting with pure plug material guarantees pure beds. Over time, cranberry beds will have volunteer seedlings. Volunteer seedlings are seedlings that grow off the original vine plug. Beds pruned for propagation will contain these volunteers and potentially result in lower-yielding new beds.
- Plugs and rooted cuttings establish quickly in beds.
- Plugs give a greater uniformity in beds than vine cuttings give, so no space is wasted, and no bare spots need replanting.
- Planting dates are flexible: Plant from spring to fall.
- Beds establish more quickly than do spreading vines.
- Uniform density and earlier fruit production make plugs the more economical way to establish beds.
- Planting plugs uses less than 10% of the material typically used for vine cuttings per acre.
- Plugs establish new varieties faster than vine cuttings.
- If you have a specific variety, only a fraction of the material is needed to increase acreage over the material needed with spreading vines
- Plugs are a great way to fill in bare spots.
- DNA-tested plugs establish true-to-type beds, a resource for future plantings.

The type of cranberry to plant is very important in determining the success and the return on investment of the cranberry bog. Currently, the bog is a mix of Howes, Early Black, and Stevens varieties. The Howes and Early Black are two of the earliest varieties of cranberry. The Stevens variety was the first hybrid created by the United States Department of Agriculture (USDA). The yield of these three varieties under optimal

conditions is around 300 barrels per acre. Rutgers University and the University of Wisconsin are breeding hybrids today that can produce 500 up to 900 barrels per acre. A high-producing vine could offset low per-barrel prices to help the bog attain a profit. **Table 1** shows some of the newest cranberry vines available. One added cost with these new hybrids is that royalties (for the patent holder) are sometimes added to the purchase price.

Once chosen, the cuttings or plugs are planted, which requires a fair amount of labor and some special machinery. Cuttings are the simplest to plant because they are just spread on the surface by hand or in rows and then spread using a hay tedder. Then the cuttings are lightly pushed into the sand using a harrow. For plugs there are several types of transplanting machines, and the labor is more intensive. A multi-row furrow maker is the simplest transplanter (**Figure 8**). Workers follow behind to drop plants into the furrow and then hand plant them. This method requires about 25 people to plant 1 acre per day, or 200 hours of labor per acre.

Figure 8. Multi-row furrow maker

A custom-built, semi-automated planter does 9 rows per pass (**Figure 9**). Each row has a planting shoe and packer wheels, with one worker per row to place the plant within the shoe. This method can plant 1.5 acres per day, using about 55 hours of labor per acre. It can be used with rooted cuttings raised in either cells or open trays. Commercially built transplanters are widely used in the vegetable industry, have the lowest labor cost (about 40 hours of labor per acre), but require the use of rooted cuttings raised in cells.[4]

After the vines or plugs are planted, the plants need special attention. The young plants need fertilizer and watering twice a day to encourage growth. After the first month, some herbicides should be spread to avoid other plants from growing and crowding out the

Table 1. Examples of New Cranberry Vines

Name	Firmness[a]	Optimal Harvest Time[a]	Average Weight (grams)	Berry Yield (barrels/acre)	Yield Source Data	Characteristics
Stevens	730	10/6-10/20	2.05	370	10 Year Average	Consistent yield, easily managed, industry standard, plagued with low-color fruit
GH1	730	10/1-10/15	1.92	380	10 Year Average	Consistent long-term yield, uniform color, winter hearty
BG	710	10/6-10/20	2.11	530	30 Acres in 2015	Consistent long-term high yield, uniform color, good rebud
Pilgrim King	730	10/1-10/15	2.68	616	Plot in 2014 & 2015	Extremely large fruit, uniform color, high yield
Valley 95	680	9/22-10/6	1.94	657	Plot in 2014 & 2015	Early selection for high yield and and high color
Valley 104	760	9/25-10/12	1.79	750	Plot in 2014 & 2015	High yield and early color
Valley 114	735	9/20-10/6	2.06	632	Plot in 2014 & 2015	High yield and early color
Valley King	760	9/20-10/6	2.68	747	Plot in 2014 & 2015	High yield, very large fruit
Midnight 8	660	9/1-9/20	1.61	570	2 Acres in 2014 & '15	High yield, very early color, excellent rebud
Midnight 9	710	9/15-10/1	1.60	570	Plot in 2015	High yield, excellent rebud
Crimson King	750	9/15-10/1	2.43	900	Plot in 2014	Highest yielding, high color throughout canopy, newest variety being expanded
Granite Red	830	10/1-10/15	2.42	438	Plot in 2014 & 2015	Extremely firm fruit, excellent fresh fruit, keeping quality, large fruit with uniform color

[a]Data Source: Ocean Spray Tests. All other data is collected at Valley Corporation. Newer varieties have a greater chance of fluctuating data.

Figure 9. Semi-automated transplanter

young plants or stealing nutrients. An Integrated Pest Management (IPM) program helps handle the insects and weeds that are a threat to the young cranberry plants. Light layers of sand are spread at the end of each season to anchor vine runners and encourage upright growth. This level of care continues until the vines start producing cranberries.

Considerations for Organic Cranberry Farming

This Alternative assumes that the renovation of Carlisle's cranberry bogs would lead to a greatly improved bog that would be managed and harvested in the traditional methods for wet-harvested cranberries. Thus, "organic" procedures would not be used, and the wet-harvested berries would be sold, as in the past, to a processing company for conversion into juice or canned products. However, this assumption (used in this report) would not prevent any future cranberry farmer from assigning all or a portion of the bog acreage to organic cranberry farming. In this case, the cranberries would be harvested and sold dry. In fact, the Town would certainly welcome such an event. We have chosen not to make organic cranberry farming the focus of this alternative for various reasons, including the following.

- Organic cranberry farming and marketing is a small, specialized market. Special knowledge, skills, and dedication are needed by the farmer.
- To be profitable, any organic cranberry farmer in Carlisle would likely have to direct market the produce to retail outlets in the area. The marketing and distributions adds significantly to the farmer's burden, especially to the time commitment.
- A number of traditional cranberry growers have recently switched to organic cranberry farming, presumably due to adverse economic conditions. In addition,

organically grown cranberries all hit the market around October unless they are frozen for later sale. These factors lead to an oversupply of the product each fall which, in turn, puts a downward pressure on prices.

- The growing of cranberries organically is very labor intensive in part because, in the absence of herbicides, weeding must be done by hand. Finding the labor at a reasonable price to do the weeding would be problematic.
- Given the significant labor requirements, organic cranberry farming is more commonly appropriate for relatively small bogs (e.g., less than 10 acres).
- Given the historic use of pesticides and herbicides at Carlisle's bog, it could take a few years to achieve "organic" status.

Other Considerations

A consideration and cost for renovation are dealing with the beavers and muskrats. The beavers and muskrats build dams and damage dikes, which impede the water flow and make it difficult to control the water at the bog. There are two options for beaver and muskrat control. One is to use beaver deceivers at each dam. These devices are expensive and have limited success. The other is to trap the beavers. Beaver and muskrat trapping costs are per animal trapped, and trapping is allowed from November 1st through April 15th of the next year. See Section 5(c): Beaver and Muskrat Control for further information.

Another consideration is dealing with the specialized machinery needed to grow and harvest the cranberries. In the past, Mark Duffy rented equipment from a company that in 2016 sold its equipment and went out of business. To continue harvesting cranberries, a farmer would have to find another place to rent machinery or buy it outright.

Renovation Costs

Section 4: Cranberry Economics provides a detailed description of the range of costs involved in cranberry-bog renovation and a general discussion of the historic and current economics of cranberry production. The economic analysis for Carlisle's Irrigated Bog estimates that renovation would cost $33,000 per acre or $660,000 to renovate the whole 20 acres. In addition, a subsidy of $30,000 per year is due to the farmer to nurture and care for the plants until they become productive. The total investment by the Town would then be approximately $800,000.

Currently the Cranberry Bog produces about 100 barrels per acre, but, with independent prices at $10 to $15 per barrel and costs at $15 to $20 per barrel, the bog loses $5 per barrel (or $500 per acre, or $10,000 overall), so cranberry production is economically unfeasible. With annual operating costs of up to $66,000 and prices for independent growers in the $15 to $20 per barrel range, then the Cranberry Bog would need to increase production to around 350 barrels per acre (a 3.5-fold increase) in order to make a small profit. This increased production is possible with the new, high-yielding vines that are listed in Table 1.

Fortunately, there are some grants, both state and federal, that can help with the renovation costs. MassDevelopment offers a guaranteed loan program that partners with banks and guarantees up to $500,000 per farm, up to 50 percent of the outstanding principal. A recent report from the Massachusetts Cranberry Revitalization Task Force highlighted the need for this program, which would help the cranberry industry by financing cranberry bog upgrades, including leveling, improving irrigation systems, and planting hybrid vines to produce a larger cranberry for juice and dried cranberries. Federal programs (USDA-Natural Resources Conservation Services cost-share programs for some aspects of renovation) and state programs (Department of Agriculture, Agricultural Environmental Enhancement Program) also cover some potential costs. These programs are directed at farmer-owned bogs rather than town-owned bogs, but maybe exceptions can be made because the state is interested in cranberry-bog renovation.

Summary Evaluation

Relative to the general evaluation criteria listed in Section 3 of the Main Report and other considerations, the following pros and cons of this alternative follow.

Pro

- Cranberry farming, which has been ongoing for over 110 years, would continue. The cultural heritage would not be lost.
- Public use of the dike trails would continue with some initial disruptions.
- Renovation would improve the bog overall and maintain the paths and vistas.
- Renovation would preserve 100% of the registered water rights.
- Renovation would allow the bog to keep special agricultural exemptions from the Wetlands Protection Act regulations.
- Renovation would preserve the last remaining cranberry bogs in Middlesex County.

Con

- Renovation has high capital costs.
- Renovation requires 3 to 5 years to achieve a producing cranberry bog. A subsidy to the farmer would likely be needed during this period.
- Constant maintenance is needed to deal with beavers and muskrats.
- High increase in traffic on Curve Street during the renovation.
- The return on investment is long, which means the profit won't make up for the amount spent on renovation for many years.
- Cranberry farming (any kind of farming) is risky. Profits are not guaranteed.
- Finding an interested and qualified cranberry farmer to manage the cranberry-growing operation may be difficult.

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3. Table 1 source: http://www.cranberryvine.com/cranberry-varieties. Table 1 reproduced with permission from Valley Corporation, Tomah, WI.

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Figures 8 and 9: http://www.integritypropagation.com/planting_planters.html

ALTERNATIVE 5

CONVERSION TO OTHER AGRICULTURAL USE

Overview of Alternative 5

This overview provides a synopsis of Alternative 5 for anyone who does not plan to read the entire appendix.

The Carlisle Cranberry Bog has been in agricultural production for over 110 years and is currently a very popular place for passive recreation with open vistas and valuable wildlife habitat. Due to a change in the cranberry market that will likely persist, this era of producing cranberries at the Cranberry Bog may be ending. Therefore, alternative uses are being explored, one of which is growing an alternative agricultural crop. This alternative requires the consideration of numerous intertwined and separate parameters that applies to all three of the agricultural fields.

Before exploring the multiple parameters involved in assessing this alternative, the soil was tested to determine pH, texture, soil moisture, the degree of sand incorporation, and drainage class by extracting soil cores from different locations in each field based on plant species composition. (The data are reported in **Appendix D**.) These tests, along with verification via soil maps from the Natural Resource Conservation Service (NRCS), revealed the soil is an organic Freetown muck soil that has variable sand layers that were added for agricultural purposes. The Freetown muck has a very high capacity for permanent water retention (water table 0 to 6 inches below surface), resulting in low storage capacity during intense water influxes. It is generally acid to extremely acid and very poorly drained. Such soils have low soil strength, resulting in low bearing capacity, meaning that heavy agricultural equipment will get mired down in saturated soil conditions. The added sand layers slightly increase the drainage rate of the upper soil layer depending on the degree of incorporation of the sand layer into the muck soil, the number of sand layers added, and especially the height of the water table. The current high moisture content of this soil will severely limit selection of an alternative crop.

The other parameters to be considered in evaluating alternative crops are climate, soil nutrients, hydrology, drainage, water supply and water rights, marketability and distribution of alternative crops, potential licensee qualifications, and local agricultural support services. According to the 2014 Third National Climate Assessment, summer droughts will occur with greater frequency and duration. Precipitation may increase but will occur more in the spring, fall, and winter with greater intensity. These changes will increase the need for more water-storage capacity for periods of drought and more water-drainage ability for intense precipitation.

Freetown muck soil is often low in the essential nutrients phosphorus, potassium, copper, manganese, and zinc. Given the variety of the percent sand and pH levels within each field and the slow rate of water movement through this type of soil, the application of fertilizers may require monitoring to prevent salt buildup or eventual chemical seepage

into output channels. As mentioned above, the natural hydrology of this land is that it is saturated due to its soil composition and its geographic location within the River Meadow Brook watershed. Growing an alternative crop here, such as tall fescue or Timothy hay, would require an extensive drainage system to lower the water table 2 to 3 feet and constant maintenance of the downstream channels to ensure this degree of drainage. However, the elevation difference between the agricultural fields and the drainage area is only 1 to 2 feet according to NRCS topographic LiDAR (**Li**ght **D**etection **A**nd **R**anging) maps. If the fields are sufficiently drained so crop roots are not saturated, then the crops will need irrigation during the growing season, especially if there is a drought and to prevent subsidence of the soil due to aerobic decomposition and lack of moisture. This combination of drainage and irrigation for an organic soil can require significantly more water than a more conventional setting with a moderately draining mineral soil. This increased water demand may affect the Town's application for water rights for the Cranberry Bog.

Just as with cranberries, other production food crops for humans are subject to multiple market dynamics such as timing, quality, prices, and physical issues such as security, weather, and robustness. However, if a perennial forage crop is grown and consumed by the licensee's livestock, then market issues are not a concern.

Every type of agricultural practice requires certain kinds of support services. The type of services needed for growing cranberries are unique and are no longer available in Carlisle. The kinds of support services needed to grow an alternative crop on a drained organic soil are not unique and, although specialized equipment is required, they are available.

The requirements for licensing the Cranberry Bog for agricultural usage are complicated and nuanced and require careful vetting of potential licensees. Converting to another crop involves an economic investment, professional expertise, and risk for both the potential licensee and the Town. The two primary limiting parameters involved in a crop conversion are the hydrology and the characteristics associated with an organic soil. Another important consideration is the in-stream location of this agricultural land, which makes it subject to multiple regulations. The long-term dormancy of two of the fields has created valuable wildlife habitat that has been recognized by the Natural Heritage and Endangered Species Program. Currently, the Cranberry Bog, with one field in production and two fields "in renovation," which are, in fact, habitat, is very popular with the public.

The above parameters and the popularity of the current situation, combined with the town's need to preserve the water rights, are some of the most important aspects for this alternative. The following report contains more detail on all the parameters considered for this assessment of alternative agricultural crops followed by a closing summary that includes the pros and cons of such a conversion.

Introduction

Alternative 5: Conversion to other Agricultural Use considers the prospect of using the Cranberry Bog fields for the production of an agricultural crop other than cranberries. This alternative may be applied to all three agricultural fields or a subset of the fields, although economies of scale may be a factor to a prospective licensee. Any alternative crop for this parcel needs to provide the same open vistas and not require obtrusive structures such as greenhouses, tall fences, or permanent large water tanks.

An economically viable model for profitable cranberry production in Carlisle, Massachusetts, depends on many parameters. These parameters will be just as important, although possibly in different ways and to different degrees, for any other agricultural crop. Detailed descriptions of the following parameters are provided in the following Parameters section.

- Climatic Conditions
- Soil Type
- Soil pH and Nutrient Availability
- Soil Moisture Levels and Drainage Classification
- Hydrology and Geomorphology
- Water Supply and Water Rights
- Marketability of Alternative Crops and Distribution Network
- Agricultural Support Services
- Potential Licensee Qualifications

A following section reviews the special considerations for the type of soil at the Cranberry Bog if agricultural crops other than cranberries are grown. The following section covers the factors, listed below, involved in draining the Cranberry Bog fields.

- Regulations
- Soil Drainage Dynamics
- Environmental Impact
- Adequacy of Drainage Area
- Elevation
- Economic Viability
- Re-establishing the Wetland after Other Agricultural Use

Before analyzing the physical parameters of the Cranberry Bog, on-site field research has been done on the soil. Soil cores have been extracted from different locations in each field based on plant species where possible. For both the Sand-Covered Bog and the In-Renovation Bog, these soil samples sites were located based on different plant communities present. Theoretically, the plant communities indicate differences in soil composition, pH, and moisture saturation patterns, thereby helping to determine the degree of soil uniformity within the field. Some plant species only grow in specific soil types under particular hydrologic conditions. The plants that are particular about moisture content of the soil, are considered to be indicator species and are often used in analyzing wetland soils. This approach was not possible in the Irrigated Bog because it has been

maintained as a cranberry production field and other plant communities are not well enough established there to exhibit discernable patterns. The locations of the soil cores in the Irrigated Bog were therefore based on an even but random distribution over the entire field, taking into account that different parts of individual sections may have various soil compositions.

The soil cores samples were used to determine pH, texture, amount of soil moisture, the degree of sand incorporation, and verify drainage class. The soil cores have been tested for pH using a standardized wet-soil pH test. Soil texture has been analyzed using the USDA Soil Texture Field Test. Soil moisture has been estimated by tactile analysis and visual detection of visible water in the sample or the core hole. Drainage class has been determined based on the guidelines issued by the Army Corps of Engineers and the Natural Resources Conservation Service (NRCS) hydrology group specification. The results from these tests (**Appendix D**) are useful for determining the current growing conditions and where professional analysis would be warranted.

Parameters

Climatic Conditions

Massachusetts' historical precipitation pattern generally consisted of winters with abundant amounts of snowfall followed by wet springs, relatively dry summers, and wet falls. This historical amount of precipitation during the spring and fall when the ground is not frozen has usually been sufficient to recharge the groundwater. In the last several decades, however, the annual precipitation events have shifted, resulting in drier summers and more extreme precipitation in the winter. This shift combined with slightly higher temperatures results in more rainfall when the ground is frozen, reducing the amount of groundwater recharge and increasing runoff volume. This alteration to the hydrologic cycle is predicted to continue and potentially increase.[1] These effects and especially the effect of a potential increase in periodic flooding should be considered when reviewing potential alternative crops. The Cranberry Bog fields are within the flood zone of the River Meadow Brook and, when combined with the soil characteristics and the high water table, these fields are very susceptible to flooding, especially as a result of intense precipitation events. Also, the low elevation relative to the surrounding area makes the Cranberry Bog fields prone to frost events.

Soil Type

The soil in the Cranberry Bog fields is not like the mineral soil common in residential yards. It is an organic soil almost exclusively comprised of dead plants and is identified by the USDA's Natural Resource Conservation Service (NRCS) as a type of Histosol soil called 52A Freetown muck (**Figure 1**).

Freetown muck is a hydric soil, which is a soil that is permanently or periodically covered by or saturated with water. The soil's biological processes are consequently anaerobic rather than aerobic when saturated and progress at a substantially slower rate than in aerobic soils. Freetown muck soil generally has a very high capacity for

Figure 1. Location of Cranberry Bog's Freetown muck soil on the NRCS Soil Map[4]

permanent water retention (water table 0 to 6 inches below surface), resulting in low storage capacity during intense water influxes. It is generally acid to extremely acid (pH 3.5 to 6.5) and very poorly drained.

Freetown muck has low soil strength due to its lack of structure caused by insufficient to nonexistent amounts of sand, silt, or clay.[3] Due to all the upstream water-control structures creating still-water conditions and constriction from aquatic vegetation that greatly slows down water movement, the suspended sand, fine silt, and clay particles tend to settle out of the water column before they reach the Cranberry Bog fields.

The USDA NRCS's soil identifications are based on scientific models and may not exactly reflect the actual conditions, especially because the Cranberry Bog is an altered landscape that has been used for cranberry agriculture for over a hundred years. As part of the agricultural process over the last century, the three agricultural fields have been inconsistently covered in sand in varying amounts and at different times. This activity slightly increases the drainage rate of the upper soil layer depending on the degree of

incorporation of the sand layer into the existing muck soil, the number of sand layers added, and the height of the water table.

Soil pH and Nutrient Availability

The pH ranges from 5.0 to 5.8 in the In-Renovation Bog based on 10 soil samples, from 5.0 to 6.7 in the Sand-Covered Bog based on 5 samples, and 4.5 to 6.0 in the Irrigated Bog based on 12 samples. These tests show the pH varies considerably, as does the incorporation of the sand into the muck soil within each of the fields. Freetown muck is often low in the essential nutrients phosphorus, potassium, copper, manganese, and zinc. Unlike mineral soils, in which a pH of 6.2 to 6.8 is optimal for nutrient availability, the optimal pH for organic soils is 5.2 to 5.8. Raising the pH of an organic soil 0.1 requires 1,000 to 1,400 pounds of lime per acre. However, an organic soil with pH above 5.8 will result in reduced availability of essential elements, especially phosphorus, manganese, and zinc.[5] Given the variety of soil composition and pH levels within each field, appropriate application of amendments may be challenging. If fertilizers are applied to compensate for nutrient deficiencies, then salt buildup and runoff into output channels need to be monitored. Analysis by a professional soil scientist is recommended before adoption of any soil enhancement plan.

Soil Moisture Levels and Drainage Classification

The Sand-Covered Bog has moist to very moist sand layers ranging from 2 to 10 inches thick on top of a 1 to 5 inch medium to dark brown horizon of a more moist, very sandy, organic muck. The muck is mostly decomposed (sapric), which is typical for wet soils formed long ago (thousands of years).

In the In-Renovation Bog, the soils in the very moist areas (southeast and northwest edges) are entirely muck soil with no sand layers. Roots from current vegetation are present, but the soil primarily comprises partially to completely decomposed muck (hemic to sapric). In some areas, the sand and organic horizons are visible, but, in other areas, the two are undifferentiated. A few areas are predominately sand in the top 10 inches of soil. Overall, the soil composition varies considerably, which partially explains the difference in vegetation in the In-Renovation Bog. This field has live sphagnum plants and other wetland obligate species distributed throughout (Appendix D).

The Irrigated Bog has been maintained as part of a productive cranberry operation. In some sections, the added sand layers are distinct from the muck, but, in most sections, the layers are undifferentiated, and the composition is sandy to very sandy muck. The sandy muck of each soil core was moist, and the sand layers were damp. In a wetter northeast area, the muck layers were saturated, and the sand layer was moist.

The severe drought in the summer of 2016 revealed important soil-moisture characteristics. This situation has enabled an examination of the soil-moisture levels under minimal precipitation conditions, meaning that, in a year with more normal levels of precipitation, the soil moisture levels would be greater than experienced during the summer of 2016. All three fields' soil-core samples showed moisture levels that were

moist to very moist, with some areas that were saturated. The drainage ditches in the fields were either filled with a few inches to a few feet of water or contained no standing water but the soil was completely saturated. Beaver activity prevented the ditches in all three fields from fully draining. Therefore, the retained ditch water may have had some effect on the soil moisture by capillary action and the horizontal seepage sometimes found naturally in muck soils or caused by muskrat activity. This high water table during a drought warrants a professional hydrological study to determine the actual reason for the appearance of a high water table in the fields.

Given these moist conditions observed in the recent drought, the process of soil saturation is evidently endosaturation (wet from the bottom up) via groundwater and capillary action. In non-drought conditions, the process of saturation is both endosaturation and episaturation (wet from the top down) via surface water.[6] The episaturation occurs from precipitation and periodic flash flooding of the River Meadow Brook. The presence of endosaturation and lack of episaturation during a drought is undeniable evidence that the muck soil has substantial water-retention capacity.

These moisture processes are relevant to understanding the drainage classification of Freetown muck and the implications for crops. This soil type is classified as a very poorly drained soil[7] according to the 1991 guidelines issued by the U.S Army Corps of Engineers due to this type of soil having "an aquic moisture regime and organic soil materials that extend from the soil surface to a depth of 16 inches or more (i.e. Histosols)."[8] NRCS places Freetown muck in Hydrology Group D, meaning it has a very low saturated hydraulic conductivity of 0.40 to 1.0 micrometers/sec (0.06 to 0.14 inches/hour).[2] Augering done by the NRCS in Westford, Massachusetts, showed that some areas of the bog muck soils have a depth of 20 to 30 feet. These hydrology details are important for <u>any</u> future plans for the Cranberry Bog, especially for determining drainage requirements for growing alternative crops on the Cranberry Bog fields.

<u>Hydrology and Geomorphology</u>

An online search for historical Carlisle maps produced maps from 1886, which is two years after the inception of the United States Geological Service's topographic mapping program. Older maps may possibly still be found in library archives. Examination of the available online historical topographic maps does not show either a wetland located where the Cranberry Bog fields exist today or any other confined water below the Hart Pond dam (**Figure 2**).

The River Meadow Brook is not labeled as such in Figure 2, but the headwaters are evident and are shown as a small stream originating in Westford that abruptly stops at Chelmsford's Hart Pond, which is bound on its southeast side by the Framingham and Lowell Railroad tracks. The brook was probably dammed before or at the time the railroad tracks were constructed. The map also shows a small stream emanating from the current Cranberry Bog area. The Cranberry Bog is at a lower elevation than the surrounding area except to the southeast.

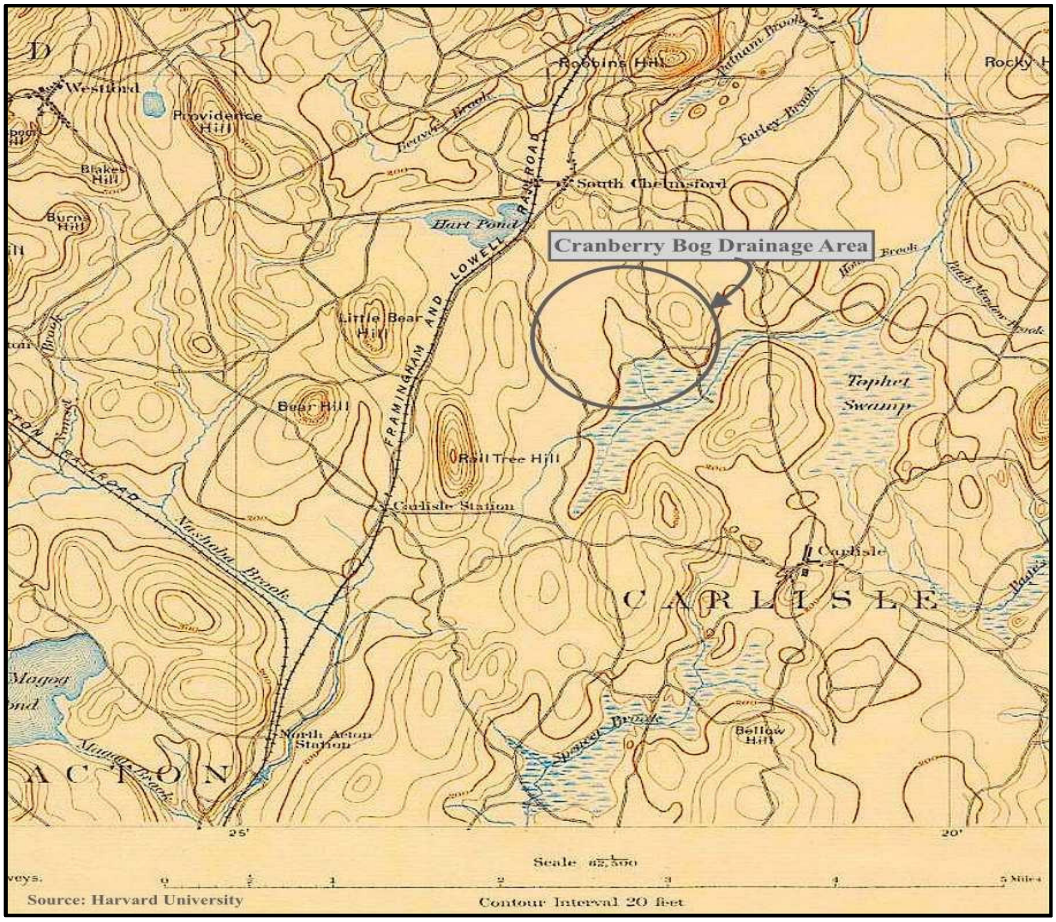


Figure 2. Topographic Map of Carlisle from 1886 Indicating Historical Cranberry Bog Drainage Area[9]

One of the few benefits from the severe summer drought in 2016 is that the depleted reservoirs revealed the former vegetative landscape that existed before the dike system was built. Both reservoirs are populated by numerous tree stumps preserved by the acidic water with evidence of man-made elevated trails cutting through the area, implying they were wet woodlands before being immersed under water. The presence of the deep Freetown muck soil in the current Cranberry Bog fields is evidence that this area was probably a depression of considerable depth with an impermeable bottom that was created by an ice block during the last glacial period. This depression slowly filled up with water and wetland plants over the millennia, ultimately creating a bog that eventually developed an irregularly braided outlet stream once the level of the bog reached a certain elevation. The Cranberry Bog fields received moisture from the runoff of the surrounding higher elevations as well as the stream. The area was most likely subjected to periodic flooding during intense precipitation events.

Understanding the dynamics of the hydrology and the hydrologic cycle is important to determine what drainage is necessary to grow alternative non-hydrophytic crops (plants that don't tolerate saturated soil), because few of these agricultural crops can withstand periodic flooding of more than 24 to 48 hours' duration. Additional drainage may not be

sufficient to prevent a low-lying area such as the Cranberry Bog from being inundated by substantial water influxes of considerable duration from intense precipitation events. Even if the top 2 to 3 feet of soil were drained and were subsequently drier, it would still be underlain by a deep, saturated muck that would have no storage capacity to absorb the intense water influxes. Professional analysis would be required to determine whether preventing water damage from these kinds of climatic or anthropocentric events is possible.

Water Supply and Water Rights

The severe drought in summer 2016 showed how vulnerable the Cranberry Bog fields are to a reduced water supply. The majority of the watershed that produces the surface water that supplies the reservoirs is located in Chelmsford. The lack of surface water flowing through the Chelmsford watershed due to multiple water-control structures and upstream beaver dams resulted in greatly reduced water levels in the reservoirs. Without the currently existing water rights to the entire watershed, any future licensee could face crop losses due to an insufficient water supply if additional water is required for irrigation of alternative crops.

Marketability of Alternative Crops and Distribution Network

Simply creating a list of crops that can grow under the conditions present at the Cranberry Bog regardless of the alterations that might take place to improve conditions for any particular crop is not sufficient. The crop must be profitable to grow, which involves knowing the demand for the crop, wholesale pricing of the crop, available markets for timely delivery, robustness of the crop to the specific weather conditions at the Cranberry Bog and to possible intrusions by the public, security of the crop, and farmers willing to grow the crop. Just because a farmer can grow a food or ornamental crop doesn't mean the farmer can easily sell it. Any crop grown in quantity requires a stable, reliable, and efficient distribution system. Growing forage crops to be used by the licensee, however, would not be subject to these market pressures.

The types of crops most often grown on muck soils are vegetables, namely potatoes, onions, carrots, parsnips, lettuce, cabbage, cauliflower, table beets, sweet corn, radishes, and spinach. Field crops grown on organic soils are corn, sugar beets, mint, peas, grasses, and small grains. Possible suitable forage crops are Timothy hay and tall fescue. Although these crops may be able to tolerate the lower pH, the hydrology may be the limiting factor. None of these crops will tolerate flood conditions or saturated soil for more than a day or two.

Agricultural Support Services

As in any business, support services can play an important, even critical role for agricultural operations. Subcontracting with an Integrated Pest Management (IPM) professional and renting specialized harvesting equipment are essential services needed by cranberry growers but are now unavailable reasonably close to Carlisle. If an alternative crop is selected for production at the Cranberry Bog, knowing whether any support services are needed and whether those services will likely be available in the

foreseeable future is important. The marketability or usability of an alternative crop can indicate enduring support services.

Potential Licensee Qualifications

Not only must the above parameters be considered when selecting suitable alternative crops, but also the reality of the situation for the community must also be considered in the decision. Managing the Cranberry Bog is neither a minor undertaking nor an opportunity for a hobby farmer. Any potential licensee must also know how to manage the muck soils and understand the hydrologic cycle of the area along with employing the necessary personnel and possessing the proper equipment. The Cranberry Bog is a dynamic situation that requires a dedicated licensee who lives near the land and has sufficient expertise and commitment to manage the multiple challenges. In order to attract such a candidate, the appropriate alternative crop(s) must be highly desirable to a prospective licensee and have the potential of maximum value to their agricultural operation in order to provide some assurance to the town that the licensee will be well motivated and the Cranberry Bog will be properly managed over many years. These requirements will greatly reduce the number of suitable alternative agricultural crops and qualified licensee candidates.

Special Considerations for Muck Soil and Agriculture

Any non-hydrophytic crop (a crop that doesn't tolerate saturated soil) grown on a muck soil requires an extensive drainage system to lower the water table anywhere from 1 to 3 feet, depending on the crop.[10] This new drainage system will also be required to handle intense precipitation events to avoid crop damage and loss of soil from erosion. Drained organic soils are more susceptible to wind and water erosion than mineral soils.

Once organic soils are drained, an irrigation system is required to moisten the soil periodically to the appropriate level but not to saturate it. If the drainage system is connected to a reservoir and incorporates valves and water-control gates, then the system can be used for raising and lowering the water table, although lowering the water table would be a slow process because of the low hydraulic conductivity of saturated muck soil. An alternative method for moistening the top layer of soil would be overhead irrigation. Either method would require an ample water supply. Efficiently controlling the water table will substantially reduce subsidence, which is described below.

Subsidence is the gradual sinking of land due to geologic or man-induced activities. As organic soils are drained, more oxygen enters the previously anaerobic environment, greatly speeding up the decomposition process. Also, as the organic matter releases the water, the volume of the organic matter is substantially reduced. Tilling enhances this process of oxygen inundation and water loss. These factors along with erosion from wind and water cause subsidence of the surface layer of organic soil. Intensively cropped (annual crops versus perennial crops) muck soil can subside 30 cm every 10 years. With proper management of the water table, the use of cover crops for annual crops, control of wind and water erosion, and judicious applications of copper fertilizer, however, the subsidence rate can be reduced to 4.7 cm every 10 years.[11]

If a precipitation event saturates the organic soil, the field will drain very slowly, potentially resulting in anaerobic soil processes that may stress crops by oxygen restriction to roots, lock up nutrients, and produce potentially toxic substances. Mismanagement of either the drainage system or the irrigation system could also create this problem.

Regardless of the type of crop, the inherent lack of stability in organic soil may cause other challenges. If the water table is not reduced to a depth of at least 3 feet, then conventional equipment will sink into the soil, damaging the field and possibly the equipment. Given the difficulty of accurately and efficiently controlling the water table in a soil with low hydraulic conductivity, specialized equipment and techniques will probably be required for crop production on organic soils.

Drained muck soils can occasionally be accidently ignited. A surface fire is combustion of any vegetation above ground. Muck fires, however, are smoldering combustion of the organic material that is underground; they are flameless and slow moving. These kinds of fires can be difficult to extinguish and consequently can persist for days or even months. The smoldering combustion occurs at a lower temperature (500 to 700° C versus 1,500 to 1,800° C for a surface fire), but, due to the potential for a long burn, the heat from these fires penetrates into the soil profile causing damage, especially to the rhizosphere (area immediately adjacent to roots).[12] Even plants adapted to fire regimes have little ability to withstand underground intense heat. The direction and extent of the lateral movement of a smoldering fire and the depth to which it proceeds can be very difficult to determine. When organic soil is dried, the soil can become hydrophobic (repels water), meaning the water or other chemicals applied to extinguish the combustion may pool on the surface or very slowly percolate the soil. Organic soil that took hundreds of years to develop can be completely destroyed in a matter of weeks by a smoldering underground fire.[13]

Special Considerations for Drainage of the Cranberry Bog Fields[14]

The decision to drain an organic soil for agricultural use is multi-faceted. Factors to consider are local, state, and federal regulations, soil dynamics, impact on the environment both in the fields and in the downstream areas, adequacy of the outlet area to receive the drainage water, elevation of the fields relative to the drainage outlet, economic feasibility, and potential future use of the property. Input from a professional source is advisable due to the complicated analysis required for some of these factors.

<u>Regulations</u>

The USDA Food and Security Act and the Farm Bills of 1985, 1990, and 1996 all contain restrictions to wetland alterations and special mandates that must be adhered to by all drainage projects. These federal laws, the Massachusetts Wetland Protection Act, and Carlisle regulations will need to be considered in any plan to alter the drainage at the Cranberry Bog.

The Army Corps of Engineers “evaluates permit applications for essentially all construction activities that occur in the Nation's waters, including wetlands.”[15] The alterations to the Cranberry Bog to grow an alternative crop may require a permit from

the Army Corps of Engineers. “During the permit process, the Corps considers the views of other Federal, state and local agencies, interest groups, and the general public.”[16] This process may result in a discussion on the environmental impact of draining a wetland to accommodate agriculture.

Soil-Drainage Dynamics

A preliminary analysis of the soil composition and characteristics is described above, but a drainage coefficient, which is the desired amount of water removed per day, is needed for drainage plans. As noted in the hydrology and geomorphology subsection above, excess water needs to be removed from the upper areas of the active root zone within 24 to 48 hours of saturation to prevent damage to crops. Therefore, the amount of water retained and the rate it can be drained are important. Many things can change a drainage coefficient, such as crop value, soil texture, lack of sufficient slope, crop residue, poor surface drainage, low crop evapotranspiration, frequency and intensity of precipitation, and timing for planting and harvesting. A professional hydrologist can calculate a drainage coefficient.

Environmental Impact

Reducing the level of the water table will undoubtedly impact the environment. A lower water table will mean a slightly different plant community, and less of the Cranberry Bog will be considered habitat assuming more acreage will ultimately be planted in crops. A crop field is a monoculture, whereas a field in renovation has plant diversity and, therefore, more diversity of wildlife than a crop field has. However, some wildlife will inhabit the crop fields, and they will be affected by the maintenance and harvesting. If the dikes are kept well mown, then the insect species and some waterfowl species will not be present due to lack of food sources and cover.

Increasing the water flow-through volume during intense precipitation events will cause more downstream flooding. The hydrologic cycle of the downstream will be altered, which will, in turn, alter the plant and wildlife species in that habitat.

Lowering the water table will introduce oxygen into the soil, which will increase the decomposition of the organic soil, releasing the carbon stored into the atmosphere as carbon dioxide (CO_2). Wetlands are normally a carbon sink because they sequester carbon through a combination of photosynthesis and a buildup of organic material in soil from roots and deposition of plant biomass. Plants add more carbon to the soil than is released because they grow at a faster rate than the soil carbon decomposes due to the soil’s anaerobic environment. Because clearing or drainage of wetlands can lead to large losses of stored organic carbon to atmospheric carbon dioxide, the practice of draining wetlands is increasingly discouraged by regulatory agencies.[17] Recent regulatory trends and funding favor the restoration of wetlands for environmental reasons rather than the draining of wetlands; this view may prove a significant hurdle to increasing the drainage of the Cranberry Bog. However, recent published research is emphasizing that the natural biotic processes of wetlands produce methane gas (CH_4), which has greater warming potential than carbon dioxide.[18] It is difficult to predict which issue will be of the most concern to regulatory agencies.

The Massachusetts Natural Heritage & Endangered Species Program (NH&ESP) has designated the Cranberry Bog area (PH 670) as "priority habitat of rare species and rare wildlife."[19] NH&ESP has certified four vernal pools in the area and is currently reviewing a fifth vernal pool application. Blanding's turtle, a threatened species, has been sighted at the Cranberry Bog. The vernal pools are a valuable source of food for this species, the sandy soils of the Cranberry Bog Sand Pit and the Sand-Covered Bog provide suitable nesting sites, the woodlands provide cover for estivation, and the wetlands make excellent overwintering sites and provide food such as bulrushes and sedges. Either disturbing these areas or lowering the water table or altering the amount of water storage will negatively impact this species.

Adequacy of Drainage Area

If the increased flow-through of water in the Cranberry Bog during intense precipitation events is going to be successful, then the downstream area must have sufficient storage capacity to absorb the increased volume. Therefore, the wetlands and downstream channels must be able to transport the volume efficiently and hold the water without adverse effect on the environment or private or public property. The capacity of downstream wetlands for a considerable distance and the legality of removing downstream beaver dams, fallen woodland trees that impede flow, and muskrats that burrow into stream banks must be assessed.

Elevation

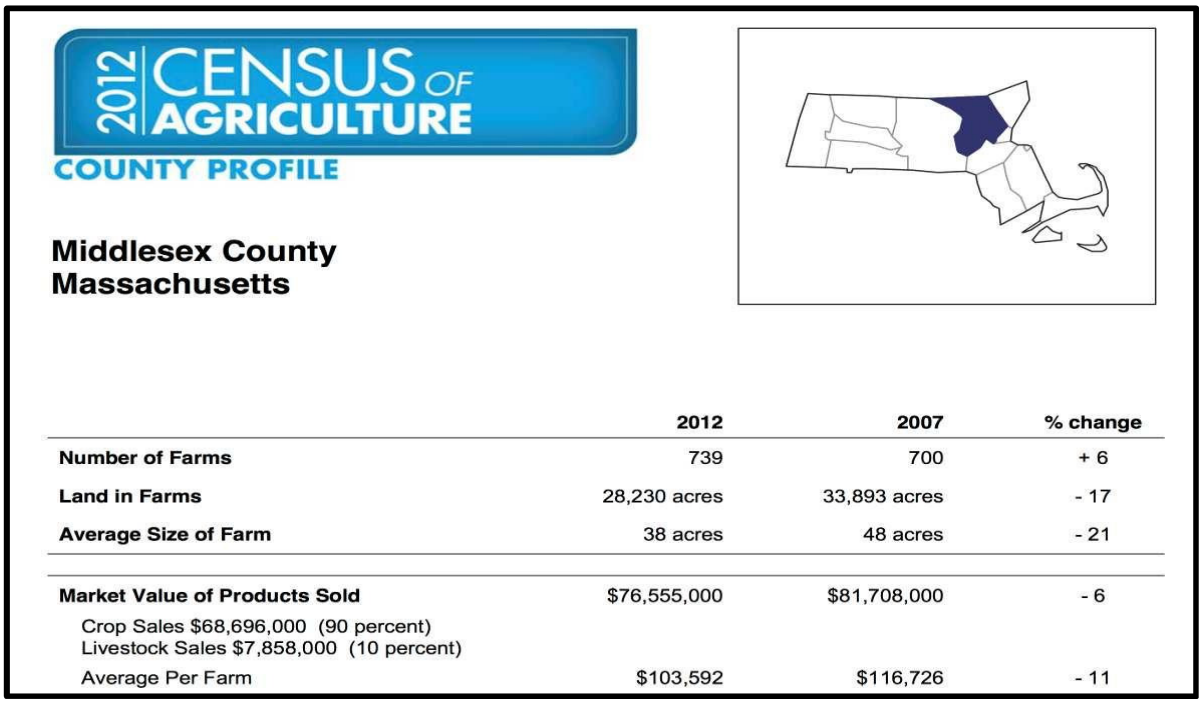
The relative elevation of the fields to the drainage ditches and the downstream drainage area are very important. Topographic LiDAR (**Li**ght **D**etection **A**nd **R**anging) maps obtained from the Westford NRCS office give various elevation points of the fields and surrounding area but do not show the depth of the drainage ditches. The Irrigated Bog has elevations from 184 to 187 feet (primarily 185 to 186 feet); the In-Renovation Bog has elevations from 184 to 186 feet (primarily 185 to 186 feet); the Sand-Covered Bog is slightly lower with elevation ranges of 183 to 185 feet (primarily 184 feet). The drainage area south of the Curve Street Dam has elevations ranging from 182 to 184 feet (primarily 183 feet). This data shows a slight decrease in elevation from the fields to the drainage area. Drainage pipes are usually positioned 3 to 5 feet below the soil surface.[20] A detailed survey of the field drainage ditches and downstream channel would need to be made by a professional to determine the feasibility of adding a drainage pipe system to the bog in addition to the current drainage ditches.

Economic Viability

Converting the Cranberry Bog for alternative agricultural crops involves considerable upfront investment in irrigation infrastructure, specialized equipment for muck soil, and alteration of the landscape, which entails removing all plant material, removing the existing irrigation system and beaver dams, leveling and amending the soil, repairing existing drainage ditches, creating new drainage ditches, installing a new subsurface drainage system, and adding an overhead irrigation system.

The first step should be identifying regulatory issues governing the Cranberry Bog and any major governmental stakeholders. The next step is for the Town to obtain geotechnical and hydrological engineering reports to determine the extent and cost of what is required for alterations. The overall design, timetable, and budget should be developed based on these engineering reports. Exactly how the expense of the renovation would be distributed between the Town and any future licensee would have to be negotiated.

Maintaining and harvesting an agricultural crop on muck soil requires specialized equipment that most farmers probably do not own, so the upfront costs could prove prohibitive to many prospective farmers. This cost may deter potential licensee candidates, especially given that crop proceeds have been decreasing (**Figure 3**).[21] Considering the amount of uncertainty surrounding the potential success of growing and harvesting any alternative crop(s), an adaptive management plan with a staggered renovation approach over multiple years might be advisable.



2012 CENSUS OF AGRICULTURE
COUNTY PROFILE

Middlesex County
Massachusetts

	2012	2007	% change
Number of Farms	739	700	+ 6
Land in Farms	28,230 acres	33,893 acres	- 17
Average Size of Farm	38 acres	48 acres	- 21
Market Value of Products Sold	$76,555,000	$81,708,000	- 6
Crop Sales $68,696,000 (90 percent) Livestock Sales $7,858,000 (10 percent)			
Average Per Farm	$103,592	$116,726	- 11

Figure 3. Reduction in Value of Products Sold from 2007 to 2012: USDA Farming Profile for Middlesex County[22]

The renovation of the Cranberry Bog to a suitable condition for growing and harvesting an alternative crop, such as tall fescue or Timothy hay, would likely require an investment of approximately $500,000 to renovate all three fields.[23] The irrigation system would be approximately $100,000 of that total, with the rest needed for the other alterations listed above. The cost is about $10,000 per acre not including the irrigation system or an initial professional geotechnical engineering and hydrological study. The type of irrigation system used for an alternative crop would differ from what is currently used for cranberry production due to the unique limitations of the soil. Each of the

agricultural fields is predominately Freetown muck. This type of soil has low structural stability and considerably limited bearing capacity (capacity of soil to support the loads applied to the ground), especially when wet. Therefore, operating the usual heavy farming equipment on this type of soil is not possible. An alternative crop requires an overhead irrigation system with a lightweight tractor with special tires for muck soil, a hose reel with over 1,000 feet of hose, a sprayer, and strategically located hydrants (**Figure 4**).

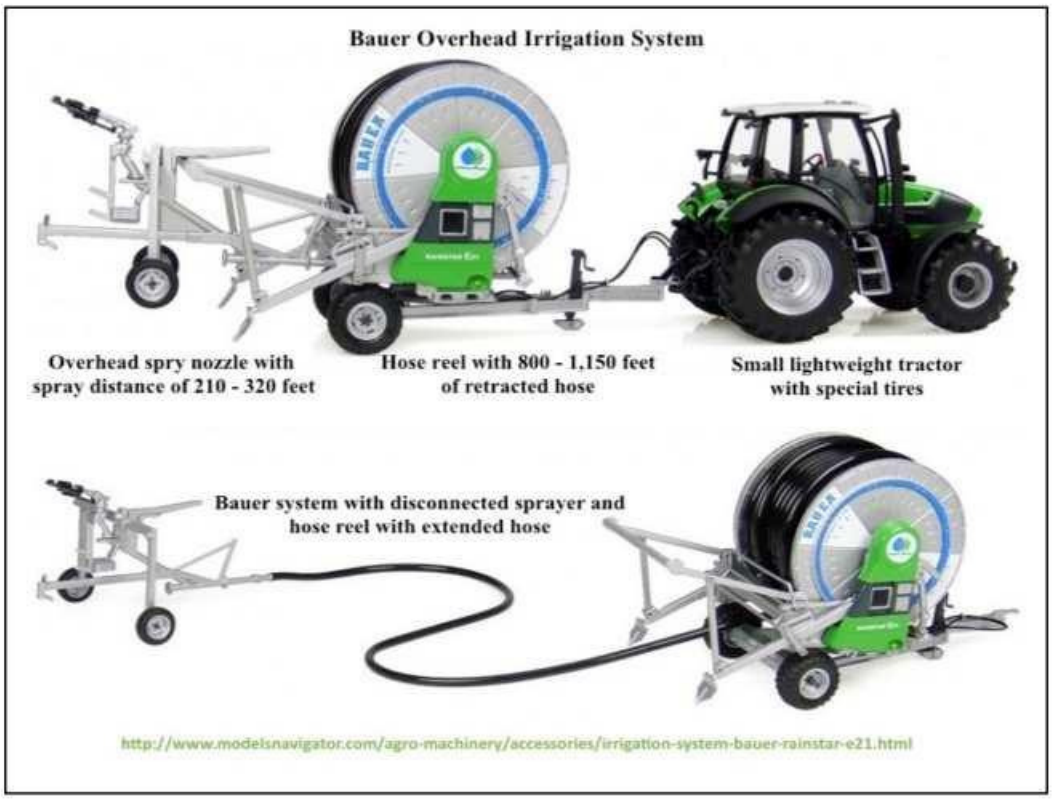


Figure 4. Specialized Overhead Irrigation Equipment (hydrants also required)[24]

Re-establishing the Wetland after Other Agricultural Use

If the economic situation shifts again, and if growing an alternative crop is no longer possible or desirable, then the town may choose to re-establish the Cranberry Bog as a wetland. Reverting to a wetland would entail removal of any irrigation and drainage equipment as well as the procedures described in either Appendix 7: Engineered Restoration or Appendix 8: Passive Restoration. Depending on the condition of the fields at the time, efforts may be needed to protect the organic soil from erosion while it is gradually re-saturated and re-populated with wetland vegetation.

Summary

Conversion of the Cranberry Bog to an alternative agricultural operation is a complex endeavor requiring a multi-year timeline, substantial costs, and professional planning and

expertise. It is not without risk to both the Town and the prospective licensee. This alternative can seem similar to rotating crops, but it is much more complicated and nuanced. Forces of nature must be recognized, quantified, and addressed if this alternative is to be undertaken successfully. Unique aspects of muck soil and the natural hydrology cannot be ignored. The hydrology is the single most limiting factor to the success of a conversion to an alternative crop or any other use.

Summary Evaluation

This list below is not prioritized or weighted in any way. The relative number of items in the pros and cons is not significant.

Pro

- Preservation of a the town's most popular conservation parcel with its open vistas
- Preservation of some or all of the town's water rights
- Licensee responsibility for maintaining the water-control structures
- Preservation of lacustrine wetlands in the form of water reservoirs for wildlife
- Continued tradition of agriculture in Carlisle
- Continued usage of the Cranberry Bog House for affordable agricultural housing
- Continued usage according to the original warrant article

Con

- Potential loss of some of the water rights
- Cost of renovation for alternative crops
- Multi-year implementation to establish an alternative crop
- Cost to the Town to maintain water-control structures and vegetation during transition
- Cost of removing irrigation and drainage systems if conversion to an alternative crop is unsuccessful
- Destruction of two fields that are currently valuable wetland habitat
- Loss of habitat for Blanding's Turtle
- Loss of passive recreation on the sand-covered field for dog owners
- Loss of bird, butterfly, bee, and wildflower habitat and corresponding activities
- The costs to the environment for the loss of a carbon sink in the form of a wetland

Special Considerations

- Balancing potentially conflicting values: Massachusetts NH&ESP has designated the Cranberry Bog as part of a priority habitat and has certified four vernal pools in this area; however, agricultural activities are exempt from NH&ESP regulatory review. Cranberries can only grow where there is an abundant supply of water. Forage crops, such as tall fescue, do not require an abundant supply of water

when they are grown on a mineral soil amended with organic matter. Therefore, the Town will need to consider both the value of continuing agricultural activities at the Cranberry Bog by growing a forage crop and the value of the priority habitat as well as the other considerations listed in this report.

- Regulatory consequences: The provisions of the Wetlands Protection Act do not pertain "to maintenance of drainage and flooding systems of cranberry bogs" or "to work performed for normal maintenance or improvement of land in agricultural use."[25] Once the Cranberry Bog does not qualify for the cranberry bog or agricultural exemptions, the provisions of the Wetland Protection Act immediately apply.

- Potential Regulatory Consequences: Alteration or removal of the flume by the Curve Street culvert may result in a review by the Massachusetts Office of Dam Safety of the Curve Street flume and culvert, also known as a "dam." The effect of a subsequent reclassification is unknown, but it may have consequential expenses.

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ALTERNATIVE 6

CREATION OF A PASSIVE RECREATION AREA

Description of Alternative 6

In this alternative, one of the bog areas would be converted into a large, open, passive recreation area. Passive recreation means organized sports that require lines on the field or other activities that would otherwise damage the grass surface are prohibited. Horses and bicycle riding may also be prohibited in the area.

The creation of a passive recreation area could involve a large number of options, leading to a wide range of costs and potential effects. In order to simplify the Town's evaluation of this alternative, just two versions of a potential recreation area are presented: one that uses clean fill and topsoil to raise the field elevation about 2 feet and one that does not add significant fill. The Town should initially evaluate this alternative on the general concept and benefits of creating a passive recreation area, on the geotechnical and hydrological feasibility of such an alteration, on the likely costs and environmental effects, and not on the particular features and layout chosen for the two versions. If this alternative is chosen, then the first step for the Town would be to hire a qualified engineering firm to talk with the stakeholders about desired features, evaluate geotechnical and hydrological aspects, prepare a detailed engineering plan, provide a reliable cost estimate, evaluate regulatory hurdles, and prepare bid documents.

Two Possible Plans

Two versions of this alternative are presented here.

Plan A uses clean fill and topsoil to raise the field elevation about 2 feet.

Plan B does not add significant fill.

For both Plans, the Sand-Covered Bog (4.5 acres) was chosen for the example of a created, passive recreation area because it is near parking areas, is of modest size, and is already a reasonably flat and accessible piece of land. The location of this bog is shown in Section 1: Figure 1. A photograph is shown in Section 1: Figure 2c. Two additional photographs of its condition in October 2016 are shown in **Figures 1 and 2**.

The proposed features to be created are as follows (**Figure 3**).

- A central, grass-covered field on a smoothed and leveled surface. This area is intended for passive recreation.
- For Plan A: A surface that has been raised about 2 feet (1.5 feet clean fill, 0.5 foot topsoil) above the current level to provide 1) a firmer base than the existing base, 2) a field less prone to puddling and flooding than the current field, and 3) a better soil than the current soil for the added plantings, including grass.
- For Plan B: No clean fill would be added to raise the level of the field, but small amounts of fill would be added on the few edge locations where bushes were to be planted.

Figure 1. View to the North East of Sand-Covered Bog – October 2016
(Photo by W. Lyman)

Figure 2. View to the North West of Sand-Covered Bog – October 2016
(Photo by W. Lyman)

Figure 3. Schematic of Passive Recreation Area

- A stone-dust pathway that goes around inside the perimeter of the bog that is suitable for walking and wheelchairs. The pathway will also go up an earthen ramp to the level of Curve Street and lead to a handicapped parking area for two cars. The path will also extend to the north to connect with the service road and path on the south side of the In-Renovation Bog.
- Two benches (cedar or granite bocks) and a picnic table
- A selection of new plantings consisting of low bushes, high bushes (e.g., highbush blueberry), wetland plants, and perennials
- Erosion protection where River Meadow Brook enters the sand-covered bog

This passive recreation area could be used for walking, dog walking, wheel-chair rides, picnics, and open-field activities such as ball playing, Frisbee playing, kite flying, and – if allowed by the Conservation Commission (ConsCom) – model airplane or drone flying. If blueberries are planted around the edges, blueberries could be picked in season.

Once constructed, the recreational area would require routine maintenance in the snow-free months. The maintenance would include seasonal lawn mowing, annual bush pruning, occasional pathway maintenance, and other miscellaneous repairs. The mowing could be done by Carlisle's Department of Public Works (DPW) or contracted out. Other maintenance activities would likely be carried out by the DPW. Because the area is on conservation land, coordination of the maintenance work would be the responsibility of ConsCom, and any contracted work would have to come from the ConsCom budget.

Creating the proposed recreational area would take about one year. During that time, the significant construction activity at the site would require appropriate safety measures to protect people and animals and environmental protection measures, such as erosion control.

Project Costs

An initial engineering study would cost about $30,000 for Plan A and perhaps only $25,000 for Plan B. The purpose of the study would be to talk with the stakeholders about desired features, prepare a detailed engineering plan, provide a reliable cost estimate, evaluate regulatory hurdles, and prepare bid documents. (The Cranberry Bog Alternatives Committee acknowledges the substantial help from Dwight DeMay, landscape architect, in preparing the cost estimates in this section.)

Plan A

The estimated construction costs for the Plan A recreation area described in Section 2 are shown in **Table 1**. The assumptions used in deriving the costs are listed both in the body of the table and in the notes below the table. The total construction cost is $382,000. Various excluded items are listed below the table notes. The total for the engineering study and construction costs is $412,000. Grant funds, such as those from Carlisle's Community Preservation Act funds, could possibly pay for a portion of this project.

Table 1. Budgetary Estimate for the Creation of a Passive Recreation Area – Plan A[a]

Item[b]	Quantity	Unit	Unit Cost ($)	Total Cost ($)
1. Erosion control	1,000	LF	7	7,000
2. Install drain tile	4	AC	1,500	6,000
3. Import, place, and compact clean fill to raise grade	9,680	CY	14	135,000
4. Import and place fine-grade topsoil	3,227	CY	30	96,800
5. Pathway with surface of stabilized stone dust	4,000	SF	3	12,000
6. Picnic table with benches	1	EA	500	500
7. Bench	2	EA	300	600
8. Parking area for 2 cars, ADA compliant	400	SF	3	1,200
9. Landscaping:				
• Grass (mowable), hydroseeded on graded topsoil	130,680	SF	0.30	39,200
• Shrub mix (height 2 to 3 feet)	100	EA	20	2,000
• Shrub (e.g., highbush blueberry)	20	EA	40	800
• Native plantings (e.g., wetland plants, perennials)	50	EA	10	500
	Sub Total			**301,600**
10. Contractor general conditions and insurance (10% of Sub Total)				30,200
	Sub Total			**331,800**
11. Contingency (15% of Sub Total)				49,800
	Total			**381,600**

Units: LF = linear foot; AC = acre; CY = cubic yard; SF = square foot; EA = each

[a] Excluding initial engineering study and plan preparation.

[b] Notes and assumptions for each item:

1. Assumed quantity; includes, for example, hay bales and riprap opposite brook entrance to recreation area
2. Hydrogeologist to confirm existing soil conditions
3. Assume 1.5 foot average import; assume 4 acre area
4. Assume 6 inch depth and 4 acre area
5. Assume 8 foot width and 500 foot length, ADA accessible, no polymer binder
6. Assume cedar
7. Assume cedar or granite block
8. Assume 400 SF
9. Assumed quantities. For hydroseeded area, includes tackifier and subsequent fertilizer; no irrigation; native and native-compatible mix of grass seeds.

Exclusions:

New gates or traffic control
New signage or information kiosks
Maintenance after construction
Escalation contingency
Additional site amenities
Obtaining jurisdictional approvals

Annual maintenance costs will depend on many factors, but a conservative number is about $2,000 per year. The biggest expense would be mowing. If the Town's DPW mows, the labor costs about $30 per hour. (Personal communication from Tim Goddard, Town Administrator. Number includes salary and benefits.) If the $2,000 was used only for labor, it would cover about two hours of DPW time per week during a 30-week maintenance season. Equipment costs would add to the total maintenance costs.

Plan B

The estimated construction costs for Plan B, shown in **Table 2**, are derived from Table 1 by subtracting the costs for clean fill and topsoil (Table 1, lines 3 and 4) and making the necessary changes to lines 10 (Contractor general conditions and insurance) and 11 (Contingency). The total estimated construction costs are $88,300, substantially lower that the estimated $381,600 for Plan A.

Table 2. Budgetary Estimate for the Creation of a Passive Recreation Area – Plan B[a]

Item[b]	Quantity	Unit	Unit Cost ($)	Total Cost ($)
1. Erosion control	1,000	LF	7	7,000
2. Install drain tile	4	AC	1,500	6,000
3. Pathway with surface of stabilized stone dust	4,000	SF	3	12,000
4. Picnic table with benches	1	EA	500	500
5. Bench	2	EA	300	600
6. Parking area for 2 cars, ADA compliant	400	SF	3	1,200
7. Landscaping:				
• Grass (mowable), hydroseeded on graded soil[c]	130,680	SF	0.30	39,200
• Shrub mix (height 2 to 3 feet)	100	EA	20	2,000
• Shrub (e.g., highbush blueberry)	20	EA	40	800
• Native plantings (e.g., wetland plants, perennials)	50	EA	10	500
	Sub Total			**69,800**
8. Contractor general conditions & insurance (10%)				6,980
	Sub Total			**76,780**
9. Contingency (15%)				11,520
	Total			**88,300**

[a] Excluding initial engineering study and plan preparation.
[b] See Table 1 for units' definitions and assumptions for each item and for exclusions.
[c] An organic soil amendment will likely be required with, or before, seeding.

Regulatory Requirements and Concerns

No rigorous assessment has been made of the regulatory requirements for the construction of a passive recreational area on conservation land, including conservation land in agriculture. The proposed initial engineering study would provide the details needed and involve the following.

Wetlands Protection Act

The Sand-Covered Bog is in the 100-year floodplain, and activity in such areas is controlled by the Wetland Protection Act (WPA). A Notice of Intent will have to be submitted to Carlisle's Conservation Commission (ConsCom), and the project may subsequently be limited by orders of conditions issued by ConsCom.

Article 97 of the Massachusetts Constitution

Article 97 of the Massachusetts Constitution states that "Lands and easements taken or acquired for such purposes [e.g., conservation] shall not be used for other purposes or otherwise disposed of except by laws enacted by a two thirds vote, taken by yeas and nays, of each branch of the general court." Both the 1986 Town Meeting vote by Carlisle residents to purchase the Cranberry Bog and the subsequent registration of the new deed mention both conservation and recreation as the allowed uses of the land the Town purchased. As documented in Appendix A of this report, the Cranberry Bog Conservation Land is used for recreation by a large number of people and has been used for recreation since its purchase by the Town. Thus, the creation of a passive recreation area on one portion of the bog would not involve a significant change in use.

Natural Heritage

The Massachusetts Endangered Species Act (MESA) protects rare species and their habitats by prohibiting, in areas where rare species are known to be present, a number of actions including those which could lead to the modification, degradation, or destruction of the rare species habitat. The Cranberry Bog and a large area around it has been designated a Priority Habitat of Rare Species (PH 670) by the MEPA program, and thus the proposed creation of a recreational area will have to be reviewed by them.

Americans with Disabilities Act

The proposed pathway in the new recreation area would allow use by individuals in wheelchairs and pedestrians. As such, the design and construction of the pathway and the connected handicapped parking spaces on Curve Street should comply with regulations and design standards of the Americans with Disabilities Act (ADA). Details are provided at www.ADA.gov.

Others

Because construction activities will take place in close proximity to a water body (River Meadow Brook) and within the 100-year flood plain, reviews, permits, or both will likely be required by other agencies such as the following.

- US Army Corps of Engineers (US Clean Water Act)
- MA Department of Environmental Protection (Chapter 91: Waterway Protection and Federal Water Pollution Control Act)
- Possibly others (see, for example, Table 1 in Appendix 7)

Summary Evaluation

Relative to the general evaluation criteria listed in Section 3 of the Main Report and other considerations, the following pros and cons of this alternative follow.

Pro

- This alternative lets the land remain as open space with full public access.
- This alternative enhances the recreational value of 4.5 acres of the bog. It provides a pathway and grassy field for easy walking and passive recreation. The grassy field provides opportunities for a variety of recreational activities. Low-height landscaping will enhance nearby visual effects while avoiding any effect on longer views by having no tree plantings. Blueberry picking can happen in August if blueberry plants are added.
- It potentially provides an area for community activities and public service (e.g., maintenance).
- The handicapped-accessible parking and pathway will provide recreational opportunities for wheelchair-dependent individuals.
- If Plan A is chosen, the likelihood of puddling or flooding in the grassy field (common at present) will be reduced by raising the level of the field with clean fill and topsoil.

Con

- A large capital investment (more than $400,000 for Plan A and more than $100,000 for Plan B, including the engineering study) would be required to create the recreational area as described.
- Annual maintenance for the recreational area would cost about $2,000 per year.
- Regulatory constraints may severely restrict what work can be done in the bog. If filling is not allowed, Plan A will be abandoned.
- If agriculture was not preserved on this portion of the bog, state-registered water rights would be lost.
- Wildlife habitat (e.g., for Killdeer and turtles) would be lost or altered.
- The classification of dams might change, and altering the dams would cost money.

ALTERNATIVE 7

ENGINEERED RESTORATION TO A NATURAL HABITAT

Description of Alternative 7

This alternative involves the use of earth-moving equipment to alter the topography of any or all of the three bog areas in a manner that restores wetland conditions, close to what were there originally. It was a popular grazing meadow and marsh along River Meadow Brook before the land was converted to a cranberry bog around 1903, according to Carlisle's Baseline Assessment for the Cranberry Bog.[1] The alteration of topography under this alternative can range from quite aggressive, such as when dams are breached and streams rerouted, to fairly passive, such as when the only activities are plugging the drainage ditches and roughening the surface of the bog leaving pits and mounds (also called hummocks and hollows). If this surface roughening is done by turning over large clods of soil bound with cranberry vines, then fresh soil is exposed on which new, non-cranberry plants can establish themselves. Which approach is used depends on the site history (e.g., how much sand was added over the years), other engineering factors, the owner's wishes, and cost. The presence of beavers can be a confounding factor because they may have their own plans in mind.

If this alternative is chosen for any bog area, an initial step would be a site study by a qualified engineering company. The study should look at such things as existing soils and their properties, local hydrology (including depth to groundwater), the benefits of an aggressive vs. passive restoration, restoration design details, effects of restoration on the local hydrology, permits required, and likely costs. Potential effects on Chelmsford's Cranberry Bog Reservation should be evaluated.

The Massachusetts Department of Fish and Game, Division of Ecological Restoration (DFG/DER), has undertaken two projects in the State to restore abandoned cranberry bogs.[2] The focus of the restoration on these sites to date has been to make them "wet" again, that is, to overcome the drying of the ground surface caused by the historic application of sand and the loss of water to the drainage ditches. When this restoration is successful, the ground is again saturated and tends to limit succession by trees and maintain open spaces and vistas. Removal of the accumulated sand in the bog is not considered an option because of the excessive cost and the presence of pesticide residuals. Following surface roughening in the DFG/DER projects, the State has usually let nature take care of future plant growth. The native seed bank has responded extremely well to restored soil moisture. In a few cases, the Division has added some supplemental plantings to increase biological diversity.

The time required to complete restoration of a bog to a natural habitat is about three years. **Figures 1 and 2** show the bog surface after roughening, and **Figures 3 and 4** show

Figure 1. The micro-topography of the Tidmarsh Farms bog after the disturbance of the bog surface. (Photo curtesy of Massachusetts Division of Ecological Restoration)

Figure 2. The topography of the Tidmarsh Farms bog over a larger scale than shown in Figure 1 after the disturbance of the bog surface. (Photo curtesy of Massachusetts Division of Ecological Restoration)

Figure 3. The restoration of the Tidmarsh Farms bog after the regrowth of vegetation. (Photo curtesy of Massachusetts Division of Ecological Restoration.)

Figure 4. The restoration of the Tidmarsh Farms bog after the regrowth of vegetation and the addition of dead wood. (Photo curtesy of Massachusetts Division of Ecological Restoration)

portions of the completed restoration with initial plant growth. Any restoration at Carlisle's cranberry bog would presumably preserve all current trails and add pedestrian bridges in any area where a dam was purposefully breached as part of the restoration process.

Restoration of the Eel River Headwaters in Plymouth, Massachusetts[3]

In 2006, Plymouth purchased 60 acres of land in the Eel River watershed containing 40 acres of abandoned cranberry bogs. Its decision to undertake an engineered restoration of the property was based on the following goals.

- Improve biological diversity (including rare wetland communities) in the headwaters area and improve ecological resilience
- Promote a healthy cold-water fishery
- Improve water quality, especially in the receiving waters of the downstream harbor, by retaining nutrients, sediments, and contaminants
- Provide the public with recreational and educational opportunities
- Provide an expanded area of wildlife habitat by connecting with abutting conservation lands

This project restored 40 acres of cranberry bogs, removed a dam, reconstructed over 1.75 miles of stream, replaced two culverts at road crossings, built a footbridge for the trail network, planted 17,000 Atlantic white cedar trees, planted other trees, shrubs, and herbs, and incorporated hundreds of large pieces of dead tree limbs or tree trunks to create in-stream habitat. The project cost $1.9 million dollars. Federal and State grants supplied $1.75 million dollars of the funding needed excluding the purchase of the property, which was paid for with funds from the Community Preservation Act. The engineering company chosen for design, permitting, and construction oversight was Inter-Fluve, Inc., which has a local office in Cambridge, Massachusetts. The engineering fee for the Eel River project was estimated to be $50,000 to 70,000 dollars. The Town of Plymouth was very pleased with its work. Plymouth has used Milone and MacBroom, with an office in Springfield, Massachusetts, for other environmental engineering jobs.

Initially, following completion of the restoration in 2010, Plymouth had a problem with the growth of invasive plants, which were controlled through volunteer efforts. The Town has had no other post-project maintenance problems and does not plan any maintenance except for trails.

Which Bogs Can be Restored?

Any or all three of the bog areas could be restored to a natural habitat. However, the Irrigated Bog might prove to be the most difficult, not only because of its size, but also because of the thick coverage of the soil with cranberry vines.

Of the two remaining bog areas, the Bog In Renovation would be the most likely candidate for restoration because it is sufficiently wet and appears to have little or no appreciable surface sand. In addition, it might be the hardest to convert to other uses. If this bog area were chosen for restoration, then breaching the upstream dam (Cranberry

Bog Dam #1), probably in two locations, and integrating the wetlands above the dam with the restored wetlands (former bog) below the dam should be seriously considered. Bridges could be built over the two breaches to maintain the trail that currently runs between these two areas.

The Sand-Covered Bog can likely be restored, but it has a significant layer of surface sand, which, even after being disturbed, might support only less diverse vegetation growth, primarily grasses.

Estimates of Restoration Costs

Based on information obtained from the DFG/DER[4], restoration costs are estimated as follows.

- Phase I – Assessment, Design, and Permitting: $100,000
- Phase II – Implementation: $10,000 to $20,000 per acre

Using this information, the total costs for restoration of different bog areas are as follows.

- All three bog areas (36 acres): $460,000 to $820,000
- Bog In Renovation only (13.5 acres): $235,000 to $370,000

A DFG/DER representative had separately estimated that restoration of the whole (36 acre) bog area would cost about $500,000, excluding any costs related to the Curve Street dam.[5] These estimated costs do not take into consideration the possibility of grants or cost sharing, which would lower the costs to the Town. (See Section 6: Technical Assistance and Cost-Sharing Opportunities.)

Regulatory Requirements

The regulatory and permitting requirements of a bog restoration have not been independently researched. They are expected, however, to be substantial. A listing of the permitting requirements encountered by the Town of Plymouth for restoration of the Eel River Headwaters is shown in **Table 1**. Phase I (Assessment, Design, and Permitting) of any restoration must identify the specific permits required.

Technical Assistance and Cost Sharing Opportunities

At a minimum, the Town can rely on some technical assistance from the Massachusetts DFG/DER at no cost. In addition, every 2 to 3 years, this agency issues a competitive RFP for entities to propose restoration projects which, if selected, would receive more substantial technical and financial help. One new such Priority Projects Program was recently started (summer 2016). Financial assistance in this program is on the order of $10,000 to $40,000.

Table 1. Permitting Requirements Encountered by the Town of Plymouth, Massachusetts, for the Restoration of the Eel River Headwaters

Permit	Agency
Massachusetts Environmental Policy Act (Environmental Notification Form)	MA Energy and Environmental Affairs
Notice of Intent	Local Conservation, Department of Environmental Protection
Clean water Act, Section 404	US Army Corps of Engineers
National Environmental Policy Act	Environmental Protection Agency
Federal Water Pollution Control Act, Section 401: Water Quality Cert	Department of Environmental Protection
National Historic Preservation Act, Project Notification Form Section 106	MA Historic Commission
National Pollution Discharge Elimination System	Environmental Protection Agency
Dam Safety Permit	Department of Conservation and Recreation, Office of Dam Safety
Turtle Enhancement and Construction Plan	Natural Heritage and Endangered Species Program
Chapter 91: Waterway Protection	Department of Environmental Protection

Source: http://www.plymouth-ma.gov/sites/plymouthma/files/uploads/projects_headwaters7.pdf

Other programs to be investigated for technical and financial help are the following.

- United States Department of Agriculture (USDA), Natural Resources Conservation Services (NRCS) – Agricultural Conservation Easement Program (ACEP)[6]: (This program replaces the USDA Wetland Reserve Program, which was ended by the US Agricultural Act of 2014.) This NRCS-administered program provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps American Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easement Partnership (WREP) component, NRCS helps to restore, protect, and enhance enrolled wetlands. Under the new law, the WREP continues to be a voluntary program through which NRCS signs agreements with eligible partners to leverage resources to carry out high-priority wetland protection, restoration, and enhancement and to improve wildlife habitat. An initial $15 million was made available by the NRCS for financial and technical assistance. Proposals were due by May 16, 2016. It is not known how much funding will be available in future years.
- Mass Wildlife Habitat Management Grant Program[7]: This program provides funds for habitat restoration and management and recreational opportunities, for both public and private lands. Applicants are eligible to receive between $10,000 and $50,000 per grant towards their approved habitat management project. Applications for grant funds are typically requested in the fall of each year.

- Massachusetts Environmental Trust (MET)[8]: MET is a grant program within the Executive Office of Energy and Environmental Affairs. Its mission is to support projects that present innovative approaches to protect and restore natural resources. Funded through the sale of environmental license plates and legal settlements, MET is one of the largest sources of grant funds for water resources in the Commonwealth of Massachusetts. Awards are typically in the range of $5,000 to $100,000. Non-profits and municipalities are most commonly funded. Deadlines for letters of inquiry or proposals are variable and depend on the specific program providing the funds.
- Carlisle's Community Preservation Act (CPA) Funds[9]: Through a 2% surcharge on property taxes, the Town of Carlisle raises funds that, with Town Meeting approval, can be used for open-space protection (including expanded use for outdoor recreation), historic preservation, and affordable housing. CPA annual revenues in recent years have been on the order of $500,000. Grants are made to groups that have submitted acceptable and approved proposals in amounts that depend, in part, on the funding available in the listed categories. Individual grants in the past have ranged from a few thousand dollars to a few hundred thousand dollars.

Maintenance Requirements

The creation of a restored wetland area should not, by design, involve the need for on-going maintenance. The wetland areas will be difficult, and perhaps dangerous, to traverse by foot or vehicle. Nevertheless, the loss of agriculture associated with bog restoration means the loss of maintenance that was previously undertaken by the bog farmer. On-going maintenance that might be required occasionally could include, for example, edge mowing, tree removal at the edge or the interior, dam repair, and control of invasive plants.

Summary Evaluation

Relative to the general evaluation criteria listed in Section 3 of the Main Report and other considerations, the following pros and cons of this alternative follow.

Pro

- The restoration creates a significant area of more diverse, natural wildlife habitat in the former bog area(s) chosen. Absent the restoration, the bog area(s) would provide relatively poor wildlife habitat for many decades.
- The restoration, by encouraging wetland and marsh habitat, will discourage the growth of trees, which would eventually block the valued vistas across the bogs. In addition, the existing trails will be maintained with new bridges built as necessary to span any dam breaches that were part of the restoration.

Con

- The restoration will require a substantial capital investment by the Town, on the order of hundreds of thousands of dollars, only part of which might be covered by grants or cost-sharing programs.
- The Town would have to pay for edge maintenance around the restored areas, e.g., mowing, tree removal, dam repair, and control of invasive plants. Maintenance within the restored area, a wetland, is unlikely except, perhaps, for occasional tree removal.
- This alternative involves major regulatory constraints and permits, which could lead to project impediments and delays.
- A bog restoration is expected to take about three years, which is not a serious problem.
- This alternative could affect dam classification, with the loss of the ability to dam water in the restored area.

References

1. Baseline Assessment for the Cranberry Bog, prepared by the Land Stewardship Committee, a subcommittee of the Carlisle Conservation Commission, March 2007, revised June 2007. Report is available on the Town's web site.
2. (a) The Eel River Headwaters Restoration Project (Plymouth, MA), completed in 2010, which included the restoration to native wetland habitat of approximately 40 acres of abandoned cranberry bogs. See: http://www.plymouth-ma.gov/sites/plymouthma/files/uploads/projects_headwaters7.pdf; (b) Tidmarsh Farms with the ongoing restoration of 250 acres of recently retired cranberry bogs and supporting upland grassland and forest in the southeastern part of the state. See: http://www.livingobservatory.org and https://www.fws.gov/coastal/coastalgrants/tidmarshFarmsRestorationProject.html.
3. Most of the information in this section came from a personal communication to W. Lyman from Kim Tower, Environmental Technician, Town of Plymouth, MA on August 11, 2016. Additional information comes from references in 2(a).
4. Personal communication to W. Lyman from Alex Hackman, DFG/DER, Boston, MA, July 28, 216.
5. Personal communication to W. Lyman from Alex Hackman, DFG/DER, Boston, MA, Dec. 4, 2015.
6. USDA – Agricultural Conservation Easement Program (ACEP): See:
7. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/acep/?cid=stelprdb1242695.
8. Mass Wildlife Habitat Management Grant Program: See: http://www.mass.gov/eea/agencies/dfg/dfw/wildlife-habitat-conservation/habitat-grant.html
9. Massachusetts Environmental Trust: See: http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/mass-enviro-trust/
10. Carlisle's Community Preservation Plan: See: http://www.carlislema.gov/Pages/CarlisleMA_CPA/Community%20Preservation%20Plan%20draft%2012-3-15.pdf

ALTERNATIVE 8

PASSIVE RESTORATION TO A NATURAL HABITAT

Description of Alternative 8

This alternative simply involves abandoning the chosen cranberry bog areas. No action is taken to assist natural restoration to a wildlife habitat, and thus no direct costs are involved.

Discussion

For years the US cranberry industry, especially for older, smaller bogs in Massachusetts, has been experiencing economic difficulties due to expanding production in different areas, insufficient consumption, and thus lower prices. Hundreds of cranberry bogs in the Commonwealth have been abandoned. In 1997, for example, a study by Camp, Dresser, & McKee documented the locations of 537 abandoned cranberry bogs in 41 Massachusetts municipalities in Barnstable, Bristol, and Plymouth Counties.[1] Abandonment has likely continued in the subsequent 20 years.

Although this alternative is attractive because of no direct cost, three negative factors should be considered.

- The quality and diversity of wildlife habitat remains relatively poor for many years. For cranberry bogs that were recently in production, simple bog abandonment leaves the cranberry-vine-laden soil in place, and the cranberry monoculture remains in place for many years, e.g., a decade. (This is further discussed below.) For bogs that have been in renovation for long periods, the cranberry monoculture probably no longer exits, but other factors, including the presence of upland with its relatively dry topsoil will be a negative factor. Both situations provide relatively poor habitat for wildlife.
- Bogs that still have their drainage ditches provide better upland habitat for bushes and trees to grow, affecting vistas.
- The Agricultural Exemption of the Wetlands Protection Act (WPA) will be lost, which means that any activity normally allowed for agricultural lands will now require review by the Conservation Commission and the issuance of Orders of Condition, with possible limitations on the work. (See Alternative 1: No Action.)

An interesting study of new, non-cranberry-plant growth in abandoned cranberry bogs was undertaken by Genevieve Noyce in 2007.[2] She looked at 14 abandoned bogs and two active ones, all in southeastern Massachusetts, to create a time sequence of more than 70 years of new plant growth. She focused her field studies on tree and shrub cover and on the biogeochemical characteristics of the bog soils. She summarized her findings as follows.

> "After abandonment, shrub and tree species increased significantly in diversity, density and cover, but the vegetation in the oldest abandoned bogs was different from oak forests in species composition and richness…. There was no trend between water table depth and the presence of trees or their growth rates."[1]

Noyce also reported the following.

- The soil acidity in the bogs ranged from 4.2 to 6.
- In general, the species diversity was low.
- The surface soils commonly contained layers of sand and organic matter.
- The amount of carbon in the soils increases with time from abandonment.
- Herbicides and pesticides were found in the soils.
- Cranberries remained the dominant species in the first decade after abandonment.
- After a decade, cranberries provided a minority of the cover, with shrubs and trees dominating. Some bogs progressed to shrub swamps.
- Older bogs have more shrubs than trees.
- A lower water table leads to a greater mass of shrubs and trees.
- Tree growth may be limited in water-saturated soils (except possibly for red maple).

Besides Carlisle's own cranberry bogs, one other local example of an abandoned cranberry bog exists alongside Route 129 in nearby Wilmington, Massachusetts. **Figures 1 and 2** provide a recent aerial view and a recent street-level view, respectively, of this bog, which was abandoned in the 1970s. The aerial view in Figure 1 shows the continuing existence of drainage ditches, which helps maintain a less saturated surface soil layer within the bog. The aerial also shows fairly large areas of the bog covered by bushes or other tall plants, including trees. The street-level view in Figure 2 shows the plant growth that can be seen from Route 129; it includes purple loosestrife, cattails, and what is thought to be silver maple. Finally, **Figure 3** shows a view of a former service road alongside the abandoned bog, which is on the left in the photo. The growth of trees and bushes has nearly obliterated the view of the bog.

Two photographs of our own Bog in Renovation are shown in **Figures 4 and 5**. Both photos show significant shrub growth (i.e. high bush and low bush blueberry, bayberry, buttonbush, northern maleberry, and invasive glossy buckthorn) in the bog and some tree growth (i.e. speckled alder, red maple, gray birch, white pine) with saplings in the bog field sections and small trees along the edges and ditches. The height of these shrubs and trees is already starting to restrict the vistas across the bog. If our own Sand-Covered Bog is abandoned, it would initially have a different assortment of plant species growing after abandonment than the assortment in the Wilmington bog because of the more frequent and aggressive herbicide treatments of the field and significant depth of sand in the surface soil layer.

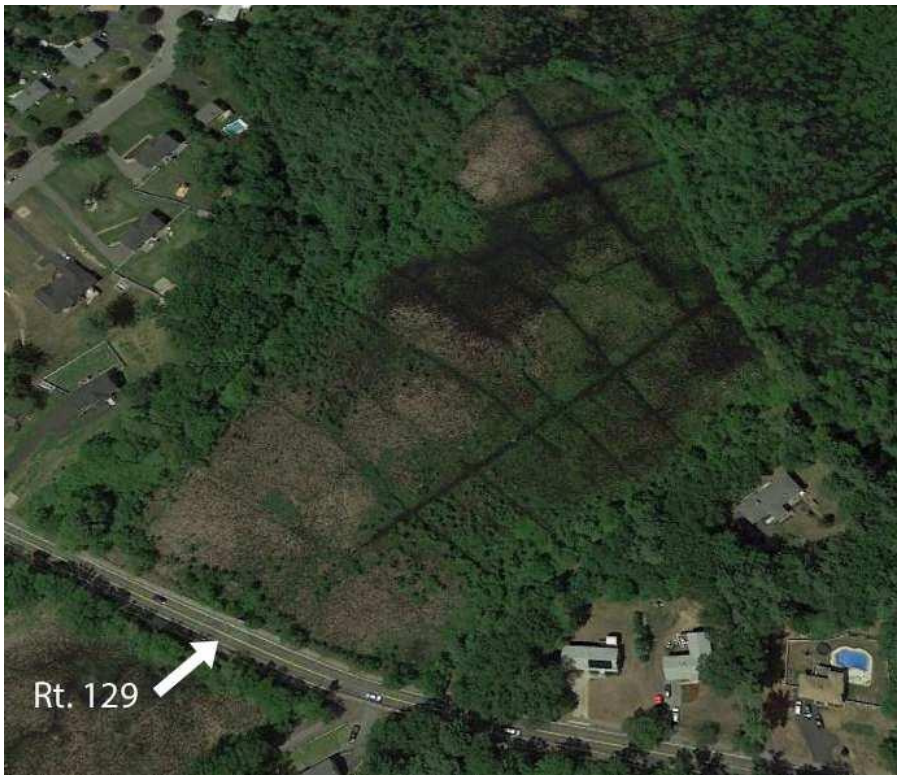

Figure 1. Aerial view of the abandoned cranberry bog in Wilmington, Massachusetts, in June 2015. The bog was abandoned in the 1970s after purchase by the Town. (Photo by Google Earth)

Figure 2. Street-level view of the abandoned Wilmington bog from Rt. 129, looking north east. The bog is nearly universally vegetated with purple loosestrife, cat tails, and what looked like silver maple saplings. (Photo by S. Willard, July 2016.)

Figure 3. Former service road (now trail) alongside the abandoned Wilmington, Massachusetts cranberry bog, which is to the left in the photo. The vista across the bog has been lost. (Photo by S. Willard)

Figure 4. Tree and shrub growth seen on the "Bog in Renovation" portion of Carlisle's Cranberry Bog, in August 2016 (Photo by W. Lyman)

Figure 5. Shrub growth seen on the "Bog in Renovation" portion of Carlisle's Cranberry Bog, in August 2016 (Photo by W. Lyman)

The species initially expected, primarily graminoids (grasses, sedges, and rushes), mosses (sphagnum, haircap, and British soldiers), and other herbaceous plants (i.e., purple loosestrife, Joe pye weed, milkweed, and ragweed), would progress to include wetland shrubs (i.e. buttonbush, northern maleberry, high-bush blueberry) and eventually moisture-loving trees that like well-drained soils (red maple, white pine). (See Alternative 5 and Appendix D.) The Sand-Covered Bog would ultimately evolve to be similar to the Bog in Renovation because of the buildup over time of deposited organic material from the vegetation that will be incorporated into the sand via bioturbation combined with seeds from the plants in the Bog in Renovation and surrounding areas. The hydrologic cycle of this field is probably similar to the Bog in Renovation field, which will influence the plant succession accordingly.

Restoration Costs

Although no direct costs are associated with bog abandonment, possible are indirect costs related to subsequent requests to maintain vistas across the bog, to deal with beaver activity, or to deal with dams that are no longer needed or allowed when the agricultural use of the land is abandoned. Any work in areas covered by the Wetlands Protection Act could involve costs related to engineering services and would require, following submittal of a WPA-mandated Notice of Intent to the Conservation Commission, limitations or restrictions on the work. The amount of such costs are not estimated here but are probably not substantial.

Regulatory Requirements

Abandoning a bog involves no regulatory requirements nor permits to be obtained. However, the abandonment of a bog may change the regulatory status of any abutting dams that were previously considered to have an agricultural purpose. The

Commonwealth could require that the stoplog structures be removed so water could no longer be purposefully impounded. (According to Wikipedia, stoplogs are hydraulic control elements that are used in floodgates to adjust the water level or flow rate in a river, canal, or reservoir.) In addition, when an "in renovation" cranberry bog is officially abandoned, the Town should inform the Commonwealth, which is then obliged to eliminate the Town's registered water rights associated with the bog(s) in question. These water rights, granted in connection with cranberry production, are allowed by the Water Management Act (Massachusetts General Laws, Chapter 21G; passed in 1985); re-registration is required every 10 years.

Summary Evaluation

Relative to the evaluation criteria for alternatives and plans described in Section 3 of the main report, the following qualitative judgements are made for four criteria.

Pro

- The abandoned bogs will provide wildlife habitat, and the quality and diversity of the wildlife habitat should improve over time, which could take many years. However, the habitat could retain an "upland" nature – as opposed to a "wetland" nature, which probably originally existed and which would be achieved with an engineered restoration – for many decades. This wetland nature could facilitate the growth of unwanted species, e.g., trees and shrubs.
- Bog abandonment preserves the trails around the bogs as long as footbridges are built or large culverts installed at the site of any dam breach.

Con

- The excessive growth of trees and tall shrubs would restrict vistas across the abandoned bogs.
- Bog abandonment may alter dam classification and result in the need to remove the stoplogs from any adjacent dam.
- Bog abandonment would mean the loss of registered water rights and the Agricultural Exemption for all activities regulated by the Wetlands Protection Act.

References

1. Massachusetts – Abandoned Cranberry Bogs, 1997. Originator: Camp, Dresser & McKee, Inc. Publisher: Massachusetts Office of Geographic and Environmental Information (MassGIS)

2. Genevieve Noyce, "Biogeochemistry and vegetation in a cranberry bog chronosequence," Mount Holyoke College, South Hadley, MA. Prepared as part of a Semester in Environmental Science, MBL, Woods Hole, MA. December 2007. Available at: http://www.mbl.edu/ses/files/2014/09/noyce07.pdf.

ALTERNATIVE 9

INSTALLATION OF A SOLAR ELECTRIC SYSTEM

Description of Alternative 9

The idea of installing a solar electric system somewhere on the Cranberry Bog Conservation Land was brought forth from the financial need to supplement an on-going cranberry production operation, to fund the conversion of the Cranberry Bog fields to a different agricultural crop, to maintain the Cranberry Bog if a natural restoration was implemented, or any combination of these alternatives. Maintenance of the Cranberry Bog, regardless of the alternative chosen, will likely cost approximately $24,500 per year (see the Alternative 3 report). This report examines the potential location of a solar electric system; the legal, physical, financial, and environmental challenges and possible solutions; the potential organizational configurations of the solar electric system; and some of the basic costs. This report is a preliminary assessment of the potential for a solar electric system installation at the Cranberry Bog and not an in-depth technical analysis.

Potential Location of a Solar Electric System

Agricultural Fields

The three agricultural fields at the bog are open with full sun exposure. However, the utility of these fields is constrained by their hydrology and soil. Given their location within the flood plain of the River Meadow Brook, the potential for flooding requires installation and management of a drainage system, especially to handle extreme weather events to reduce potential equipment loss. These fields contain organic muck soil that has low bearing capacity, with possibly not enough soil stability for supporting the solar panels because ground-mounted solar panels are usually placed on heavy concrete foundations. (For more details on the hydrology and soil stability, refer to Alternative 5: Conversion to Other Agricultural Use). The issues of drainage and soil integrity require an assessment by a geotechnical engineer. Furthermore, the large size of the ground-mounted solar panels would obstruct views, radically alter the visual landscape, and completely change the ambience of the Cranberry Bog, one of Carlisle's most popular conservation parcels.

Sand Pit

A more likely location for a solar electric system than the agricultural fields is the Sand Pit across Curve Street from the Cranberry Bog House (**Figure 1**). The Sand Pit is a total of 18 acres that is primarily a mixed hardwood forest with wetlands and a dense understory in the center and on its eastern side, with the River Meadow Brook flowing north to south through the middle of the eastern side. On its western side, approximately 2 acres of land are cleared from the excavation of sand for cranberry production, which has lowered the elevation of this area. Curve Street borders the Sand Pit on the western side, Great Brook Farm State Park on the eastern side, Hart Farm housing development

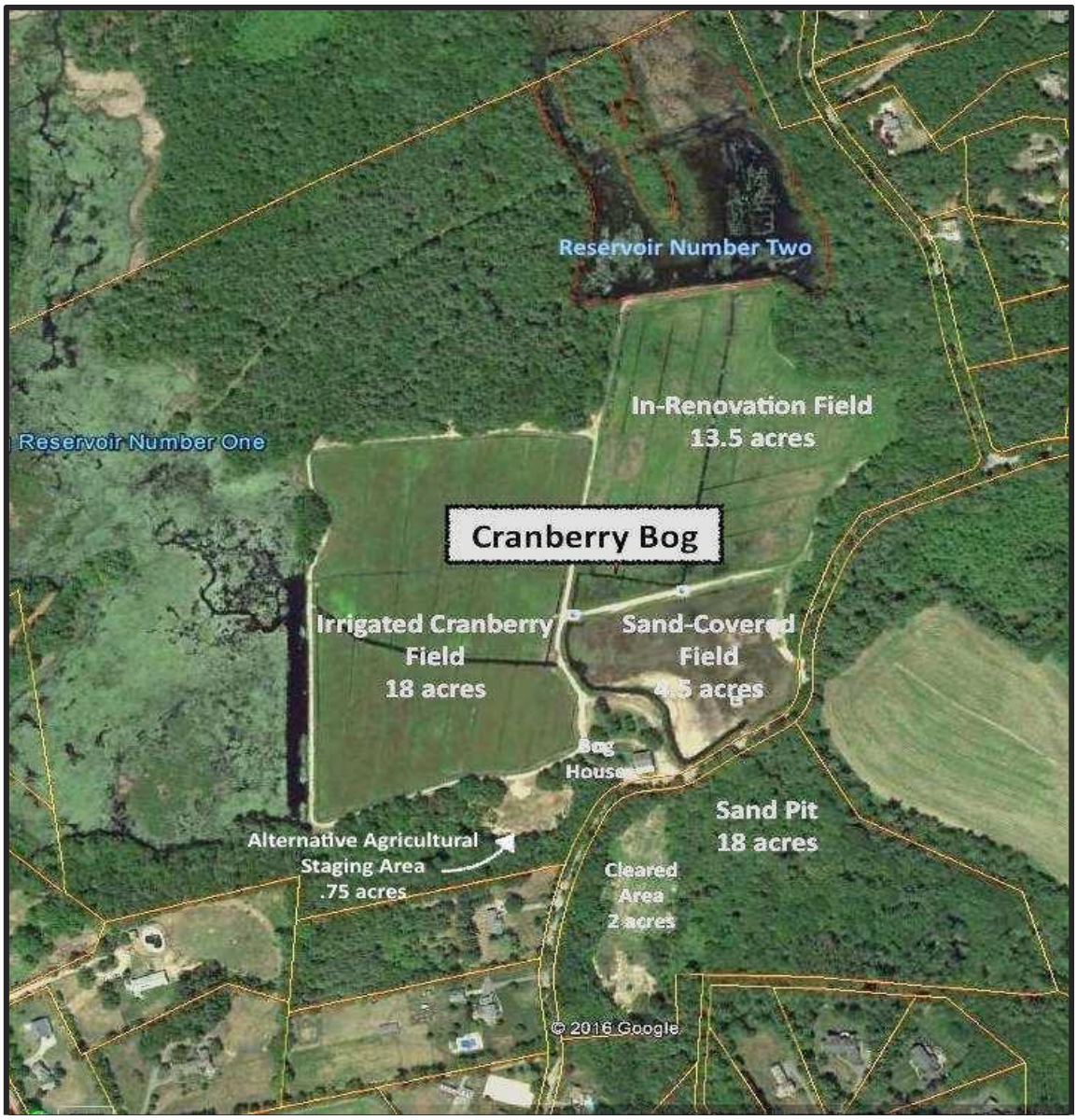

Figure 1. Features of the Cranberry Bog Conservation Land
Source: Google maps with annotation by D. Geltner

on the south, and the Cranberry Bog fields and Cranberry Bog House on the north. Houses are present to the west and south of the Sand Pit. The Light Detection and Ranging (LiDAR) maps from The Natural Resource Conservation Service (NRCS) show the elevations range from 198 feet near Curve Street on the west to 182 feet along the River Meadow Brook, rising again to 185 to 190 feet on the east side of the brook. The Sand Pit is the area considered in this report for a potential solar electric system. The entire 18 acres is considered for conversion.

Conversion Considerations for Installation of a Solar Electric System

Physical Characteristics

The Sand Pit will require multiple alterations to accommodate a solar electric system. One major consideration is the ability of the soil to support infrastructure. To obtain the most accurate bids for the solar electric system construction, the National Renewable Energy Laboratory (NREL) advises municipalities to have a professional third-party conduct tests for soil type and assess potential wind impact before issuing any requests for proposal (RFPs) for a solar installation. The design and cost of a project can be substantially affected by wind and soil conditions.[5]

The NRCS classifies the soil on the western side of the Sand Pit (about 5.94 acres) as Hinckley loamy sand (253B) that is capable of supporting structures and rapidly drains, resulting in a very low water table of approximately 6 feet. The water table, drainage, and soil type will need to be verified because the current level of the ground on the western area is 5 to 10 feet below the original grade due to the excavation of sand from this area. The past excavation has resulted in substantial banks on the west, south, and east sides of this area. The remainder of the Sand Pit is classified by the NRCS as Deerfield loamy sand (256B) located in the center (about 8.46 acres), with Scarboro mucky fine sandy loam (6A) on the far eastern corner (about 3.6 acres). The Deerfield loamy sand is also capable of supporting structures and drains moderately to rapidly, but it often has a high water table from 1.5 to 3 feet. The Scarboro mucky fine sandy loam has low soil strength and a very high water table from 0 to 0.5 feet (**Figure 2**).

The optimal soil for the solar electric system is the Hinckley loamy sand on the west side, but the lower elevation of this area relative to the surrounding areas is a concern and a benefit. The banks on the east, west, and south sides are a benefit in that they aid in obscuring the solar panels from the view from Curve Street and in protecting them from strong winds. The lower elevation, however, increases the effect of the shadows cast by trees. The lower elevation also is challenging to drain. Several options for addressing this situation follow.

- Increase the elevation, which entails the addition of a considerable amount of fill and topsoil to raise the area under the solar panels to 198 feet. This option would be very expensive and would eliminate the wind protection provided by the relatively lower elevation.
- Increase the elevation a few feet under the solar panels and grade it to drain to the east. The east bank could be excavated and used as fill for the raised solar area, assuming it has appropriate drainage characteristics. If this soil is redistributed in this manner, the eastern area could receive water from the solar array area, draining into the River Meadow Brook. The eastern area must not be excavated below the level of the 100-year flood plain. Some protection from wind would remain.

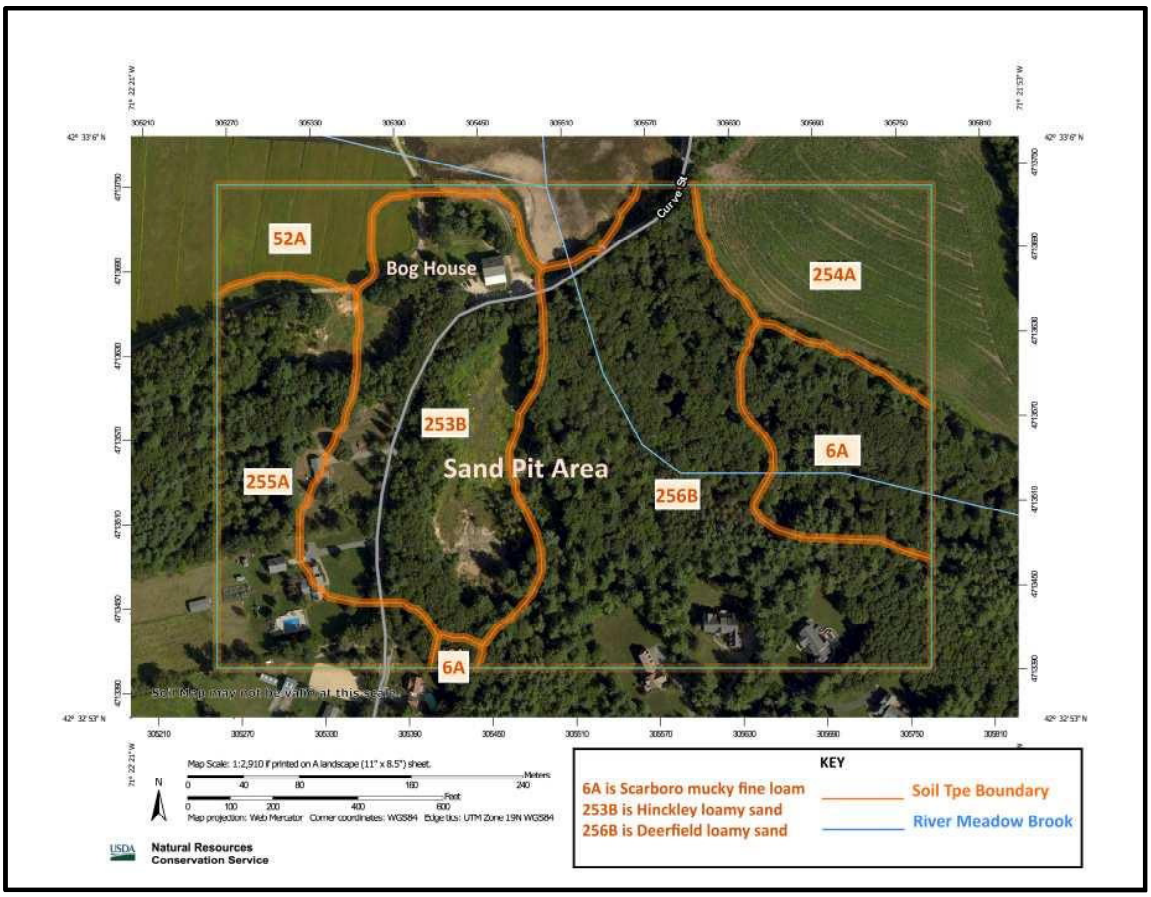

Figure 2. Cranberry Bog Sand Pit Soils on the NRCS Soil Map[6]
Source: Google maps with annotation by D. Geltner

- Do not increase the elevation under the solar panels, which would provide more wind protection than the other options. The soil still needs to be leveled, however, to even out the surface for solar panels and to ensure proper drainage of the area. The land should be graded to slope gently from the west side (190 feet) to the lower elevations of the east side near River Meadow Brook (186 to 188 feet).

If the elevation is not increased or only partially increased, the jagged steep edges of the 5-to-10-foot banks should be re-graded to lessen their steep slope and then planted to prevent erosion. The area should be surveyed to evaluate the various elevations and determine the appropriate grade to establish for drainage.

A considerable number of trees should be removed to allow ample sunlight into the area from 9 AM to 3 PM year-round and accommodate orienting the solar panels to 196º (solar south), which is approximately south-southwest. This tree removal will occur primarily on the west and south sides of the Sand Pit where the houses are located, although the very tall, mature, eastern white pines on the east side will also be removed because of the very long shadow they cast in the morning. Ideally, there should be a substantial vegetative buffer on the south and west borders to minimize the visual impact to the

surrounding residents. The solar panels would optimally be positioned more to the east and north within the cleared area of the Sand Pit with a substantial cleared buffer area surrounding it. If the Deerfield loamy sand or Scarboro mucky fine sandy loam soils are verified, then the solar panels should not be installed in these areas, but these areas can serve as part of the cleared buffer zone.

The type of soil considerably limits the location and size of the array. The environmental considerations discussed in the Environmental Aspects section (below) add further limits. The area available for a solar electric system is, consequently, approximately 2 acres of the 5.94 acres of Hinckley soil (**Figure 3**). Engineering remedies may be available to compensate for the soil restrictions, which would increase the potential area for the solar electric system.

Figure 3. Possible Location of Solar Electric System
Source: Google maps with annotation by D. Geltner

Environmental Aspects

The Sand Pit has been recently utilized for agricultural activities, but the majority of the property has been undisturbed for a long time, resulting in successional vegetation and, subsequently, an increase in wildlife diversity. An application was submitted recently to the Natural Heritage and Endangered Species Program for certification of a vernal pool in the southwestern part of the Sand Pit area (GPS Coordinates N 42 deg. 32.953 min, W 71 deg. 22.170 min). Fourteen egg masses of spotted salamanders and three egg masses of wood frogs were found in the spring of 2014[1]. Herpetologists recommend a range of 500 to 800 feet of a woodland habitat buffer to preserve the functionality of the

vernal pool for all types of salamanders and frogs; woodlands combined with marshy areas are essential for their life cycle.[2] The buffer area recommended around this vernal pool includes some of the proposed solar array area as well as abutting private property (**Figure 4**).

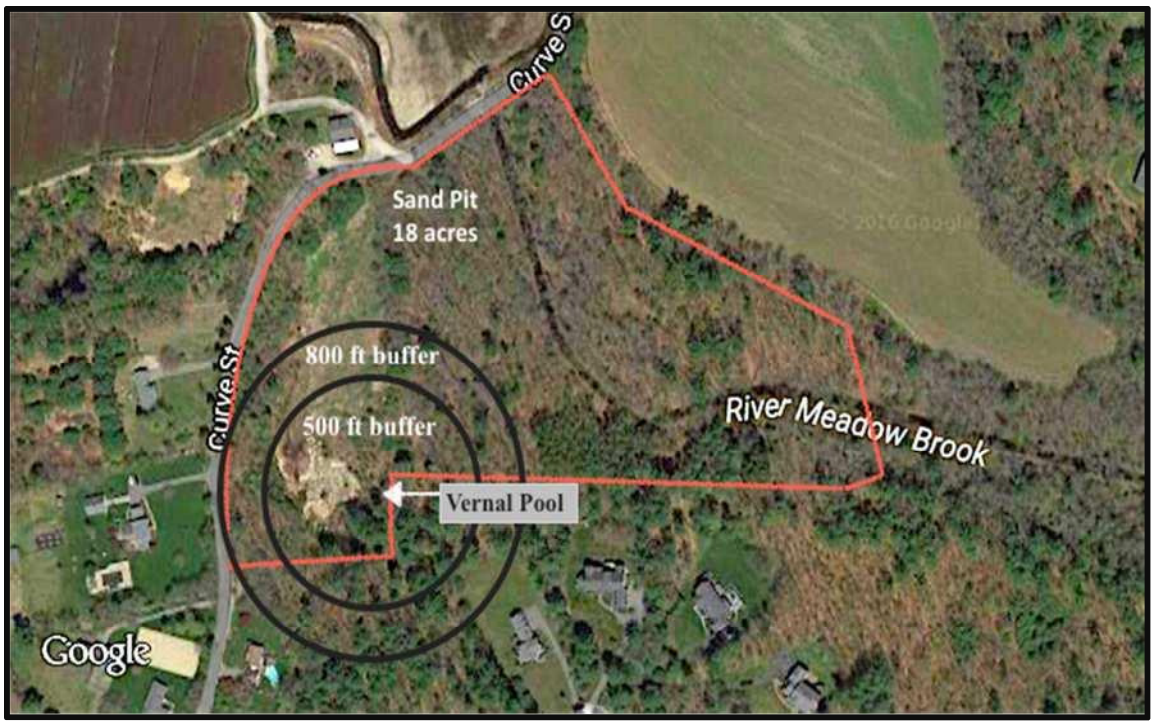

Figure 4. New Vernal Pool and Required Habitat Buffer Area
Source: Google maps with annotation by D. Geltner

Numerous mammals and birds utilize the Sand Pit's early successional habitat, with its variety of succession plants. This type of habitat provides an abundant seed-based food supply due to the predominance of annual plants, which are prolific seed producers. Successional habitat also provides good cover for ground birds and small mammals, a hunting ground for predatory birds and mammals, and breeding habitat. The Sand Pit has several water sources that further enhance the value of this habitat. The Sand Pit, along with the rest of the Cranberry Bog Conservation land, is part of a priority habitat designated by the Natural Heritage And Endangered Species Program resulting from their acceptance of a rare species report submitted to that agency.[16] The addition of a solar electric system will affect this habitat due to disruption from the construction activities, alteration of the land to accommodate the solar electric system, and the installation of a fence surrounding the array that will impede the movement of wildlife.

Regulatory Aspects

The primary constricting factor to the installation of a solar electric system at the Cranberry Bog is the Land Disposition Policy of the Energy and Environmental Affairs (EEA) to address Article 97 of the Massachusetts Constitution. On August 15, 2016, Miyares and Harrington, LLP, of 40 Grove Street, Suite 190, Wellesley, Massachusetts,

issued a legal opinion at the request of the Carlisle Conservation Commission regarding whether the installation of solar panels on any area of the Cranberry Bog conservation land would be considered disposition of land "for other purposes" (Appendix B). Their opinion on Article 97 interpretation of the phrase "for other purposes" states, ". . . it would be prudent to assume that a court would hold that installation of solar panels on the Carlisle Cranberry Bog land would be a use of the land 'for other purposes' requiring" a unanimous vote of the Carlisle Conservation Commission, a two-thirds vote of the Town, and a two-thirds vote by the Massachusetts legislature.

The Office of Energy and Environmental Affairs (EEA) also requires that a conversion "for other purposes" does not "destroy or threaten a unique or significant resource (e.g. significant habitat, rare or unusual terrain, or areas of significant public recreation), as determined by EEA and its agencies; as part of the disposition, real estate of equal or greater fair market value or value in use of proposed use, whichever is greater, and significantly greater resource value as determined by EEA and its agencies, are granted to the disposing agency or its designee, so that the mission and legal mandate of EEA and its agencies and the constitutional rights of the citizens of Massachusetts are protected and enhanced…"[4]

This regulation presents a substantial impediment to constructing a solar electric system on any conservation land. For Carlisle to pursue installing a solar electric system in the Sand Pit at the Cranberry Bog, the Town would have to take all of the following steps.

- Acquire a geotechnical analysis of the land to validate the appropriateness of the site
- Thoroughly assess the costs involved in analyzing, designing, and converting the land for a solar electric system installation
- Acquire an unanimous approval vote of the Carlisle Conservation Commission
- Acquire a two-thirds approval vote of the town
- Acquire a two-thirds approval vote of the Massachusetts legislature
- Prove that this conversion will not destroy or threaten a unique or significant resource
- Locate and purchase real estate of equal or greater fair market value and significantly greater resource value
- Secure funding for the geotechnical study, the substitute land purchase, and wetland resource areas delineation
- Possibly secure funding, depending on the solar electric system configuration, for land conversion, solar electric system installation, maintenance, and operation
- Acquire estimates for the design, acquisition, and installation of a solar electric system, emphasizing minimal disturbance to the surrounding habitat areas
- Delineate the wetlands resource areas in the Sand Pit area
- Measure out the vernal pool buffer zone

Unlike agricultural activities, which are subject to some exemptions under the Massachusetts Wetlands Protection Act (MGL Ch. 131 S. 40) and its Regulations (310 CMR 10.00), a solar electric system installation in the Sand Pit is likely to have at least portions of the array, tree clearing, and associated grading in or near wetland

jurisdictional areas (100-foot Buffer Zone, 200-foot Riverfront Area, and 100-Year Flood Zone). The project and associated wetland regulatory areas would need to be identified on an engineered plan and submitted under a Notice of Intent to the Conservation Commission and to the Natural Heritage and Endangered Species Program for review and approval before any work associated with the solar electric system installation can be initiated. The Conservation Commission's decision, issued in an Order of Conditions tailored to the project, can be appealed by any abutter to the property, any ten Carlisle citizens, or by Massachusetts Department of Environmental Protection itself.

The Solar Bylaw Advisory Committee is currently going through the review process for a new solar bylaw to be presented at the 2017 Carlisle Town Meeting. The bylaw will specify the rules and regulations for allowable nameplate kilowatt capacity, maximum aggregate area of equipment and structures, minimum lot size, minimum property line setbacks, maximum heights of ground-mounted systems, screening guidelines for ground-mounted systems, qualifications for by-right accessory use, and authorizations and permits required. The current proposal defines a large-scale ground-mounted system as having a nameplate capacity greater than 250 kilowatts, less than or equal to 1.5 acres of aggregate area of equipment and structures, a setback of 40 feet, and less than or equal to 12 feet maximum height.

Other Aspects

Land disposition regulations, in addition to the presence of wetland resource areas, rare species, and a vernal pool, confine the installation of a solar electric system in the Sand Pit. Another potentially confining factor is that the Cranberry Bog House requires a new septic system and well, which could be located in the Sand Pit. Multiple details must be considered in locating a well and septic field in the Sand Pit and positioning them and a solar electric system in the same area presents certain conflicts.

- The soils present in the Sand Pit may not be suitable for septic fields because they either drain too fast or the water table is too high.
- Wells and septic fields require exclusive buffer areas. A septic field must be 100 feet from a water-supply well.
- The presence of a solar electric system would require on-going access.
- Heavy equipment or roads must not cross a septic field unless it is specifically designed to handle that load.
- Curve Street is between the Bog House and The Sand Pit, increasing the cost of installing a well and septic field in the Sand Pit.
- If all three utilities are to be installed, then the location of these utilities must be determined simultaneously.

Another location for the septic field is the Cranberry Bog land west of the Bog House in the Alternative Agriculture Staging Area (Figure 1). This area was also excavated for agricultural activities and is approximately 10 feet below its original grade. The soil is 253B Hinckley loamy sand, the same as the western part of the Sand Pit. The soil is "excessively draining and has severe limitations for septic tank absorption fields."[6] This constraint might be overcome with a mounded septic field, which would be less obtrusive

and closer to the Cranberry Bog House than a septic field in the Sand Pit. However, this area west of the Bog House may be within 100 feet of the Cranberry Bog's irrigated field.

The placement of the well could be on higher ground to the north of the Cranberry Bog House near the northwest corner of the Bog House. A qualified professional could determine whether the close proximity of the Cranberry Bog fields is problematic or whether there is a better location.

Potential Solar Electric System Options

Three basic administrative options are possible for towns. These options are not mutually exclusive and can be combined in different ways depending on the goals of a municipality. These options are described to show what is involved in installing a solar electric system on the Cranberry Bog property for the purpose of reducing electricity costs. If Carlisle decides to pursue Alternative 9, a special committee will be needed, along with the assistance of solar energy professionals, to ascertain the appropriate option that pertains specifically to Carlisle and estimate the potential costs and net metering credits.

The three basic options have various members, with each member having a role with certain rights and responsibilities. Any one of the various members can fulfill any or all of these roles. The possible types of members are listed below.

- **Host customer** is the customer of record (either a person, public entity, or private entity) with the electric distribution company and the person or entity whose name appears on the account of a net metering facility. The host customer applies for net metering services by submitting a schedule Z to the utility company. The host customer decides what happens to any allocated compensation for excess generation (such as net metering credits). Each net metering facility can only have one host customer.[10]
- **Site owner** is the person, public entity, or private entity that holds legal title to the land.
- **Solar system owner** is the person, public entity, or private entity that owns the solar equipment and related materials. The solar electric system owner is usually responsible for procuring, installing, maintaining, commissioning, and operating the solar electric system. This entity arranges financing and monetizes available tax credits and other financial incentives. This entity also makes all arrangements with the utility company for connection to the electric utility's grid.
- **Customer (or Participants)** may be a person, public entity, or private entity that purchases the electricity or net metering credits.

Option 1 involves a town as the host customer and site owner and a private third party as the solar electric system owner. The organization of Option 2 is slightly different with the town as the customer and a private third party as the host customer and solar electric system owner. Either the town or the private entity may be the site owner for Option 2 depending on whether the solar electric system is on-site or off-site. Option 3 involves the same members as in Option 1 and Option 2 but also includes residents as customers.

Option 3 allows multiple role configurations of the members. Each of these three options has the potential to generate some savings for the town by lowering the cost of electricity.

Option 1: Power Purchase Agreement for a Solar Electric System[7]

Power Purchase Agreements (PPAs) are a method available to towns in Massachusetts to finance on-site solar electric systems for which the town is the host customer and the site owner. Through a request for proposal, a private entity is selected to be the solar electric system owner that provides a solar energy source for the purpose of reducing a town's cost of electricity. The private entity finances, procures, installs, maintains, commissions, and operates a solar electric system for the host customer.

A long-term contract, known as a power purchase agreement, is negotiated with the private entity whereby the town purchases 100% of the electricity generated by the solar electric system for a negotiated price. The solar electric system is connected to the town's electric meter, proportionally reducing the town's consumption of electricity from the electric utility grid. If all the electricity generated is not used directly by the town, then the town can receive net metering credits to be applied to the town's utility bill through a net metering agreement as described in Option 2. The town, as the host customer, is responsible for establishing a net metering agreement with the public utility since only the host customer of the solar system array may apply for net metering credits.

The private entity provides the financing for the project in return for the federal 30% investment tax credit and accelerated depreciation of the solar electric system, state tax credits, revenue from the sale of electricity to the town, and tradable Renewable Energy Certificates (RECs) based on the amount of megawatt-hours generated by the solar electric system.[5] Renewable Energy Certificates are negotiable on the state-sponsored REC market where utilities are required by state laws to purchase a specified amount of renewable energy to meet environmental compliance regulations. A town benefits because there are minimal upfront costs and a stipulated price for electricity providing long-term savings.

Most PPAs are for a term of 15 to 25 years, although shorter terms are available. It is more cost effective for towns to participate in a PPA than to own and operate a solar electric system because, although towns can receive construction rebates, net metering credits, and RECs, they cannot qualify for valuable federal or state tax credits.

Option 2: Net Metering Agreement for a Solar Electric System[7]

Net metering of a solar electric system allows individuals and towns to generate their own electricity in order to offset their electricity usage. The solar system is connected to a "net-meter" that measures the net (consumed minus generated) quantity of electricity that the consumer uses. The net-meter spins forward when the consumer uses electricity from the electric grid, and it spins backward when the consumer generates excess electricity.

In a Net Metering Agreement (NMA), a private entity (the solar electric system owner that is also the host customer) enters into a contract with the town (the customer), whereby the private entity has financed, procured, installed, commissioned, and currently maintains and operates a solar electric system. The town agrees to the long-term purchase

of some or all of the net metering credits created by the solar electric system. By purchasing net metering credits from the private entity, the town is designated by the private entity to receive a monetary credit on its monthly utility bill. The town pays the private entity an amount less than that monetary credit, thus realizing a small cost savings. Like the PPA, only the host customer of the solar electric system, which in this case is the private entity, may apply for net metering credits with the electric utility company.

For instance, the NMA might be for a fixed discount in which the town is designated to receive 100% of the value of the net-metering credits and pays the solar system owner a percentage of that value, such as 95%, resulting in a 5% savings for the town.[7] The town may allocate the monetary credits to one or more accounts, provided the accounts are within the same utility load zone of the electric utility company. In an NMA, the solar system may be on-site or off-site. An NMA can be incorporated into a PPA whereby the town is the site owner and the host customer.

The electricity is purchased with Option 1, and the net metering credits are purchased with Option 2. Both Option 1 and Option 2 have the most potential to produce the greatest economic benefit to the town by lowering the town's monthly electric expenses. The potential electric cost savings are impossible to determine until private entities are invited to assess the potential of the property to support a solar electric system, the costs involved, and the federal and state incentives in place at the time. The pros and cons of PPAs and NMAs are listed in **Table 1**.

Option 3: Community Shared Solar Electric System[8]

Community Shared Solar (CSS) arrangements can be a variety of configurations that provide residents, who have feasibility issues regarding installation of a solar electric system, with an alternative way to access renewable energy and the town with a source of some electricity cost savings. Only 22% to 27% of residences in Massachusetts are suitable for solar electric system installations, making CSS a popular option.[9] Different configurations of this option may incorporate various aspects of PPAs and NMAs.

The basic configuration of a community shared solar electric system usually involves the following members.

- **Site owner** may be the town or a private entity.
- **Participants** may be the town, community members, and local businesses.
- **Host Customer** is the town.
- **Solar electric system owner** is a private entity.

Multiple owner-participant arrangements are allowed to help communities address location, financing, and participation issues. In general, participants may be customers, site owners, solar electric system owners, or any combination. A person or entity can own part of a solar electric system as an investor and receive electricity from it as a customer.

Table 1. Pros and Cons of Option 1 and Option 2 (PPAs and NMAs)

Topic	Pros	Cons
Upfront Costs[5]	Both PPAs and NMAs usually require no upfront capital, although up-front payments may help reduce the initial and long-term cost of electricity.	Providing financing for upfront costs can increase the level of risk for the town.
Installation Issues[5]	Off-Site installations, whether supported by PPAs or NMAs, eliminate any space or structural issues, as well as any construction oversight or management by the town.	On-site installations, whether supported by PPAs or NMAs, require structurally sound open space on which to build.
Ongoing Maintenance[5]	Systems hosted but not owned by a town (for both PPAs and NMAs) typically require the owner and not the town to maintain the system.	
Electricity Costs[5]	PPAs generally provide the town with a pre-determined rate of electricity.	Terms can include periodic cost escalations. (e.g. $0.XX per kWh of electricity consumed with an X% annual escalation rate).
Regulatory[8]		The state or the federal government may change the incentives, tax credits, REC programs, and net metering rules at any time, making a PPA arrangement economically unfeasible. On April 11, 2106, the net-metering benefits available to privately owned projects were reduced to 60% of retail rate in Massachusetts.
Market Influences	The cost of electricity may go up (likely).	The cost of electricity may go down (unlikely).
		The solar electric system owner may leave the solar industry, sell or transfer its interest in the PPA agreement, or file for bankruptcy.
Deterioration		Solar panels degrade at a rate of approximately 1% per year and usually come with a 20-year warranty. At the end of the PPA, the town will need to replace the solar panels.
Insufficient Savings		Savings in electricity costs may not fully support the cost of agriculture or maintenance at the Bog.
Unallocated Savings		Any savings from the town electric bill are not specifically allocated to support the Cranberry Bog.

Some possible configurations of community shared solar are a public lease model, a participant ownership model, and a virtual net metering model. The Commonwealth of Massachusetts publication, *Community Shared Solar: Review and Recommendations for Massachusetts Models* (2012) has detailed descriptions of these models. Providing an in-depth description on all these models is not within the scope of this report; the public lease model is briefly described here, however, as an example of one possibility that would generate some savings for the town.

The public lease model is designed to meet demand by residents for a renewable energy option with the town as the site owner, host customer, and participant. In this model, the solar electric system is on a town site. All the participants receive net metering credits using virtual net metering but do not have an ownership stake. Virtual net metering is a legal framework enabled in Massachusetts that allows the host customer, who qualifies for net metering credits for its solar electric system electricity production, to transfer those credits to other customers within the same local utility service territory. Usually the town engages a qualified CSS vendor to design, install, and administer the CSS.
The town, as site owner, issues a lease agreement with the CSS vendor and receives a lease payment. The town realizes savings from net metering credits and revenue from the lease payment. Many of the pros and cons of the PPA and NMA models also apply to the CSS. A few other considerations are listed in **Table 2**.

Table 2. Pros and Cons of Option 3 (CSS)

Topic	Pros	Cons
Financial	Benefits many residents directly	Less percentage of net metering credits for town depending on the number of other participants
	Income from lease agreement	Financial risk because of upfront organizational costs
Responsibility	No ownership of CSS means no securities requirements	Responsibility for organizing the community shared solar system
	Project management overseen by CSS vendor	Commitment for specified time by resident participants

Solar Electric System Costs and Other Considerations

Providing specific costs for the installation of a solar electric system at the Cranberry Bog is not within the scope of this report. Pricing data on a solar electric system installation requires professional and technical analysis and planning. Costs directly depend on factors unique to each situation. For instance, commissioning a solar electric system built on the Cranberry Bog conservation land may be a significant cost because it includes determining how and where to connect the solar electric system to the local utility grid. According to Steve Hinton, a Carlisle Energy Task Force member, no suitable connection point is nearby; the nearest connection is approximately one mile away on Lowell Road.

Some government reports give examples of costs and net metering credit value. The Commonwealth of Massachusetts *Community Shared Solar Review and Recommendations Massachusetts Models*, which was published in 2012, includes a hypothetical example of the financial benefits for a public lease model of a CSS project.[9] The data from this hypothetical model are in **Table 3** and are based on a 100 kWh (kilowatt-hour) solar electric system generating 125,000 kWh annually with 20 participants. The lease payments to the site owner are not included.

Table 3. Estimated 1st Year Benefits of a 100 kWh CSS Project, Public Lease Model

	Projection ($)	Assumption	Recipient
Net Metering Credit Value	20,000	@ $0.16 per kWh	All Participants
Net Metering Credit Purchase Cost	16,250	@ $0.13 per kWh	All Participants
Net Benefit	3,750	N/A	All Participants
Est. 1st Year Benefit per Participant	187.50	20 Participants	Each Participant

This example demonstrates that the net benefit is not substantial with a CSS. The land lease payments are not included in this example, but these payments are usually minimal to increase the price per kWh received by each participant. The assumption with a CSS public lease model is to benefit primarily the residential participants more than the town.

The National Renewable Energy Laboratory (NREL) published *U.S. Photovoltaic Prices and Cost Breakdowns: Q1 2015 Benchmarks for Residential, Commercial, and Utility-Scale Systems* in September of 2015. This report contains a U.S. solar industry summary on the cost per watt for solar electric system installations. The report unfortunately does not separate out the municipal installations from residential, small commercial, and large utility. A municipal solar installation will not have the same economies of scale or regulatory requirements and costs of a large utility solar installation even though the ground-mounted design would be similar. The small commercial solar installation may not be as large but incurs many of the same costs and is, therefore, more representative of the price per watt for a municipal solar installation.

The NREL summary breaks solar installation costs into the three categories of hardware, soft costs: installation labor, and soft costs: other. Hardware includes the solar modules, inverters, racking, and all balance-of-system hardware required to complete the system. The soft costs: installation labor includes the labor and any labor-related costs. The soft costs: other category includes non-hardware and non-installation-labor costs. **Figure 5** shows the price per watt of the different solar electric system categories. The total cost per watt ranges from $1.77 for 100 MW utilities to $3.09 for 5 kW residential systems, demonstrating definite economies of scale.

A sense of the cost savings can also be derived from several town solar electric systems in eastern Massachusetts that were installed on landfills. In Acton, a solar electric system produces 1.6 MW of electricity on 17.5 acres of a landfill and save the town $15,000 to $85,000 depending on the market rate of electricity.[13] In Billerica, a solar electric system with 20,000 solar panels on the capped Shaffer landfill generate 6 MW of electricity, and the town receives $3 million in energy credits.[14] Sudbury saves approximately $100,000

on its electric bills each year due to a 1.5 MW solar electric system with 6,000 panels situated on 18 acres of a former landfill.[15]

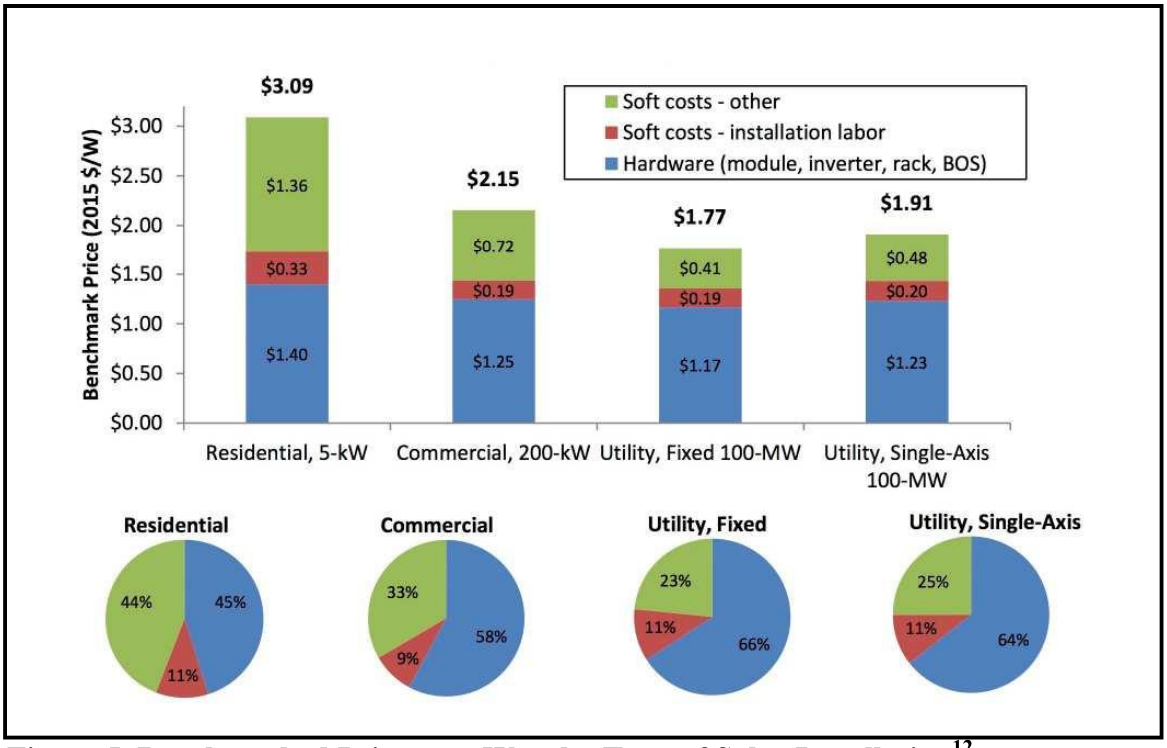

Figure 5. Benchmarked Prices per Watt by Type of Solar Installation[12]

Although the number of factors contributing to the cost of various solar electric system options prevents predicting exact costs and electricity cost savings for Carlisle, a few guidelines are available for planning purposes.

- Solar installations are usually 5 to 10 watts per square foot of usable space (not including a buffer zone of cleared land).[5] The approximately 2 acres of cleared land available in the Sand Pit yields 87,120 square feet of usable space. The two acres could generate 435 to 871 kilowatts (kW) of electricity.

- One kilowatt of photovoltaic capacity can produce between 1,000 and 1,500 kilowatt-hours (kWh) of electricity annually in Massachusetts, assuming optimal operational conditions.[11] Based on the calculation above, a two-acre solar electric system could produce 435,000 kWh to 1.3 kWh per year.

- A one-megawatt (MW) solar electric system requires four to five acres of total land area (solar array footprint and cleared buffer zone). One megawatt fulfills the electrical needs of approximately 200 households.[8]

- Each municipality can only be a host customer for up to ten MW of net metering capacity.[7]

- The value of a REC in Massachusetts has ranged from $257 to $470 and represents a major financial mechanism for solar development.[8]

- Community shared solar facilities are awarded one REC for each megawatt-hour of electricity they produce.[8]

- As of April, 2016, the collective electric-generating capacity of projects owned by municipalities or other public entities cannot exceed 8% of a local utility's historical load.[8]

Summary

The concept of installing a solar electric system at the Cranberry Bog may be possible, but numerous challenges and potentially conflicting goals for the use of the land exist: The soils must meet structural integrity standards; the drainage issues must be resolved; sections of the Sand Pit are considered wetlands and priority habitat; and the Bog House well and septic system may be located within the same area. The most substantial challenge is from the Office of Energy and Environmental Affairs' Land Disposition Policy to address Article 97 of the Massachusetts Constitution that requires multiple, difficult, consecutive legal processes and replacement of the disposed land. One consideration regarding the replacement requirement is that the entire 18 acres of the Sand Pit most likely isn't needed; only a subsection of perhaps 4 to 5 acres needs to be replaced.

Even though accurate estimates of potential cost savings cannot be obtained at this time, the solar installations in Acton, Billerica, and Sudbury demonstrate that such projects can be very successful. However, the additional financial burden to Carlisle of replacing even 4 to 5 acres of land makes Alternative 9 an unlikely choice unless no other conceivable place exists in Carlisle to install a solar electric system.

One other very important consideration is the economic dependency of the solar industry on the current incentive programs offered by the state and federal governments and the regulations governing the electricity reimbursement rates. Even small adjustments to the regulations can have detrimental domino effect on the robustness of the solar industry. In April, 2016, Governor Charlie Baker signed bill H.4173, which reduces the net metering credit to 60% of the retail rate from 100% for privately owned solar projects. This bill negatively affects community shared solar or any solar system that is usually owned by a private entity.[8]

For Alternative 9 to be a feasible option for the town, all of the above challenges identified in this report will need to be resolved, which will take considerable time, a remarkable effort on the part of volunteers and town staff, and significant funds.

Summary Evaluation

Pro

- Establishes a renewable energy source for Carlisle
- Supports the Green Communities program in Carlisle
- Reduces electricity costs for the town
- Allows applying electricity-cost savings to the management of the Cranberry Bog Conservation Land

Con

- Requires meeting Article 97 requirements for disposition and replacement of the conservation land
- Invokes the Wetlands Protection Act regulations
- Impacts a NHESP priority habitat area potentially resulting in loss of wildlife habitat and species
- Does not guarantee that electricity costs savings will be applied to the management of the Cranberry Bog Conservation Land
- Faces an unpredictable Massachusetts solar energy regulatory environment
- Has a negative aesthetic effect on the neighborhood
- Has some upfront capital costs
- Uses an area that may be needed for a new septic system and well for the Cranberry Bog House

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ALTERNATIVE 10

UPGRADE OF TWO BOG HOUSE APARTMENTS

FOR RENTAL USE

Description of Alternative 10

This alternative involves renovating and renting the Bog House property located on Curve Street to generate income to support ongoing operations, whether agriculture or other use. The Bog House has strong potential to generate income if some investment is made up front. Two options were explored. The high-end option provides a net annual income of $57,600 with an investment of $860,000 upfront. The low-end option provides a net annual income of $24,000 with an investment of $368,500 upfront. Both options may show a return on investment after approximately 15 years. Both options may be financed by long-term debt, eliminating the need for upfront investment. Further investigation, including hiring a design and engineering firm, will be needed to validate these preliminary findings if the Town of Carlisle wishes to exercise this option.

Brief History of the Bog House

As per the Town of Carlisle's website:[1]

> *"The four-story Bog House on Curve St. was constructed in 1905 by the original developers of the Cranberry Bog, Warren and James Nickles. Over the years it has been used for cranberry processing, produce storage (e.g., squash), equipment storage, housing for bog managers and other workers, and a dance hall for the bog workers years ago."*

The house is currently used by bog farmer Mr. Mark Duffy, both as a residence for farm workers and as a storage area for equipment.

Analysis Methodology and Limitations

Current Layout and Condition

The current house is divided into two apartments: a studio apartment on the first floor and larger apartment on the second floor. The house has other storage areas, an unfinished basement, and an unfinished attic. The house was built and has been used as an agricultural property rather than a conventional residence, and the current finishes and condition reflect that. The house does not have central heating, and the plumbing systems, especially the well and septic system, are outmoded. **Figure 1** shows the current layout of first and second floor.

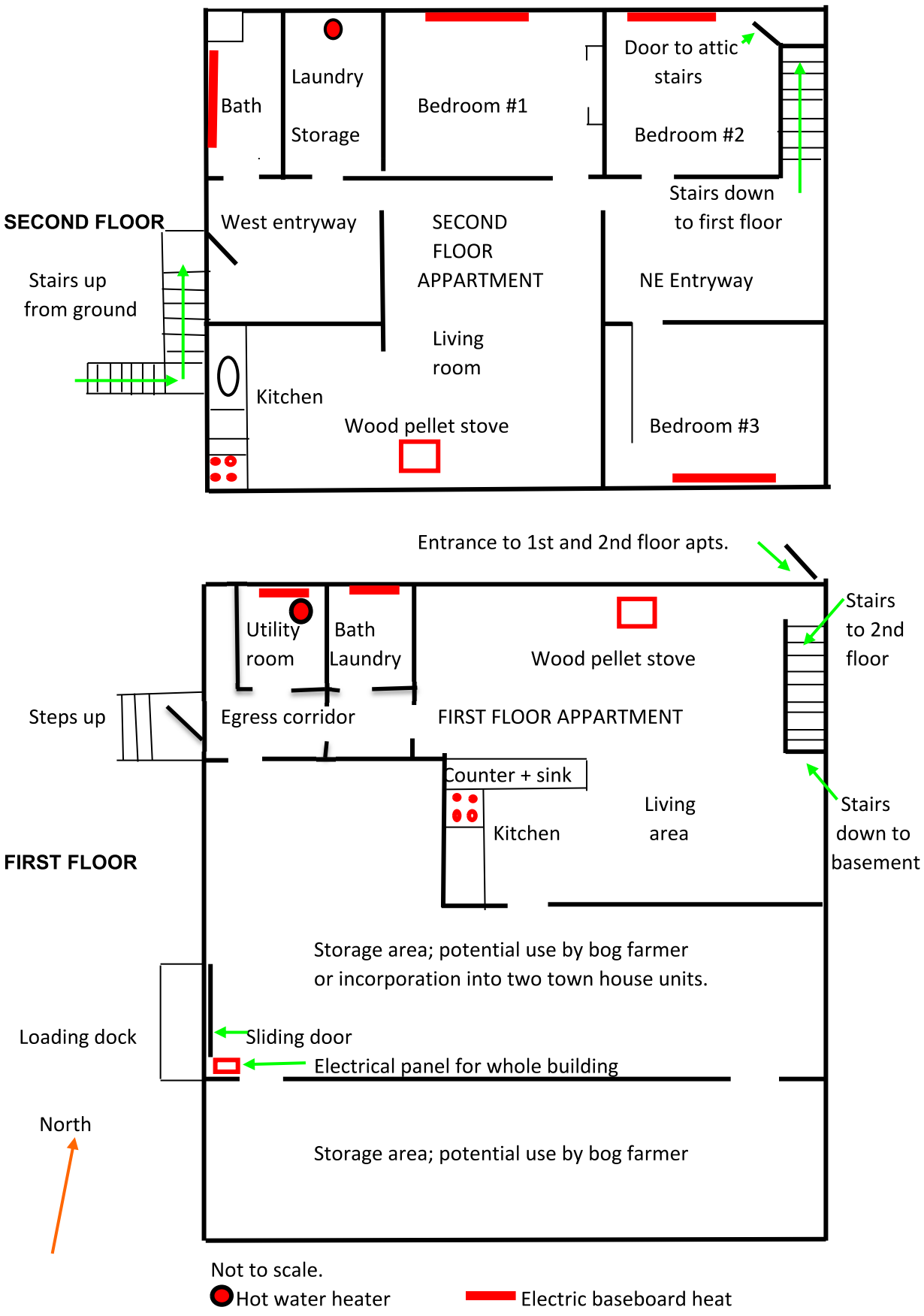

Figure 1. Schematic Diagram of First and Second Floors of Bog House

Rent Potential

The analysis on rent potential was done by consulting with long-time Carlisle resident and local realtor Brigitte Senkler.[2] Two layouts were considered.

a) **Preserve the Current Layout:** Renovate the two current apartments on the first and second floors of the house. These apartments are approximately 1,000 square feet and 2,000 square feet, respectively;
b) **New layout with two modern Town Homes:** Make major changes to the layout to yield two side-by-side townhomes of approximately 2,500 square feet each.

Building Costs

Building costs were estimated by consulting with local resident and builder Christopher Hart who owns The Hart Wright Company.[3]

Key Assumptions

The building is assumed to be structurally sound based on both quick visual inspection and information that both the siding and the roof were replaced recently. Second, relocating the septic system to the land across the street from the property rather than on the current bog area was assumed to be possible. Finally, interior renovations were assumed to include all surfaces and fixtures from the drywall in. All estimates reflect these assumptions.

The Analysis Presented is Preliminary

Estimates presented in this section are extremely preliminary and can vary considerably from the actual figures should this option be pursued. As just one example, labor rates may be higher for work performed on town properties than on private property.

The objective of this analysis is to provide guidance. This analysis is not to be used without further work by professionals, such as a design and architectural firm, to detail choices about layout and construction materials and to verify the structural integrity of the house.

Evaluated Options: Financial Summary

Current Layout with Two Apartments

A financial summary of this option is provided in **Tables 1 and 2**. This option assumes basic-to-mid-level finishes appropriate for the proposed apartments.

Construct Two Town Homes

A financial summary of this option is provided in **Tables 3 and 4**. This option assumes mid-to-premium-level finishes appropriate for the proposed town homes.

Table 1. Investment and Revenue Summary for Current Layout Option

Item	Item Detail	Living Area (square feet)	Price/ Square Foot ($)	Cost ($)	Income ($)
Investment					
Fixed Costs	New septic system			25,000	
	New domestic well			10,000	
	Total			35,000	
Interior Renovation Costs	1st floor apartment	1,000	100	100,000	
	2nd floor apartment	2,000	100	200,000	
Monthly Expenses	Maintenance			250	
	Vacancy & Realtor Fee			250	
	Total			500	
Cost Summary	Total construction costs			335,000	
	Design & Architecture			33,500	
	Total			368,500	
Revenue					
Rent Estimates (monthly)	1st floor apartment				1,000
	2nd floor apartment				1,500
Net monthly revenue					2,000
Net annual revenue					24,000

Table 2. Income Expected by Using One-Time Investment vs. 30-Year Debt
(Using current apartment layout option)

Payment Option	Total Debt ($)	Term (years)	Interest Rate (%)	Monthly Debt Payment ($)	Total Investment ($)	Net Annual Income ($)
One-Time Investment	N/A	N/A	N/A	N/A	368,500	24,000
30-Year Debt	368,500	30	2	1,362	N/A	7,656

Table 3. Investment and Revenue Summary for Construction of Two Town Houses

Item	Item Detail	Living Area (square feet)	Price/ Square Foot ($)	Cost ($)	Income ($)
Investment					
Fixed Costs	New septic system			35,000	
	New domestic well			15,000	
	Total			50,000	
Interior Renovation Costs	1st floor apartment	2,500	150	375,000	
	2nd floor apartment	2,500	150	375,000	
Monthly Expenses	Maintenance			600	
	Vacancy & Realtor Fee			600	
	Total			1,200	
Cost Summary	Total construction costs			800,000	
	Design & Architecture			60,000	
	Total			860,500	
Revenue					
Rent Estimates (monthly)	1st floor apartment				3,000
	2nd floor apartment				3,000
Net monthly revenue					4,800
Net annual revenue					57,600

Table 4. Income Expected by Using One-Time Investment vs. 30-Year Debt
(Based on construction of two town houses)

Payment Option	Total Debt ($)	Term (years)	Interest Rate (%)	Monthly Debt Payment ($)	Total Investment ($)	Net Annual Income ($)
One-Time Investment	N/A	N/A	N/A	N/A	860,000	57,600
30-Year Debt	860,000	30	2	3,179	N/A	19,452

Project Financing

Refurbishment of the bog house, although providing a positive return on investment, requires substantial cash investment upfront. Some funds may be available through state and local grants such as the Community Preservation Act (CPA). The CPA is legislation enacted in 2000 and provides state matching funds for participating towns. Funds can be used for the preservation of open space, preservation of historic resources, and affordable housing.[4]

Next Steps

Design Study

Hiring an architectural and design firm would allow the above analysis to be verified and lay out the renovation plan in much greater detail. Such a study may cost around $15,000 to 20,000. If the project moves forward, some of this investment would be recovered from the design budget of the full project.

Legal and Regulatory

Because the Bog House is a conservation property, detailed investigation into feasibility, including permissibility under Article 97, local building permits and zoning laws, the Wetlands Protection Act, and other regulations, needs to be assessed. Qualification for Chapter 40B planning [5] may also be assessed.

Summary Evaluation

Relative to the evaluation criteria for alternatives and plans described in Section 3 of the main report, the following qualitative judgements are made for four criteria.

Pro

- Preservation of Bog House, an historic building
- Use of the bog house will support agriculture at bog
- Availability of two apartments.
- Town revenue gain
- Additional income from the rental apartments available to support conservation and recreation, including ongoing agriculture, at the cranberry bog.

Con

- Town capital investments: Depending on the financing mechanism chosen, the investment may add initially to residents' tax burden, although preliminary analysis shows that this option provides a positive return on investment.
- Regulatory constraints and other risks
- The unconfirmed feasibility of using the bog house as a rental property

- The time required for renovation. Renovation will require at least 12 months before income would accrue to the town.

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APPENDIX A

CRANBERRY BOG CAR AND VISITOR COUNTS:

SEPTEMBER 2016

To better document the use of the Cranberry Bog by the public, the Cranberry Bog Alternatives Committee (CBAC) undertook a survey during a 17-day period in September 2016 (Sept. 10 through 26). During this period, various CBAC members went to the bog at random times during the day and counted the number of cars and visitors seen. Some observers also counted the number of dogs seen.

In total, 32 discontinuous observations were made in the 17-day period covering the hours from 7 AM to 7 PM. Individual observations lasted from 10 to 30 minutes. Only people and dogs seen in the open bog areas were counted. All cars parked by the Bog House and in the vicinity along Curve St. were counted. Full details on the 32 observations are provided in **Table A-1**. The average, standard deviation, and number of observations for the number of cars, people, and dogs seen in each observation are provided at the bottom of the table. For example, the average number of people seen in the 32 observations was 12, with a standard deviation of 3.8 (46%). The percent standard deviations for all three averages are large: 43% (cars), 46% (people), and 56% (dogs). The average ratio of people to cars is 1.5:1, which is lower than the ratio of 2.5:1 that the Massachusetts Department of Conservation and Recreation sometimes uses to estimate visitors to State parks that have a single entry point, allowing counting of cars.

The survey data showed that, during the study period, the bog had, on average, approximately 290 visitors each day. The average visit time for each person was assumed to be 30 minutes. For comparison, the average bog visitor, keeping a steady pace, can walk the perimeter of the bog area in 25 minutes. Because visitors were at the bog during each of 32 random observations, it was assumed that visitors were there from 7 AM to 7 PM each day. Therefore, the number of visitors per day is calculated as follows.

$$\frac{\text{visitors}}{\text{day}} = \frac{\text{average 12 visitors}}{\text{30-min observation}} \times \frac{\text{60 min}}{\text{1 hour}} \times \frac{\text{12 hours observation}}{\text{day}} = \frac{\text{288 visitors}}{\text{day}}$$

Similarly, on average, approximately 160 dogs visited each day. These data substantiate the significant value of the bog to the public for recreation, especially dog walking.

Figures A-1 and A-2 show the number of cars and people, respectively, counted in each observation versus the time of day. The counts increase as the day progresses.
Figure A-3 shows the average number of people seen on each day of the week. More people visit the bog on Friday, Saturday, and Sunday than during the rest of the week.

Table A-1. Cranberry Bog Car & Visitor Counts - September 2016

By	Day	Date	Time	People (P)	Cars (C)	P/C	Comments	Observation Time (min)
DG	Sat.	9/10/2016	10:00 AM	20	11	1.8	3 walk-ons	10
DG	"	9/10/2016	6:15 PM	17	9	1.9	6 came by bike	10
DG	Sun.	9/11/2016	7:00 AM	4	3	1.3	2 walk-ons	10
WL	"	9/11/2016	2:00 PM	N/A	13	N/A	Drive-by count	N/A
DG	"	9/11/2016	6:40 PM	17	7	2.4	5 walk-ons	10
JB	Mon.	9/12/2016	7:00 AM	11	7 1/2	1.6	7 dogs (7 or 8 cars)	30
DG	"	9/12/2016	11:30 AM	10	6	1.7		10
JB	"	9/12/2016	4:30 PM	12	8	1.5	5 dogs	30
DG	Tue.	9/13/2016	7:09 AM	7	4	1.8		10
WL	"	9/13/2016	11:15 AM	6	6	1.0	6 dogs (1/person)	15
SP	"	9/13/2016	5:15 PM	18	7	2.6	10 dogs	no report
DG	"	9/13/2016	6:00 PM	10	6	1.7	7 dogs	10
SP	"	9/13/2016	6:50 PM	N/A	12	N/A	Drive-by count	N/A
WL	Wed.	9/14/2016	10:30 AM	9	9	1.0	4 dogs, 3 bicycles	15
WL	Thurs.	9/15/2016	1:10 PM	6	6	1.0	2 dogs	15
JB	Fri.	9/16/2016	7:00 AM	13	8	1.6	9 dogs	30
WL	"	9/16/2016	3:30 PM	10	13	0.8	9 dogs, -[a]	30
WL	Sat.	9/17/2006	1:35 PM	11	10	1.1	3 dogs; family of 5[a]	20
WL	Sun.	9/18/2016	1:15 PM	7	4	1.8	3 dogs, -[b]	25
DG	"	9/18/2016	6:45 PM	16	15	1.1		10
DG	Mon.	9/19/2016	9:50 AM	5	5	1.0		10
SP	"	9/19/2016	5:00 PM	11	8	1.4	8 dogs	no report
WL	Tue.	9/20/2016	1:20 PM	7	7	1.0	4 dogs	25
DG	"	9/20/2016	6:30 PM	20	15	1.3		10
SP	"	9/20/2016	7:00 PM	23	11	2.1	8 dogs	no report
WL	Wed.	9/21/2016	10:50 AM	8	7	1.1	1 dog; family of 5[a]	25
WL	Thurs.	9/22/2016	1:00 PM	4	4	1.0	5 dogs	25
WL	Fri.	9/23/2016	3:15 PM	13	8	1.6	6 dogs	25
SP	"	9/23/2016	5:30 PM	21	9	2.3	11 dogs	30
WL	Sat.	9/24/2016	3:40 PM	N/A	20	N/A	Drive-by count	N/A
SW	Sun.	9/25/2016	12:15 PM	17	11	1.5	17 dogs	40
DG	Mon.	9/26/2016	4:22 PM	16	14	1.1		10

	P	C	P/C	# Dogs
Average	**12.0**	**8.8**	**1.5**	**6.6**
Standard Deviation	**5.5**	**3.8**	**0.5**	**3.7**
Number of data points	**29**	**32**	**29**	**19**

a. Obviously did not see all people who came in cars.

b. Patriots game on!

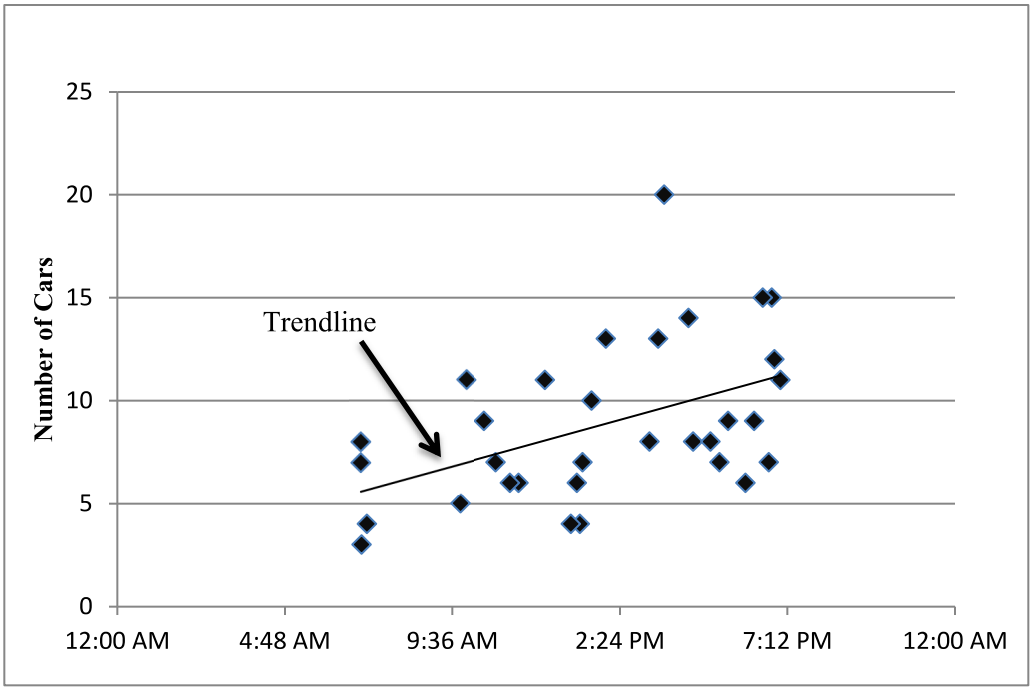

Figure A-1. Number of Cars Parked at Bog vs. Time of Day

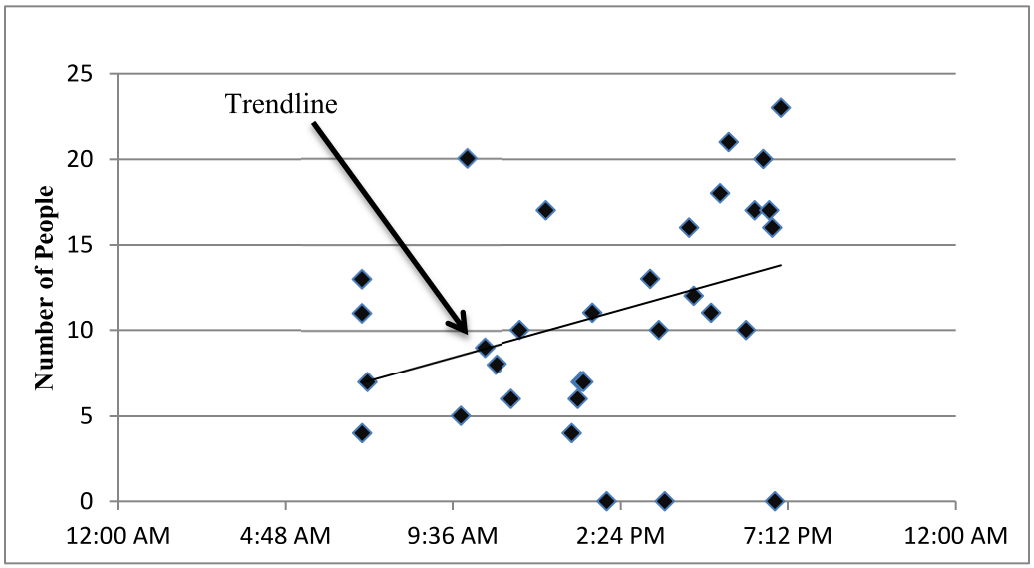

Figure A-2. Number of People at Bog vs. Time of Day

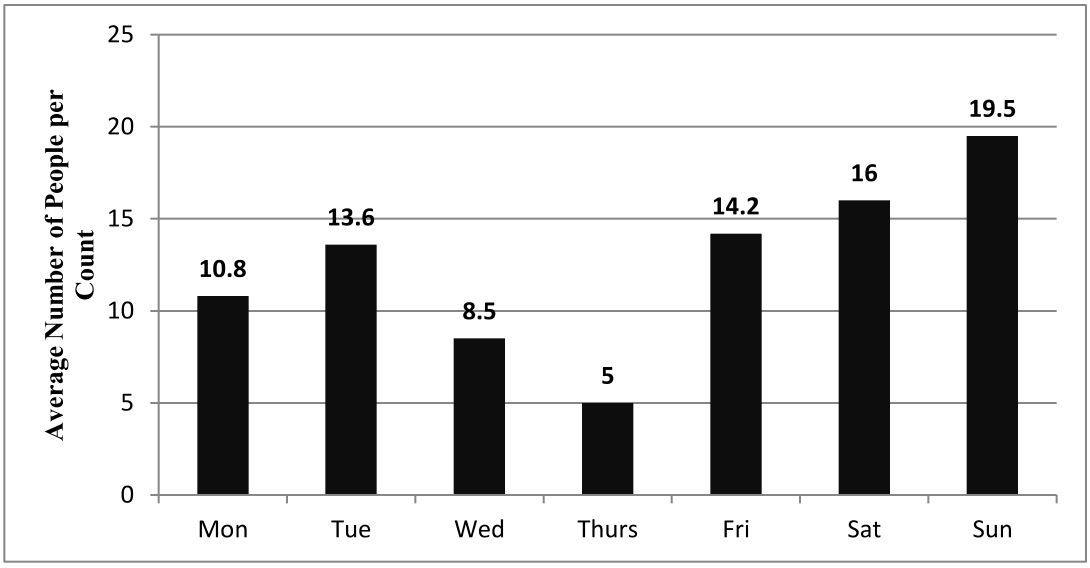

Figure A-3. Average Bog Visitor Count vs. Day of Week - Sept. 2016

APPENDIX B

LETTER FROM CARLISLE'S TOWN COUNSEL
ANSWERING THREE QUESTIONS POSED BY THE CBAC

Letter from Rebekah Lacey, Miyares and Harrington LLP,
to Luke Ascolillo, Selectman, Board of Selectmen, Carlisle, MA,
dated August 15, 2016.

Miyares and Harrington LLP

A private law firm in the public interest

J. Raymond Miyares
Thomas J. Harrington
Christopher H. Heep
Donna M. Brewer
Jennie M. Merrill

Rebekah Lacey

Ivria Glass Fried
Eric Reustle
Blake M. Mensing

August 15, 2016

By E-Mail (luke.ascolillo@comcast.net)
Luke Ascolillo, Selectman
Carlisle Board of Selectmen
66 Westford Street
Carlisle, MA 01741

Re: Carlisle Cranberry Bog Conservation Land

Dear Luke:

You have asked the following questions about the Carlisle Cranberry Bog conservation land, in light of discussions about possible future uses of the property:

1. It appears that continuation of cranberry growing on the land would require a subsidy from the Town (at least for the near term) because of current market prices for cranberries. It has been suggested that solar panels could be placed on the land and used to generate funds to provide this subsidy. Would this use trigger Article 97 of the Massachusetts Constitution, requiring a two-thirds vote of the Legislature to approve, even if the funds are used exclusively to support agriculture?

2. A memorandum from Francis DiLuna, Esq. to the Carlisle Conservation Commission dated April 13, 2000, notes that Massachusetts law preserves the right of any person to dam any non-navigable stream (and thereby flood the lands of others upstream) in order to cultivate and grow cranberries. *G.L.* c. 253, §§ 39-40. If the Town stops growing cranberries, would it need to remove the water control structures currently located in the bog? If Carlisle is either required to or chooses to remove those water control structures, would owners of property (e.g., along Heart's Pond upstream) who might be negatively impacted by their removal have any recourse?

3. What would be the implications of the cessation of cranberry farming for the *Water Management Act* registration held by the Town, allowing withdrawal of 360,000 gallons per day?

Our answers are below.

1. Solar Panels and Article 97

Article 97 of the Amendments to the Massachusetts Constitution, adopted in 1972, states as follows:

> The people shall have the right to clean air and water, freedom from excessive and unnecessary noise, and the natural, scenic, historic, and esthetic qualities of their environment; and the protection of the people in their right to the conservation, development and utilization of the agricultural, mineral, forest, water, air and other natural resources is hereby declared to be a public purpose.
>
> The general court shall have the power to enact legislation necessary or expedient to protect such rights.
>
> In the furtherance of the foregoing powers, the general court shall have the power to provide for the taking, upon payment of just compensation therefor, or for the acquisition by purchase or otherwise, of lands and easements or such other interests therein as may be deemed necessary to accomplish these purposes.
>
> Lands and easements taken or acquired for such purposes shall not be used for other purposes or otherwise disposed of except by laws enacted by a two thirds vote, taken by yeas and nays, of each branch of the general court.

The Carlisle Cranberry Bog is a parcel of approximately 151 acres previously owned by the Lowell Cranberry Company. The Town acquired the land from Lowell Cranberry by both a deed and an order of taking, recorded respectively in Book 3841, Page 267 and Book 3841, Page 268 at the Middlesex North Registry of Deeds on December 19, 1986 (both attached as Exhibit A). Both documents state that the land is being conveyed/taken "for conservation purposes, as provided by General Laws c. 40, Section 8c, and/or for outdoor recreation to be managed by the Conservation Commission of the Town of Carlisle." Thus, the land is clearly land "taken or acquired" for the "purposes" articulated in Article 97. The case law and Opinions of the Attorney General interpreting Article 97 have not clearly defined what constitutes use of such land "for other purposes" that triggers the Article 97 requirement for a two-thirds vote of the Legislature. However, in our opinion, it would be prudent to assume that a court would hold that installation of solar panels on the Carlisle Cranberry Bog conservation land would be a use of the land "for other purposes" requiring such a vote.

Although one could argue that the public purpose articulated in Article 97, "the protection of the people in their right to the conservation, development and utilization of the agricultural, mineral, forest, water, air and other natural resources," should be interpreted broadly, courts have interpreted Article 97's focus as protecting the use and enjoyment of public open spaces. *See Mahajan v. Department of Environmental Protection*,

464 Mass. 604, 615-619 (2013); *Nickolas v. City of Marlborough*, 32 Mass. L. Rptr. 125 (Mass. Super. Ct., May 9, 2014); *Curley v. Town of Billerica*, 2013 WL 4029208 (Mass. Land Ct., Aug. 8, 2013). The purposes stated in the Cranberry Bog deed also appear to center on open space. The statute referenced in the deed (*M.G.L.* c. 40, § 8C) provides for the creation of conservation commissions and allows them to acquire interests in land to "conserve and properly utilize open spaces in land and water areas" within the city or town in which the commission is established. If solar panels are constructed on the Cranberry Bog parcel and a legal challenge is brought arguing that a two-thirds vote of the Legislature was required for this construction, we believe that the Town would have an uphill battle countering this argument. A court might well hold that construction of solar panels does not appear to comport with the directive to "conserve...open spaces," nor does it fulfill the alternative "outdoor recreation" purpose set forth in the deed. The court would likely be skeptical of the argument that use of funds generated from the use of the solar panels to support cranberry cultivation is "for conservation purposes," because that rationale could justify almost any fee-generating structure or activity on conservation land. For these reasons, we would recommend seeking a two-thirds vote of the Legislature prior to installation of solar panels on the Cranberry Bog land.

Moreover, in addition to the issue of change in use, we note that the installation of revenue-generating solar panels would most likely require a lease to a solar energy development company and conveyance of utility easements, both of which would be "dispositions" that would clearly trigger the Article 97 vote requirement.

2. Implications of Cessation of Cranberry Farming: Dams

The answer to the second question is a little complicated; it is a question of property rights that is governed by statutes, common law, and the recorded instruments conveying the property to the Town and to its predecessors in the chain of title.

As you noted, the April 2000 memo from Attorney Francis DiLuna to the Conservation Commission (attached as Exhibit B) referenced a Massachusetts statute (*M.G.L.* c. 253, §§ 39, 40) that gives any person the right to dam a non-navigable stream, thereby flooding the lands of others upstream, for the purpose of cranberry cultivation. As Attorney DiLuna stated, this statute confers a private right of eminent domain, allowing the cranberry grower to appropriate some of the property rights of upstream landowners. It is part of a set of statutes known as the mill acts, which also confer the same private right of eminent domain on a person who erects and maintains a dam to power a water mill or to maintain an ice pond, subject to a requirement to pay annual damages to those whose lands are flooded. *M.G.L.* c. 253, §§ 1-43. Although there are no cases regarding cessation of cranberry growing, the Massachusetts Supreme Judicial Court has held that cessation of use of a mill extinguishes the right conferred by the statute to flood upstream lands. *Baird v. Hunter*, 29 Mass. 556, 562 (1832). Thus, if cranberry growing in the Carlisle Cranberry

Bog ceased, any upstream owner whose land is flooded by the dams in the bog could likely bring a successful action to have the dams removed. The Bog Alternatives Committee should determine whether there are any such upstream owners or whether the property flooded by the dams is all owned by the Town of Carlisle. Of course, even if there are such owners, it is possible that they would not object to the continued flooding of their lands.

In addition to the rights that could be asserted by owners of flooded land upstream, water rights could be asserted by owners of riparian land (i.e., land adjacent to the stream) both upstream and downstream. In Massachusetts, riparian landowners have the right to "reasonable use" of the water in the stream running through their land. *Stratton v. Mt. Hermon Boys' School*, 216 Mass. 83, 85 (1913). An upstream or (more likely) downstream owner whose use of the stream is affected by the bog dams could assert that allowing the dams to remain in place after cranberry cultivation has ceased is unreasonable.

It is possible that the Town could rely on a claim of deeded rights to counter assertion of the above-described statutory and common-law rights by other property owners. According to Attorney DiLuna's memorandum (at p. 1), the 1922 conveyance of the cranberry bog land to the Town's predecessor in interest included "all water power, water privileges and flowage rights" from Heart's Pond in Chelmsford. Further research would be required to determine whether these rights did in fact pass to the Town and whether they arguably include the right to maintain the cranberry bog dams.

If, on the other hand, the Town wishes to remove the dams, it does not appear that there is any theory under which upstream or downstream property owners could prevent this action. *Taft v. Bridgeton Worsted Co.*, 237 Mass. 385, 389 (1921) ("The defendant had a right at any time to take down its dam or to cease to impound the water for any reason which seemed to it sufficient.").

In addition to these property rights considerations, note that operation, maintenance or removal of the dams after the cessation of cranberry growing may be governed by the *Dam Safety Statute* (G.L. c. 253, §§ 44-50) and regulations (302 CMR 10.00), depending on the size and other characteristics of the dams. *See* 302 CMR 10.03(2) (definition of "Dam"). Also, cessation of cranberry growing would negate the agricultural exemption that currently applies to operation and maintenance of the dams under the *Wetlands Protection Act* (*M.G.L.* c. 131, § 40) and regulations (310 CMR 10.00). We can provide further information about the requirements of these regulatory schemes when needed.

3. Implications of Cessation of Cranberry Farming: Water Management Act Registration

The *Water Management Act* (*M.G.L.* c. 21G), passed in 1985, governs withdrawals of surface water or groundwater exceeding 100,000 gallons per day.[1] Such withdrawals must either be "registered" withdrawals existing when the Act was passed or permitted withdrawals authorized by MassDEP.

The Town holds a *Water Management Act* registration (attached as Exhibit C) allowing it to withdraw up to 360,000 gallons per day from the surface water bodies on the Carlisle Cranberry Bog conservation land for the purpose of cultivation of cranberries. The "informational sheet" attached to the registration states that "this registration is for cranberry cultivation only; any change in use is subject to Department review and may require a permit application." MassDEP would likely take the position that the Town's right to withdraw its registered volume of water is limited to use for cranberry cultivation; however, in our view, neither the *Water Management Act* nor its implementing regulations (310 CMR 36.00) prevent a registered withdrawal from being put to a new use by the person or entity holding the registration statement. On the other hand, MassDEP approval would clearly be required for any change to the location of the withdrawal point; therefore, the only logistically realistic alternative use for the water may be another form of agriculture at the same location. If the Town wishes to pursue a new use for the Cranberry Bog conservation land that would require continued water withdrawals, we should discuss this issue further.

Sincerely,

Rebekah Lacey

Enclosures

cc: T. Goddard
S. Willard

[1] More precisely, under MassDEP's Water Management Regulations, the threshold volume requiring a permit or registration is an average daily withdrawal volume of 100,000 gallons for any period of three consecutive months, from a total withdrawal of not less than 9,000,000 gallons. 310 CMR 36.03.

Exhibit A

BK3841

BK3841 PG 267

79031

Lowell Cranberry Company

a corporation duly established under the laws of Massachusetts and having its usual place of business at 484 Main Street, Wareham, Plymouth County, Massachusetts, for consideration paid, grants to Town of Carlisle

of Middlesex County, Massachusetts with ~~quitclaim~~ covenants for conservation purposes, as provided by General Laws c.40, Section 8c, ~~the land in~~ and/or for outdoor recreation to be managed by the Conservation Commission of the Town of Carisle,

~~[illegible]~~

All land presently owned by Lowell Cranberry Company formerly Lowell Cranberry Company, in the Town of Carlisle.

Meaning and intending to convey, without limitation, Lots 2, 3 and 4 on Assessor's Plate 30, and Lot 15 on Assessor's Plate 31, both of which Plates were prepared by John E. O'Donnell & Associates, Auburn, Maine for the Carlisle Board of Assessors, revised to January 1, 1985.

Subject to all easements of record.

For title reference, see deeds to grantor recorded with the Middlesex North District Registry of Deeds, Book 658, Page 151; Book 779, Page 448; Book 861, Page 117; Book 892, Page 156; and Book 894, Page 547.

The consideration for this transfer is ONE MILLION EIGHT HUNDRED SIXTEEN FIVE HUNDRED FORTY DOLLARS ($1,816,540.00).

1986 DEC 19 PM 2:13

Property Address: off Acton Road, Carlisle

COMMONWEALTH OF MASSACHUSETTS DEEDS EXCISE 142.80

COMMONWEALTH OF MASSACHUSETTS DEEDS EXCISE 999.99

COMMONWEALTH OF MASSACHUSETTS DEEDS EXCISE 999.99

COMMONWEALTH OF MASSACHUSETTS DEEDS EXCISE 999.99

In witness whereof, the said Lowell Cranberry Company has caused its corporate seal to be hereto affixed and these presents to be signed, acknowledged and delivered in its name and behalf by George Pappageorge its President, Treasurer hereto duly authorized, this 18th day of December in the year one thousand nine hundred and eighty-six

Signed and sealed in presence of

LOWELL CRANBERRY COMPANY

by George Pappageorge, President and Treasurer

The Commonwealth of Massachusetts

Bristol ss. December 18 1986

Then personally appeared the above named George Pappageorge and acknowledged the foregoing instrument to be the free act and deed of the Lowell Cranberry Company

before me

Notary Public—Justice of the Peace

My commission expires Dec. 30, 1987

BK3841 PG 268

79032

COMMONWEALTH OF MASSACHUSETTS

Middlesex, ss. TOWN OF CARLISLE

ORDER OF TAKING

At a meeting of the Board of Selectmen of the Town of Carlisle held this 14th day of July, 1986, it is ordered:

The Board of Selectmen of the Town of Carlisle, duly elected, qualified, and acting as such, on behalf of the Town and by virtue of and in accordance with the authority of the vote under Article 37 of the warrant of the Annual Town Meeting legally called and held on May 12, 1986, and of the provisions of Chapter 40, §14 of the General Laws, as amended, and of any and every other power and authority us hereunto in any way enabling, do hereby take in fee simple absolute on behalf of the Town, and for conservation purposes, as provided by Chapter 40, §8C of the General Laws, and/or for outdoor recreation to be managed and controlled by the Conservation Commission of the Town of Carlisle the following described parcels of land situated in said Town of Carlisle:

A certain parcel of land containing approximately 151 acres believed to be owned by The Lowell Cranberry Company, and known as the Cranberry Bog which is located off both sides of Curve Street in Carlisle, and described by deeds to the Lowell Cranberry Company recorded with Middlesex North District Deeds in Book 779, page 448, Book 892, page 156; Book 861, page 117; Book 658, page 151; and Book 894, page 547, meaning and intending to take all land owned by The Lowell Cranberry Company in Carlisle and roughly bounded as follows:

Lot 15 of Assessors plate 31, containing approximately 18 acres of land bounded on the North by Curve Street; on the East by land of the Commonwealth of Massachusetts and on the South by Lots 4, 7, and 12 of Assessors plate 28;

1986 DEC 19 PM 2:13

Lot 2 of Assessors plate 30 containing approximately 92 acres of land bounded on the North by the Carlisle/Chelmsford town line; on the East by Lot 5, and Martin Street; bounded on the South by Lot 4, and Lot 1, and on the west by Lots 9, 10, Fisk Street, and Lot 11, all on Assessors plate 30; and

Lot 3 of Assessors plate 30 with the building thereon, containing approximately .5 acres and bounded on the South by Curve Street; on the West by Lot 2; and on the East North and West by Lot 4, all on Assessors plate 30; and

Lot 4 of Assessors plate 30, containing approximately 40.2 acres; bounded on the South-Southwest by Curve Street and Lot 3, and on the East, North and West by Lot 2; and for a more detailed description of said lots, see the deeds posted at the Carlisle Town Hall during its usual business hours.

Any and all trees and structures upon the land hereby taken are specifically included in this taking.

We determine that damages are sustained by the persons whose property is taken by this Order as shown on Schedule A, annexed hereto and made a part hereof, and we accordingly award said damages.

The listing of such persons is not intended to limit the taking as above described and the fee in the above-described parcels taken whether their ownership is as stated above or not.

Also, for the purpose stated, but not in any limitations thereof, all right, title and interest of any person or persons in the parcels of land above described which is inconsistent with the taking of the easement herein.

PG 270

SCHEDULE A

LOTS	NAME AND ADDRESS	BOOK & PAGE		APPROX. AREA TAKEN	DAMAGES
Lot 15, Assessors Plate 31; Lots 2, 3 & 4 Assessors Plate 30	Lowell Cranberry Company	779/448; 892/156; 861/117; 658/151; 894/547;	+ -	151 A.	$1,816,540.00

IN WITNESS WHEREFORE, we, the duly elected and qualified Selectmen of the Town of Carlisle, have hereunto set our hands this 15th day of December, 1986.

SELECTMEN OF THE TOWN OF CARLISLE

Katharine P. Simonds, Chairman

David C. Stewart

Harold S. Sauer

COMMONWEALTH OF MASSACHUSETTS

Middlesex, ss. December 15, 1986

Then personally appeared the above named Selectmen of the Town of Carlisle, and acknowledged the foregoing instrument to be their free act and deed, before me,

Notary Public
My Commission Expires:
October 2, 1992

Exhibit B

CONFIDENTIAL Attorney Client Privilege

To: Carlisle Conservation Commission
From: Francis A. DiLuna, Esquire
Date: April 13, 2000
RE: Development of Chelmsford Barnes Terrace Wellfield

FACTS

1. The proposed project in Chelmsford will withdraw 360,000 gallons per minute.

2. The Town of Carlisle is permitted to withdraw 357,000 gallons per day to operate 100 year old, 40 acre Carlisle Cranberry Bog managed by the Carlisle Cranberry Corporation.

3. The Carlisle Cranberry Bogs are historically part of a 159 acre parcel of property lying in both Chelmsford and Carlisle. The Bogs were formerly owned by the Lowell Cranberry Company. The only land in cranberry production is the cranberry bog in Carlisle.

4. On March 24, 1922, the Nickles Cranberry Company, Inc. sold the cranberry bog land other nonproductive lands to the Lowell Cranberry Company (see Book 658, Page 151). Included as a part of that conveyance were "all water power, water privileges and flowage rights" from Hart's Pond. I cannot find an instrument that further terminates these rights. However, I have not conducted an extensive search to determine whether others also hold such rights making our rights non-exclusive.

5. The Town acquired title to the property in 1986.

6. Carlisle acquired the cranberry bog land for conservation purposes pursuant to the provisions of G.L. c.40, §8C. The provisions of §8C allow conservation commissions to acquire interests in property to "limit the future use of or otherwise conserve and properly utilize open spaces in land and water areas within its city or town ...." Consequently, the utilization of this land as an active cranberry bog is a legal and allowed use.

LEGAL ISSUES CONCERNING WATER RIGHTS

Great Ponds

A great pond is any pond containing more than ten acres in its natural state. The title to great ponds, which had not been granted to towns or individuals prior to the Colonial Ordinance, is in the Commonwealth for the benefit of the public, and, if a great pond had previously been granted to a town but had not passed to a private person, the legal title remains in the town, but **the beneficial right is in the public**, *Attorney General v. Revere Cooper Co.*, 152 Mass. 444,

(1890); *Watuppa Reservoir Co. v. Fall River*, 147 Mass. 548, (1888); *West Roxbury v. Stoddard*, 89 Mass. (7 Allen) 158 (1963); *Commonwealth v. Roxbury*, 75 Mass. (9 Gray) 451 (1857).

Public rights in great ponds include:

- fishing and fowling, see *Stater v. Gunn*, 170 Mass. 509 (1898);
- boating, bathing, and skating or riding on the ice, see *Triangle Center, Inc. v. Department of Public Works*, 386 Mass. 858, 438 (1982) (the "common enemy" rule was rejected as "deplorably rigid and anarchic");
- cutting and removing ice for any purpose; and
- **taking water for domestic or agricultural purposes**, see *Slater v. Gunn*, 170 Mass. 509, (1898); *Potter v. Howe*, 141 Mass. 357, (1886); *Fay v. Salem & Danvers Aqueduct Co.*, 111 Mass. 27 (1872); *Cummings v. Barrett*, 64 Mass. (10 Cush.) 186 (1852); *West Roxbury v. Stoddard*, 89 Mass. (7 Allen) 158 (1863);

The exercise of any of the above public rights is allowed provided that such exercise does not unreasonably interfere with the like rights of others.

Fresh Water – Dams And Reservoirs

Massachusetts's law still preserves the right of any person to dam any non-navigable stream and thereby flood the land or lands of others upstream. This private right of eminent domain exists for the following purposes:

- to erect and maintain a water mill, see G.L. c. 256 §§ 1-38;
- to cultivate and grow cranberries, see M.G.L. c.253, §§39, 40; and
- to maintain an ice pond between November first and March first, see G.L. c. 253 § 41.

Anyone who uses or benefits form the damming of a cranberry bog dam must contribute ratably to the expense of erecting and maintaining the dam as determined by the appropriate municipal board, see G.L. c. 253 § 40.

Fresh Water – Consumption And Drainage

Between 1865 and 1979, Massachusetts followed the Gannon Rule, which held that a property owner is liable for damages to adjoining property resulting from activities undertaken on the owner's property that affect the flow of surface waters. See *Gannon v. Hargadon*, 92 Mass. (10 Allen) 106 (1865). The Gannon Rule applied equally to subterranean waters. See *Kennison v. Inhabitants of Beverly*, 146 Mass. 467, (1888). The appeals Court gain followed the Gannon or "Common Enemy" Rule for the last time in 1979 but several of the justices commented and gave notice that it was the intention of the Court to change the doctrine in future decisions. See *Tucker v. Badoian*, 376 Mass. 907, (1978). The Justices adopted a "reasonable use" standard that introduces, in the resolution of quarrels between landowners about surface

waters, the considerations typical of the law of private nuisance. Under the "Rule of Reasonableness" each possessor is legally privileged to make a reasonable use of his or her land, even though the flow of surface waters is altered and causes some harm to others, but incurs liability when his or her harmful interference with the flow of surface waters is unreasonable. See *Tucker v. Badoian*, 376 Mass. 907, 916-919, (1978).

Fresh Water – Great Ponds

A great pond is any pond containing more than ten acres in its natural state. See M.G.L. L. c. 91 § 35. The title to great ponds, which had not been granted to towns or individuals prior to the Colonial Ordinance, is in the Commonwealth for the benefit of the public and if a great pond had previously been granted to a town but had not passed to a private person, the legal title remains in the town, but **the beneficial right is in the public**. See *Attorney General v. Revere Cooper Co.*, 152 Mass. 444 (1890).

Public rights in great ponds include:

- fishing and fowling;
- boating, bathing and skating or riding on the ice, see *People's Ice Co. v. Davenport*, 149 Mass. 322 (1889); *Hittinger v. Eames*, 121 Mass. 539 (1877); *Fay v. Salem & Danvers Aqueduct Co.*, 111 Mass. 27 (1872); *West Roxbury v. Stoddard*, 89 Mass. (7Allen) 158 (1863);
- cutting and removing ice for any purpose; and
- taking water for domestic or agricultural purposes, See *Slater v. Gunn*, 170 Mass. 509 (1898); *Potter v. Howe*, 141 Mass. 357 (1886); *Fay v. Salem & Danvers Aqueduct Co.*, 111 Mass. 27 (1872); *Cummings v. Barrett*, 64 Mass. (10 Cush.) (1852); *West Roxbury v. Stoddard*, 89 Mass. (7 Allen) (1863).

provided the exercise of any right of this nature does not unreasonably interfere with the like rights of others.

Fresh Water – Dams and Reservoirs

Massachusetts' law still preserves the right of any person to dam any non-navigable stream and thereby flood the land or lands of others upstream. This private right of eminent domain exists for the following purposes:

- to erect and maintain a water mill;
- to cultivate and grow cranberries, see M.G.L. c. 253 §§ 39, 40; and
- to maintain an ice pond between November first and March first.

Anyone who uses or benefits from the damming of a cranberry bog dam must contribute ratably to the expense of erecting and maintaining the dam as determined by the appropriate municipal board, see M.G.L. c. 253 § 40.

The right to flood lands of others also is given to domestic reservoir corporations, but the statute does not specifically allow a jury determining the amount of damages to set the dam height or the annual damming period.

ACTION LIST

- utilize political channels to request the Secretary of Environmental Affairs to reconsider the waiver of MEPA process and therefore, require the preparation of an Environmental Impact Report;
- participate in the Article 97 process;
- participate in the Water Management Act Process;
    - submit a Lack of Impact of Water by the Carlisle Bogs and Information concerning Chelmsford Wellfield Impact on Bogs;
    - submit an itemized list of complaints prior to Chelmsford's application for water withdrawal permit;
- participate in Chelmsford Conservation Commission hearing process and possibly appeal any Orders issued.

Exhibit C

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NORTHEAST REGIONAL OFFICE
205B Lowell Street, Wilmington, MA 01887 • (978) 694-3200

DEVAL L. PATRICK
Governor

TIMOTHY P. MURRAY
Lieutenant Governor

IAN A. BOWLES
Secretary

LAURIE BURT
Commissioner

September 10, 2007

Douglas A.G. Stevenson, Chairman
Town of Carlisle
Board of Selectmen
P.O. Box 827
Carlisle, Massachusetts 01741

RE: CARLISLE
Registration Number 3-14-051.01
WMA
Renewed Registration

RECEIVED
OCT - 1 2007
CARLISLE
CONSERVATION COMMISSION

Dear Mr. Stevenson:

Enclosed please find your renewed verified registration statement, number **3-14-051.01,** for water rights under the Water Management Act (M.G.L. 21G). **Your registration has been renewed through January 1, 2018.** Further information regarding the Water Management Act program is attached.

Please note that the signature on this cover letter indicates formal issuance of the attached document. If you have any questions regarding this letter, please contact Kellie O'Keefe by E-mail at kellie.okeefe@state.ma.us or by telephone at (978) 694-3248.

Sincerely,

Eric Worrall
Deputy Regional Director
Bureau of Resource Protection

cc: Duane LeVangie, WMP/Boston (with attachment)
Madonna J. McKenzie, Town Admin., Town of Carlisle, 66 Westford St., Carlisle, MA 01741
Mark Duffy, President, Carlisle Cranberry Inc., 247 North Rd., Carlisle, MA 01741

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WATER MANAGEMENT ACT – CRANBERRY BOG INFORMATIONAL SHEET

Enclosed please find your verified registration statement for water rights under the Water Management Act (M.G.L. 21G). Please note annual reporting requirements, your renewal date, and any conditions that may apply. The regulations governing this statement can be found at 310 CMR 36.00-36.16. DEP's Timely Action and Fee Provision, 310 CMR 4.00, authorizes an annual compliance fee for Water Management Act registrations and permits. Please also note that this registration is for cranberry cultivation only; any change in use is subject to Department review and may require a permit application.

Please be aware that if you increase your planted acreage through the purchase of formerly unregistered bogs or through construction of new bogs, there are thresholds that may require you to obtain a Water Management Act withdrawal permit. Permits are required for:

- Increases in acreage by more than 4.66 acres of "old style" bogs above your registered acreage in each river basin. Old style bogs do not employ Best Management Practices (BMP's).

- Increases in acreage by more than 9.3 acres above your registered acreage in each river basin, including acreage Certified by NRCS as employing BMP's.

- Addition of new withdrawal points not previously registered which withdraw in excess of 100,000 gallons per day or 9 million gallons in a consecutive three-month period of time.

Also, prior to commencement of any on-site activity subject to jurisdiction under the Massachusetts Wetlands Protection Act (M.G.L. c. 131, s40) and its Regulations (310 CMR 10.00), you must file a Request for Determination of Applicability or Notice of Intent application with the local Conservation Commission. You will receive either a negative Determination of Applicability or an Order of Conditions approving/regulating the proposed project.

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NORTHEAST REGIONAL OFFICE
205B Lowell Street, Wilmington, MA 01887 • (978) 694-3200

DEVAL L. PATRICK
Governor

TIMOTHY P. MURRAY
Lieutenant Governor

IAN A. BOWLES
Secretary

LAURIE BURT
Commissioner

REGISTRATION STATEMENT FOR VERIFIED WATER WITHDRAWAL

Verified Registration under MGL c. 21G for the water withdrawal identified below is accepted by the Department of Environmental Protection (the Department).

GENERAL INFORMATION

Registration Number: **3-14-051.01** River Basin: **Concord**

Registrant: **Town of Carlisle**
Carlisle Cranberry Inc.,
66 Westford Street
Carlisle, Massachusetts 02330

Number of withdrawal points: **1**

Groundwater: **0**

Surface water: **1**

Location(s): **Martin and Fiske Streets, Carlisle, Massachusetts**

Use: **Cranberry Production**

Acres: **40 acres**

Average Volume per Day (MGD): **0.36**

Days of Operation: **365**

Total Annual Volume (MGY): **131.40**

NOTE:
MGD-Million Gallons per Day
MGY – Million Gallons per Year

CONDITIONS AND REQUIREMENTS

Compliance with registration conditions is required by 310 CMR 36.08. Those applicable are described below.

Metering

Install source meter for withdrawal point: N/A

Calibrate meter: N/A

Records

The Registrant is required to maintain withdrawal records as follows:

Annual records of bog acreage in production. Individual records of water withdrawal are required to be maintained, if the Department so notifies the Registrant in the future.

Verification:

The Department verified registrations based on the results of a water use study conducted by the University of Massachusetts Cranberry Experiment Station, and on documentation of acreage in production from 1981-1985.

OTHER CONDITIONS and REQUIREMENTS:

REPORTING

The Registrant is required by 310 CMR 36.11 to file an annual statement of withdrawal by the date specified by the Department on the form sent to the Registrant for this purpose. The Registrant shall include all withdrawal records from the previous calendar year with the annual report, including any interim monthly reports that the Department has required the Registrant to keep, in accordance with 310 CMR 36.08.

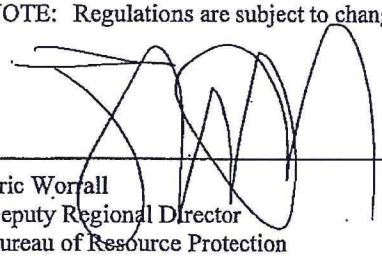
REGISTRATION RENEWAL

This registration statement expires on January 1, 2018, unless a renewal registration request is filed with the Department prior to that date, in accordance with 310 CMR 36.10.

REGISTRATION TRANSFER

Transfer of this registration is governed by the provisions of 310 CMR 36.09. Note that registrations for cranberry cultivation verified using the results of the Cranberry Water Use Study may be transferred as provided in 310 CMR 36.09(1) only if the transfer is for continued cranberry cultivation.

NOTE: Regulations are subject to change. The applicant is responsible to comply with current regulations.



Eric Worrall
Deputy Regional Director
Bureau of Resource Protection

September 10, 2007
Date

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
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Commissioner

Document Transmittal Sheet

DATE: 9/24/2007

TO:BOARD OF SELECTMEN
TOWN OF CARLISLE
TOWN HALL, 66 WESTFORD STREET
CARLISLE, MASSACHUSETTS 01741

ATTN: MADONNA J. MCKENZIE, TOWN ADMINISTRATOR

FROM: KELLIE O'KEEFE, ENVIRONMENTAL ANALYST
WATER MANAGEMENT PROGRAM, NERO

RE: CARLISLE CRANBERRY REGISTRATION RENEWAL

****

[ ] APPROVAL [ ] COMMENT [ ] FYI

[ ] NOTE AND RETURN [ ] AS REQUESTED

Message

Madonna- I have attached the original of the Carlisle Cranberry Registration Renewal for your records. As you can see it was returned as "not deliverable as addressed" using the P.O. Box.

APPENDIX C

LETTER FROM CARLISLE'S TOWN COUNSEL ANSWERING QUESTIONS POSED BY THE CBAC REGARDING WATER RIGHTS

Letter from Jennnie M. Merrill, Miyares and Harrington LLP,
to Sylvia Willard, Conservation Administrator, Carlisle, Massachusetts,
dated January 18, 2017

Miyares and Harrington LLP

A private law firm in the public interest

J. Raymond Miyares
Thomas J. Harrington
Christopher H. Heep
Donna M. Brewer
Jennie M. Merrill

Rebekah Lacey

Ivria Glass Fried
Eric Reustle
Blake M. Mensing

January 18, 2017

Sylvia Willard, Administrator
Carlisle Conservation Commission
66 Westford Street
Carlisle, MA 01741

Re: *Water Management Act*-Cranberry bog Registration Questions

Dear Ms. Willard:

You asked several questions relating to Carlisle's Water Management Act registration for water withdrawals for the 40 acres of cranberry bog located within the Town, which can be grouped into two categories: (1) what impacts will a change in crop have on the volume of water that may be withdrawn on the cranberry bog property?; and (2) what would a change in crop require the Town to do to either preserve its total annual volume or arrive at a new volume of withdrawal from a new withdrawal point?

As discussed in more detail below, based on our review of the relevant statutes and regulations and conversations with the Department of Environmental Protection (DEP), we reach the following conclusions: Depending on the Town's water needs, the Town has the following options: (1) the Town may withdraw up to 100,000 gallons per day (GPD) without modifying its registration, preserving its rights under the registration without using the water allowed under that registration so long as it files the required paperwork with DEP; (2) if the Town requires more than 100,000 GPD, it can modify its registration to allow the town to withdraw 81,000 GPD in addition to the 100,000 GPD threshold volume; and (3) if the Town requires more than 181,000 GPD of water, it will have to to apply for a permit.

To better understand how we arrived at these conclusions a brief overview of some of the major legal concepts that underpin the *Water Management Act*, Chapter 21G of the Massachusetts General Laws (WMA), and its implementing regulations, 310 CMR 36.00, is warranted:

- **Water Management Act: Registered Withdrawals versus Permitted Withdrawals**

The WMA, adopted in 1985, authorizes the DEP to regulate the volume of water withdrawn from the Commonwealth's groundwater and surface water supplies. In concert

with the DEP regulations, the WMA regulates the withdrawal of water under two programs: (1) the registration program; and (2) the permit program. A WMA registration or a permit is required for any withdrawal exceeding the "threshold volume," which is an average daily withdrawal of 100,000 gallons for any period of three consecutive months, from a total withdrawal of not less than 9,000,000 gallons. 310 CMR 36.03.

Registered Withdrawals

The registration program was available for "existing withdrawals," defined as "the average volume of water withdrawn from a particular water source during the five years prior to January 1986." *M.G.L.* c. 21G, § 2. The deadline for filing registration statements was January 1, 1988. Each registration statement entitles its holder to withdraw up to the specified volume of water from the listed withdrawal point(s) in a particular river basin for a period of ten years. Holders of registration statements apply to the DEP for renewal every ten years. Registration statement holders that do not renew their registration statement prior to the expiration of the ten-year period lose the right to withdraw the grandfathered volume of water. There are no new registration statements, only successive renewals of those in existence at the January 1, 1988 submission deadline. As will be described more fully below, cranberry cultivators withdraw and use water in a manner that complicates the application of this grandfathering provision.

Permitted Withdrawals

The WMA created the permit program for water withdrawals that exceed the 100,000 GPD threshold volume and commence after 1985. The permit program is the only option available to those that did not timely obtain or renew a registration statement for withdrawals of water above the threshold volume. Water withdrawal permits are specific to the metered volume withdrawn, the use of the water, and the withdrawal point.

Unique Considerations for Cranberry Bog Water Usage

When the Water Management Act was in its nascent stages, it became clear that cranberry bog water usage was generally not metered. The DEP therefore agreed to issue withdrawal registrations for existing cranberry bog water withdrawals based on an estimated water use of 10 acre-feet[1] of water per acre, per year. This formula can be converted to approximately 3,258,514 gallons per year or 8,927 GPD. *See Cranberry Water Use, An Information Fact Sheet*, U. Mass. (June 2001) *available at* www.umass.edu/cranberry/downloads/Cranberry%20Water%20Use.pdf (hereinafter "*Cranberry Water Use Fact Sheet*"). Carlisle's cranberry bog has a single un-metered withdrawal point under its registration statement. In accordance with DEP's formula, the

[1] An acre-foot is a unit of volume equal to the volume of water required to cover a land area of one acre with one foot of depth, or 43,560 cubic feet. Ten acre-feet would be 435,600 cubic feet of water.

registered volume for the 40 acres of cranberry bog is 0.36 million gallons per day (MGD) (8,927 gallons/acre/day times 40 acres, rounded to two significant figures).

An additional quirk of cranberry bog water usage is that the DEP considers the majority of the water used to be a nonconsumptive use. A nonconsumptive use is "any use of water which results in its being discharged back into the same water source at or near the withdrawal point in substantially unimpaired quality and quantity." *See* 310 CMR 36.03. DEP's Jim McLaughlin has stated that the DEP assumes that cranberry bog water is only 22.5% consumptive and the other 77.5% of the cranberry water withdrawn to be a nonconsumptive use, likely because of its use in flood harvesting[2] and as a frost protection measure.[3] These figures were derived from the typical cranberry irrigation rate of 10 acre-feet per acre per year and the actual average Massachusetts watershed evapotranspiration of 27 inches per year (27"/120" = 22.5%).[4] As discussed in further detail below, DEP's distinction between consumptive and nonconsumptive uses of cranberry registration water dictates how DEP allows a cranberry cultivation registration statement to be modified.

- **Carlisle's Registration and Potential Modification Thereof.**

The Town of Carlisle is considering converting its cranberry bogs to another agricultural use. In the event that this occurs, you have asked for guidance on how this decision will impact the Town's current registration statement. The options available to and requirements of the Town depend on the volume of water that the Town requires for its new activity. As described in more detail below, the key volumes that will dictate the Town's rights and responsibilities are: (1) 100,000 GPD; (2) between 100,001 GPD and 181,000 GPD; and (3) more than 181,000 GPD.

A registration statement states both the volume of water withdrawn and the particular use in place at the time of the original registration. We do not believe that the WMA, in general, allows DEP to control the use of registered withdrawals; however, DEP treats cranberry cultivation registrations as a separate category that requires DEP approval if the registration holder elects to use the water for a different crop. Since this practice is not formalized in the regulations, we reached out to DEP's resident cranberry expert under the WMA, Jim McLaughlin. He revealed that DEP typically allows a change

---

[2] Flood harvesting is, as the name implies, a method to harvest the cranberries by flooding the bog with up to a foot of water. Flood harvesting, also known as wet harvesting, is used to harvest approximately 90% of the total crop. *See* Cape Cod Cranberry Grower's Association, *How Cranberries Grow: Fall, available at* http://www.cranberries.org/how-cranberries-grow/fall. The water used for flood harvesting is reused on different swathes of the bog and is ultimately returned to the water source in near its original quality and quantity. *See Cranberry Water Use Fact Sheet* at 2.

[3] Mr. McLaughlin's March 13, 2013 email stated that DEP assumed that 20% of cranberry water is consumptive. In follow up conversations with Mr. McLaughlin, he clarified that the figure is actually 22.5%.

[4] This calculation was derived in 2003 by Mr. McLaughlin and Dr. Neil Fennessey, a UMass-Dartmouth Professor of Civil and Environmental Engineering.

in crop to something other than cranberry cultivation without implicating the WMA. He explained that water usage for non-cranberry crops does not usually approach the volumes required for cranberry cultivation and therefore do not trigger the WMA's threshold volume of 100,000 GPD.

(1) Activities that do not require more than the 100,000 GPD "threshold volume" of water.

If the Town's new farming activities will not require more than the 100,000 GPD threshold volume of water, Mr. McLaughlin advised, and we concur, that the Town should maintain its current registration statement and continue to file its annual cranberry registration reports to preserve the registration volume and allow the Town to switch back to cranberries if necessary. The annual reports would show zero GPD for cranberry cultivation, but that would be sufficient to preserve the full volume of 360,000 GPD under the current registration statement if there were ever a need or desire for a reversion to cranberry cultivation. Under this scenario, the Town could conduct a multi-year trial run for other crops to see if the change in commodity was more profitable, safe in the knowledge that the cranberry volume was still available if those crops did not produce the desired results. Under this approach, the Town would not be required to apply for a modification to its registration or a permit unless the new crop required a volume of water that would trigger either of these requirements.

(2) Activities that require more than the 100,000 GPD "threshold volume" but less than 181,001 GPD of water.

If a new crop required a volume of water exceeding the 100,000 GPD threshold volume, Mr. McLaughlin informed us that the DEP's standard operating procedure is to require a modification of the registration statement. Because water use for cranberry growing is mostly nonconsumptive only a fraction of the registered volume can be converted to another consumptive use, such as irrigating another crop. Therefore, if a modification of the registration is required, the Town could seek approval to modify the registration statement due to a change in commodity. DEP's practice is to assume that 22.5% of the volume of water allowed in the cranberry registration statement is consumptive and may be converted to other uses. Therefore, if Carlisle sought to modify its registration statement, DEP would allow such a modification by reducing the registered volume to 81,000 GPD (22.5% of the 36,000 GPD registered volume) and allowing this volume of water to be used on activities other than cranberry growing. The Town could then use this volume of water in addition to the 100,000 GPD threshold volume for a total of 181,000 GPD.

(3) Activities that require more than 181,000 GPD of water.

If the new crop requires water withdrawals in excess of 181,000 GPD then Carlisle will have to apply for a permit. 310 CMR 36.16(1)(b).

In addition to your questions regarding overall impact of changing the current crop from cranberry cultivation to another crop, you also asked what would constitute a new withdrawal point?

The WMA Regulations provide the following definitions:

> Withdrawal Point means any well or intake structure used to withdraw water from a water source.
>
> ...
>
> Water Source means any natural or artificial aquifer or body of surface water, including its watershed where ground and surface water are interconnected in a single hydrological system...

310 CMR 36.03

Therefore, a new withdrawal point would be one other than the one described in the Town's initial registration statement, which should reference an "intake structure" and a "body of surface water." The Town's current registration statement for the cranberry bog registration states that the withdrawal point is located at "Martin and Fiske Streets, Carlisle." Presumably, the Town's initial registration statement filed in the 1980s described the withdrawal point more precisely; if not, the Town should obtain information from the current cranberry farmer regarding the withdrawal point that he has used in practice.

If you have any questions please call me at (617) 489-1600.

Sincerely,

Jennie M. Merrill

APPENDIX D

DATA COLLECTED TO SUPPORT THE PREPARATION OF THE REPORT ON ALTERNATIVE 5: CONVERSION TO OTHER AGRICULTURAL USE

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Soil Core Photos for the In-Renovation Field, taken 8-6-16 ….……..D-13

Soil Core Photos for the Irrigated Field, taken 8-30-16 ……...…...…D-15

Plants on the Cranberry Bog Fields by Indicator Code[a] (Footnotes follow Table 2)

The indicator code of a plant is a qualitative code that signifies the preferred hydrological environment of a plant. Each plant's indicator code conveys to ecologists certain information about the soil type, hydrology, and drainage of an environment and is used to aid in delineating that environment. Obligate wetland and obligate upland plants are indicator species because they have a very strong preference, respectively, for a wetland or upland environment. Obligate wetland, facultative wetland, and facultative plants have adapted unique anatomical and physiological features for tolerating the anaerobic characteristic of saturated soil allowing them to dominate wetlands. These plants are, therefore, particularly useful for delineating wetlands. **Table 1** describes the indicator codes as specified by the USDA's Natural Resources Conservation Service. **Table 2** lists the plants found in the three Cranberry Bog fields, sorted by indicator code.

Table 1. Indicator Code Descriptions for Plant Species' Occurrence Preference

Indicator Status	Indicator Code	Plant Characteristic	Occurrence	
			In Wetlands	In Non-wetlands
Obligate Wetland	OBL	Hydrophyte	Almost always	Not usually
Facultative Wetland	FACW	Hydrophyte	Usually	Possibly
Facultative	FAC	Hydrophyte	Usually	Usually
Facultative Upland	FACU	Nonhydrophyte	Possibly	Usually
Obligate Upland	UPL	Nonhydrophyte	Rarely	Usually

Table 2. Plants Found on the Cranberry Bog Fields by Indicator Code

Indicator Code	Plant (*Botanical name*)	Plant (Common name)	Sand-Covered	In-Renovation	Irrigated Bog
OBL	*Asclepias incarnata*	Swamp milkweed	X	X	
	Carex lurida	Shallow sedge	X	X	X
	Cephalanthus occidentalis	Buttonbush	X	X	X
	Eutrochium maculatum L.	Joe Pye Weed	X	X	X
	Lythrum salicaria	Purple Loosestrife	X	X	X
	Myrica gale L.	Bayberry		X	X
	Osmunda regalis L.	Royal Fern		X	
	Polygonum amphibium L.	Water Knotweed		X	X
	Pontederia cordata	Pickerel Weed	X	X	X
	Sagittaria latifolia	Arrowhead		X	
	Scirpus atrovirens	Bulrush	X	X	X
	Scirpus cyperinus	Woolgrass	X	X	X
	Sphagnum palustre	Sphagnum moss	X	X	X
	Typha angustifolia L.	Narrow-leaved cattail		X	X
	Typha latifolia	Broad-leaved cattail	X	X	X
Number of Types of Obligate Species Found			10	15	12
FACW	*Alnus incana*	Speckled Alder	X	X	X[b]
	Carex tribuloides		X		
	Lyonia ligustrina	Maleberry	X	X	
	Panicum rigidulum	Redtop panicgrass	X		
	Phragmites australis	Common Reed Grass			X
	Spiraea alba	White Meadowsweet	X	X	X[c]

Indicator Code	Plant (*Botanical name*)	Plant (Common name)	Sand-Covered	In-Renovation	Irrigated Bog
	Spiraea alba var. latifolia	Pink Meadowsweet	X	X	X
	Symphyotrichum novae-angliae	New England aster		X	X
	Thelypteris palustris	Eastern Marsh Fern	X	X	
	Vaccinium corymbosum	Highbush Blueberry		X	X
Number of Types of Facultative Wetland Species Found			7	6	6
FAC	*Acer Rubrum*	Swamp maple		X	X
	Betula populifolia	Gray Birch		X	X[b]
	Euthamia graminifolia	Flat-topped goldenrod		X	X
	Eutrochium maculatum	Joe Pye weed	X	X	X
	Rubus hispidus	Swamp Dewberry	X	X	X
	Toxicodendron radicans	Eastern poison ivy		X	X
Number of Types of Facultative Species Found			2	6	6
FACU	*Ambrosia L.*	Ragweed	X	X	X
	Elaeagnus angustifolia	Olive tree	X[b]		
	Frangula alnus[c]	Glossy Buckthorn		X[c]	X[c]
	Juniperus virginiana	Eastern red cedar	X[b]		
	Pinus strobus L.	White Pine	X	X	X[b]
	Polygala sanguinea L.	Purple Milkwort	X		
	Solidago arguta Aiton	Atlantic Goldenrod		X	
	Vaccinium angustifolium	Lowbush Blueberry	X	X	X
	Vitis labrusca	Fox Grape		X	X
Number of Types of Facultative Upland Species Found			6	6	5

[a] Road banks along fields excluded but drainage ditches included

[b] Only one or a few specimen(s) found

[c] Non-native plant or non-native invasive plant species

Soil Horizons of Organic Soil

Mineral soils develop from the physical and chemical weathering of bedrock and the mineralization of organic matter by soil organisms. These processes of weathering and mineralization alter the original mineral and organic compounds, mobilizing them. As the newly created mineral compounds are released, they precipitate down through the soil profile, enriching some sections while depleting other sections. This movement of these chemicals creates distinct layers of soil that soil ecologists refer to as horizons. Specific alphabetic letters are used to identify each type of horizon of mineral soils that have particular characteristics.

Organic soils comprise predominately plant and animal matter and lack compounds from bedrock in sufficient amounts to develop the same kinds of horizons. The concept of using an alphabetic nomenclature to recognize the differing horizons found within the Cranberry Bog soils has been borrowed for the Cranberry Bog soil reports. For these organic soils, the letters simply identify the vertical location of the horizon and indicate that one or more characteristics vary from the other horizons. The differentiating characteristics may be texture, moisture level, or degree of decomposition of the organic matter. In the following soil reports, the letter "A" indicates the first horizon just below the surface, followed by "B" for the second horizon below the surface and "C" for the third horizon below the surface. If a horizon's soil varies only in moisture content but not texture or degree of decomposition from another horizon, then the same horizon letter is used for each horizon with the addition of a subscript to distinguish them.

Soil Analysis of the Sand-Covered Field

The Conditions

On Sunday, June 19, 2016, soil core samples were taken from five locations. The weather was sunny and humid. Historically, 0.66 inch of rain has fallen since July 1 and 1.99 inches of rain since June 1. Since the beginning of the year, this area is 5.37 inches below the average precipitation. During most of the summer months, the Sand-Covered field usually has areas of standing water or is soggy underfoot, but this summer the entire field has been dry on the surface.

The Locations (**Figure 1**)

The selection of the sampling points was based on differences in vegetation.

- Location 1. a moss-covered area
- Location 2. an area covered with reddish-purple tinted grass
- Location 3. an area covered in bulrushes. Location 3 is the area that is usually soggy or has some standing water and the presence of bulrushes, a wetland obligate plant.
- Location 4. an area with minimal vegetation
- Location 5. an area with a mix of vegetation

The intention was to take two soil cores at each sample location from the same hole, with the second core deeper than the first, to be sure of the depth of the sand. In Locations 2, 3, and 4, a mix of sand and small pebbles prevented the taking of a second core. For the sake of consistency, only the testing on the first core is reported here unless some remarkable detail warrants comment.

The Results (**Table 3**)

- Moisture. Every soil core had varying degrees of moisture content and, as anticipated, was almost 100% coarse sand. The depth of the sand horizon ranged from 4 to 12 inches thick. The soil was at field capacity moisture (very moist to the touch but no dripping water from the sample).
- Soil Composition. The sand horizon was on top of a 1 to 5 inch medium-to-dark-brown horizon of very sandy organic muck. The muck was mostly decomposed (sapric), which is typical for wet soils formed long ago (thousands of years). Because of the anaerobic conditions, the organic matter (primarily sphagnum plus other plants) decomposed very slowly. The color of the sand ranged from tan to a yellow-red tan.

Figure 1. Soil Core Locations in the Sand-Covered Field

Table 3. Characteristics for Each Soil Core Sample of the Sand-Covered Field

Location	Vegetation	Soil Horizon		Texture	Moisture	pH
		ID[a]	Thickness (inches)			
1	Moss-covered	A	9	Sand	Moist	5.5
		B_1	1	Sandy muck	More moist	5.8
		B_2	1	Sandy muck	Wet	5.5
2	Red grass	A	3.5	Sand	Moist	6.2
		B	1	Sandy muck	More moist	6.3
		C	1.5	Sand with small gravel	Moist	6.7
3	Bulrushes	A	6	Sand	Moist	5.5
		B	5	Sandy muck	More moist	6.5
4	Grasses	A	12	Sand	Moist	5.5
5	Mostly barren	A	11	Sand	Moist	5.5
		B	2	Sandy muck	Moist	5.0

[a] Labels for sequential layers of soil starting from the surface and going down.

Soil Analysis of the In-Renovation Field

The Conditions

On Sunday, August 6, 2016, soil core samples were taken from 10 locations on the In-Renovation field. The weather was sunny, hot, and humid. Historically, 0.92 inches of rain has fallen since July 1 and 1.99 inches of rain since June 1. So far in August, 3.03 inches of rain has fallen. Since the beginning of the year, this area is 8.26 inches below the average precipitation. During most of the summer months, the In-Renovation field usually has areas of intermittent standing water on the southern eighth of the field and is soggy underfoot in various other places. The northern eighth of the field is usually saturated without standing water. However, this summer with the drought, the entire field has been much less saturated but still remarkably moist. No water has been flowing into the In-Renovation field from the northern reservoir since May. The northern reservoir is nearly dry, although recent precipitation has slightly replenished it.

The Locations (**Figure 2**)

The selection of the sampling points was based on differences in vegetation or known historical levels of saturation.

- Location 1 (section 12 southeast). known to remain saturated, location next to depressed tractor tracks
- Location 2 (section 12 southeast). known to remain saturated, but away from sunken tractor tracks

- Location 3 (section 12 southeast). southeast corner next to a white pine tree, a plant that does not do well in a saturated soil but does like a well drained, moist soil
- Location 4 (section 9). northeast corner where there is the most plant diversity growing in the In-Renovation field; this area includes alder, lyonia, bayberry, lowbush and highbush blueberry, cranberry, royal fern, sphagnum moss, cattails, smart weed, spirea, goldenrod, Joe pye weed, maple saplings, and many others
- Location 5 (section 7). area with white pines and speckled alder
- Location 6 (section 2 north). area predominated by cattails, sedges, and purple loosestrife
- Location 7 (section 2 south). mowed area, plants unknown due to mowing
- Location 8 (section 3 north). depression in mowed field, plants unknown due to mowing
- Location 9 (section 2 center). normally a wet area with predominately sedges and other herbaceous plants
- Location 10 (section 3 center). diverse plant area with the most swamp dewberry, blueberries, and many other herbaceous perennials, but no trees; this area contains the most even balance of plant species distribution of the In-Renovation field

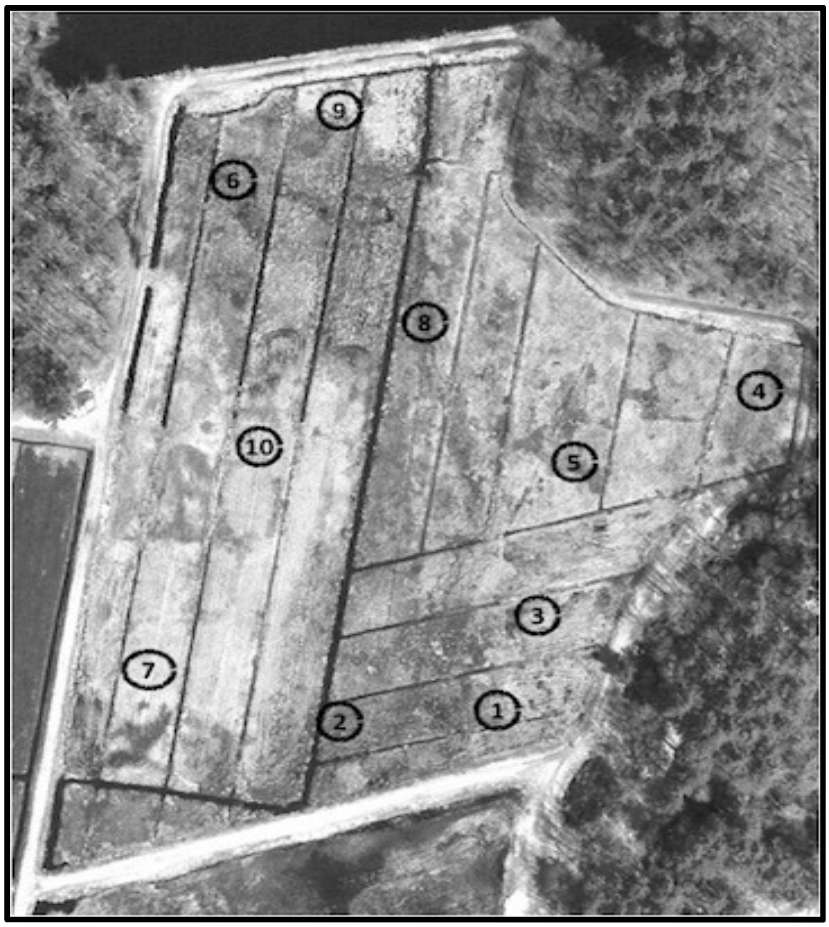

Figure 2. Soil Core Locations in the In-Renovation Field

The Methodology

One core sample was taken from each location. In the more saturated locations, the suction from the anaerobic soil conditions pulled out some of the soil core, resulting in a gap in the soil sample. Even gently rocking the corer back and forth did not sufficiently reduce the powerful suction of the anaerobic soil to prevent the gaps for core samples 2 and 3. The northern and the southern parts of the In-Renovation field were the most saturated.

The Results (**Table 4**)

- Moisture. Every soil core was moist to very moist as anticipated, given the soil core results from the Sand-Covered field. The plants showed no sign of water stress, and most plants were bearing fruit.
- Soil Composition. Cores 1 and 2 were entirely muck soil with no sand layers and the wettest soil. Roots from current vegetation were visible, but the original sphagnum was mostly decomposed (hemic to sapric) muck. In some areas, the sand and organic horizons were visible, but, in other areas, the two were mixed. A few areas were mostly sand. Overall, the composition of the soil varies considerably, which partially explains the difference in vegetation.

Soil Analysis of the Irrigated Field

The Conditions

On August 26 through August 30, soil core samples were taken from 12 locations on the Iirrigated field (the field in production). The weather was sunny, hot, and humid, and Carlisle was still in a severe drought. The Iirrigated field never has areas of intermittent standing water due to the number of drainage channels that have been maintained over the years and the sand that has been added. The western reservoir that services the Irrigated field was very low, with some exposed mud bottom in the shallower areas.

The Locations (**Figure 3**)

The sampling points were evenly distributed over the 22 sections. Some consideration was given to plant communities other than cranberries.

The Methodology

One core sample was taken from each location. In the more saturated locations, the suction from the anaerobic soil conditions sucked out some of the soil core, resulting in a gap in the soil sample.

Table 4. Characteristics of Each Soil Core Sample of the In-Renovation Field

Location	Vegetation	Soil Horizon		Texture	Moisture	pH
		ID[a]	Thickness (inches)			
1	Adjacent to tractor tracks	A	15	Muck	Very moist to saturated	5.8
2	Beyond tractor tracks	A	10	Muck	Very moist to saturated	5.8
3	Near white pine tree	A	12	Sandy muck	Moist to saturated	5.8
4	Most plant diversity	A	5	Sandy muck	Moist	5.5
		B	9	Muck	Moist	5.0
5	Alder grove	A	6	Sand, gravel barrier	Moist	5.0
6	Cattails	A	12	Very sandy muck	Moist	5.0
7	Mowed area	A	15	Sandy muck	Moist	5.8
8	Damp depression in mowed area	A	4	Sandy muck	Damp	5.5
		B	8	Very sandy muck	Damp	5.0
9	Sedges	A	5	Sandy muck	Very moist	5.5
		B	8	Muck	Very moist	5.5
10	Diverse & balanced with blueberries, dewberry & others	A	2	Sand	Moist	5.5
		B	7	Sandy muck	Very moist	5.8
		C	2	Mucky sand	Very moist to saturated	5.5

[a] Labels for sequential layers of soil starting from the surface and going down

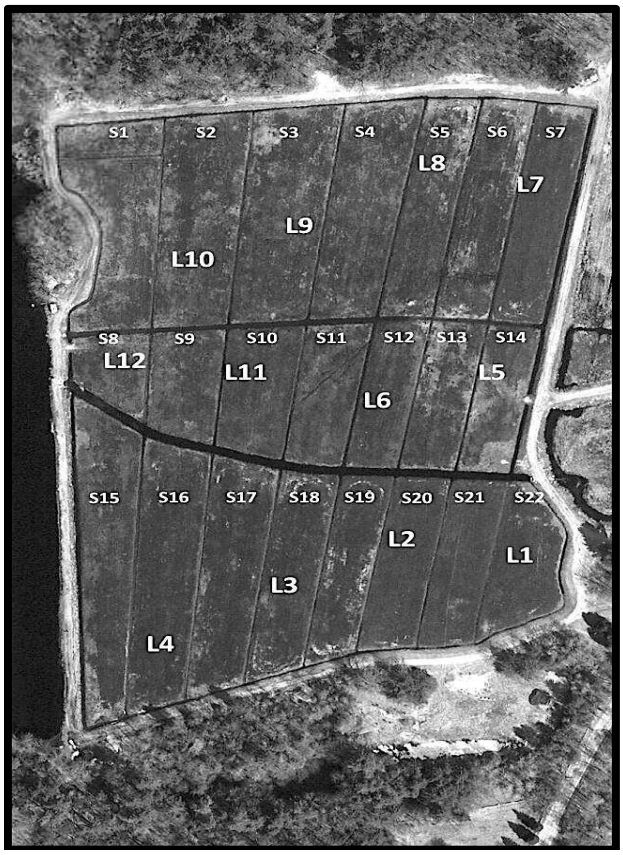

Figure 3. Irrigated Field with Sections (S) and Soil Core Locations (L)

The Results (**Table 5**)

- Moisture. Every soil core was damp to very moist. The soil in Section 8 was the most saturated soil of the 12 sections tested.

- Soil Composition. The soil horizons were either sand, sandy muck mixture, or mostly decomposed hemic (some plant fibers) to sapric (no visible plant fibers) muck. Four cores had distinct sand horizons, and all cores had a muck layer. Eight cores had sandy muck horizons. Even with the prolonged severe drought, the muck horizons had ample soil moisture. The sand and sandy muck, however, tended to be dryer and showed uneven evidence of cranberry plant stress due to the drought.

Table 5. Characteristics for Each Soil Core Sample

Core	Section	Soil Horizon		Texture	Moisture	pH
		ID[a]	Thickness (inches)			
1	22	A	8	Sand	Damp	5.0
		B	6	Muck	Moist	5.3
2	20	A	4	Muck	Moist	5.5
		B	10	Sand	Damp	4.8
3	18	A	14	Sandy muck	Moist	5.5
4	16	A	14	Sandy muck	Moist	4.8
5	14	A	13	Sandy muck	Damp	4.5
6	12	A	13	Sandy muck	Damp	5.0
7	7	A	7	Sand	Damp	5.0
		B	7	Muck	Moist	6.0
8	5	A	9	Sandy muck	Damp	5.5
		B	6	Muck	Moist	5.0
9	3	A	5	Sandy muck	Damp	5.0
		B	7	Muck	Moist	5.2
10	2	A	9	Sand	Moist	5.2
		B	6	Muck	Moist	5.0
11	10	A	8	Sandy muck	Damp	4.5
12	8	A	8	Very sandy muck	Moist	5.5
		B	8	Very sandy muck	Very moist to wet	4.7

[a] Labels for sequential layers of soil starting from the surface and going down

Sand-Covered Field Soil Cores 6-19-16

Core 1 - Moss-Covered

Core 2 - Red Grass

Core 3 - Bulrushes

Core 4 - Mixed

Core 5 - Barren

In-Renovation Field Soil Cores 8-6-16

Core 1 - Adjacent Tractor Marks

Core 2 - Beyond Tractor Marks

Core 3 - Near White Pine

Core 4 – Most Plant Diversity

Core 5 – Alder Groves

Core 6 – Cattails

In-Renovation Field Soil Cores 8-6-16 (continued)

Core 7 – Mowed & Drier

Core 8 – Damp Depression

Core 9 – Sedges

Core 10 – Diverse &
Evenly Distributed Plants
Plus Blueberries

Irrigated Field Soil Cores 8-26-16

Core 1 – Section 22

Core 2 - Section 20

Core 3 – Section 18

Core 4 – Section 16

Core 5 – Section 14

Core 6 – Section 12

Irrigated Field Soil Cores 9-3-16 (continued)

Core 7 – Section 7

Core 8 – Section 5

Core 9 – Section 3

Core 10 – Section 2

Core 11 – Section 10

Core 12 – Section 8

Art by Phyllis Hughes