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Water Security at Whiting Farm: 2016 Report

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Water Security at Whiting Farm: 2016 Report

PROPOSAL

Submitted to: John F. Murphy Homes & Kim Finnerty
Submission Date: December 14, 2016
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Executive Summary

This report provides an analysis of the current water use at Whiting Farm in Auburn, ME, and provides suggestions for implementing systems that will reduce water use, make Whiting Farm independent in water acquisition, and provide ways to try to ensure water security going into the future.

Currently, Whiting Farm suffers from unreliable and unsustainable water use exacerbated by the drought that occurred in the past few months. The farm system as a whole uses an enormous amount of water every day, and is reliant on an insufficient source of water—a hand dug well sourced from a seasonal irrigation pond. The Whiting water system could be improved from a variety of additions and changes to the current water use. As Whiting’s current well is not a dependable source of water for the farm, investigation into the location and depth of a new well is mapped out in this report. The installation of a washing station in conjunction with the new well is also suggested to improve water use and effort required to wash vegetables for sale at the on site farm stand. The idea of installing rainfall collection systems for use on Whiting’s greenhouses has been investigated, and specifically it has been found that implementing gutter-catchment structures on the outer surface of greenhouses is the most efficient form of rain catchment. This method has been shown to collect as much as 20,000 gallons in a season in areas with similar rainfall characteristics as Maine, and on smaller greenhouses, meaning Whiting could exceed 20,000 gallons of collected rainwater per season. Within the greenhouses, installing a new system to water the poinsettia cash crops is discussed to mitigate the 3.5 hours and 3000 gallons of water currently required. Two methods, ebb & flow and capillary mat, are suggested to improve the water use efficiency and time required to water, and are compared in terms of cost of installation, water use efficiency, ability of water reuse, and ease of use. The installation of a bathroom facility is also very important because there currently is no bathroom facility on site and would allow for larger groups of people to be maintained on the property. In order to try to prevent creating additional need for water, investigation into the possibility of a composting toilet and septic system on the farm is discussed.
Introduction

Our community engaged project is centered around Whiting Farm, a small, local farm in Auburn, Maine, run by Kim Finnerty and The John F. Murphy Homes foundation. Whiting Farm sustains itself by growing and selling flowers and vegetables. Here in Maine, considered a “water rich state” (Sen Gupta, Jain, & Kim, 2011), freshwater resources are naturally readily available and heavily relied on (Schmitt 2003). However, droughts can and do occur, usually toward the end of the summer months but sometimes stretching across multiple years. Drought affects surface water resources by reducing water quantity and altering water quality (Schmitt 2003). These droughts can cause widespread socio-economic impact, including 17,000 private wells going dry and $32 million in crop losses during the 1999-2002 drought in Maine (Lombard 2004). Maine’s people, agriculture, and economy are exceptionally vulnerable to these “hydroclimate extremes” (Sen Gupta, Jain, & Kim, 2011) because they rely on naturally sourced water, including local farms and farmers in our area, such as our community partner. In the past several months, Maine and much of New England has been in the depths of the worst drought in more than a decade (McGuire 2016), with one third (33%) of the state facing moderate to extreme drought, compared to only 10% of the state facing moderate drought the same time last year (Artusa, 2016). The Lewiston/Auburn area falls in the “severe drought” category. As the worst drought in more than a decade has gone from severe to extreme in southern Maine, many families and businesses who rely on shallow private wells have run out of water (McGuire 2016).

Whiting Farm, a local, small scale farm located in Auburn, ME, is currently run by Kim Finnerty, the chief of operations at the farm. In the past, Whiting was a family owned and operated farm for several decades, but after family members faced serious health problems, the farm could no longer be productive or taken care of, and the property was bought by John F. Murphy Homes, a non-profit company with the goal of providing those with developmental and physical disabilities the opportunity to improve and develop skills, independence, social skills and community involvement (“What We Do”). After the initial involvement of the John F. Murphy Homes, Kim Finnerty was appointed as the onsite program director, effectively running operations on the farm property on a day to day basis. Kim grows a variety of crops in large greenhouses and in fields on the farm, with poinsettias and mums as her cash crops in addition to
growing a variety of vegetables. This wide variety of crops requires the farm and Kim to be operational at Whiting essentially all year round.

Since Kim’s establishment in this role at Whiting, she has identified quite a few improvements necessary for the continued success of the farm in the future. In the past, Kim, along with other Bates Environmental Studies groups, has investigated the application of a septic system on the Whiting property (Horstmeyer et al., 2015) and new, more efficient energy sources for the farm (Yudkin et al., 2015), and has also carried out projects that have reused lots of waste found on the property (Baker et al., 2015). Looking forward, Kim has plans to expand the operations of the farm to include cooking classes, educational events, hosting long-term interns on property and establishing more wildflower and vegetable production.

Kim’s new goal for the continued growth of Whiting Farm is the establishment of systems for the improvement of water efficiency around the farm and water security going into the future. This new goal does not just come from her desire to take steps to become a more environmentally conscience presence in the community, but is also a necessary improvement to ensure a secure water source for Whiting’s future. Fairly recently, the dug well relied on to irrigate the farm ran dry, which was only the second time it has run dry in the history of the farm. To prepare to accommodate for future conditions where water scarcity may be an issue of even more relevance, Kim has indicated a few problem areas within the farm system where water is an issue, and we have suggested a few alterations to try to reduce the amount of water and time spent on irrigation at Whiting, possibly reuse some of the water being wasted, and acquire additional water from new sources.

This study includes our analysis and consultation on five different elements that could lead Whiting to becoming water secure in the future. These elements include the installation of rainfall collection systems on site, the analysis of current watering practices and suggestions for more time- and water- efficient methods of watering poinsettias, an overview of ideas for bathroom facilities, and more efficient methods to wash farm stand produce. The installation of a new well on site is currently being undertaken, but suggestions for the placement and size of a new well are included in this proposal for use as the investigation of this project continues.
Farm System

Currently at the farm, water is sourced from an 80+ year old hand dug well. When there is normal precipitation, the well is filled from natural surface groundwater, but during times of drought, like the past few months, there is a lack of groundwater and the well runs dry. In this case, water is pumped into the well from a nearby seasonal irrigation pond, which means that the well water is no longer clean or sanitary. The water is then pumped, using an aboveground pump, out of the well to a 5,000 gallon holding tank across the property. During peak production, watering in the greenhouses requires upwards of 4,500 gallons of water per day, so the holding tank must be refilled daily. The water from the holding tank is then pumped through each of the five greenhouses holding poinsettias, mums, other produce and out to the growing fields (see Figure 1). The greenhouses holding the mums are equipped with a new drip irrigation system, but the greenhouses with the poinsettias are watered by hand which uses considerably more water. The vegetables grown in the fields and greenhouses are sold at an on site farm stand, but in order to wash the vegetables water must be sourced from elsewhere because the water from the pond and well is not sanitary.

Looking at the water use on the farm as a whole, there are many places where water use could be improved. The sourcing of water from the shallow well and irrigation pond is unreliable and unsustainable.

Figure 1: Overview of water use at Whiting Farm.
Amounts of water used are based on peak production time and varies throughout the year.
The current well merely goes below the water table and gets recharged with groundwater, which means it is much more vulnerable during dry weather. A deeper well that goes into the bedrock would typically not dry out even during drought periods. This would allow for a more efficient and reliable water source for the whole farm. Other areas, like irrigating the poinsettias, could be improved to use less water, and new aspects could be installed, like rainwater catchment, to collect additional water to supplement the water supply. This would allow for the whole farm to be more water efficient and be confident in their water supply.

Well Installation

Introduction:
Of the pieces required for water security at Whiting Farm, the installation and implementation of a new well is going to happen first. Since changing into the hands of the John F. Murphy Homes, the farm has relied on the a smaller dug well on the property which has worked with the scaled down agriculture and increased educational goal farm. Unfortunately, drought and long summers have taken their toll on the 8 ft dug well and it’s yield was exceeded this past fall for the first time in over 20 years. Fortunately the growing season was saved by rewiring the system and pumping water from the aboveground irrigation pond through the well. While it was a temporary solution, it also compromised the cleanliness and limited future use of the dug well. Thus Whiting Farm needs a new well and accompanying system that can pump over 5,000 gallons of water a day -- maximum estimate of water needed per day in peak growing season; and recharge adequately to repeat it again following day. The well needs to be deep enough to reach the layer of bedrock under the northwest portion of the farm to access the groundwater that permeates in the cracks and fissures (Appendix 1). Maine has strict well drilling regulations, and future development on Whiting Farm has to be taken into account before taking any immediate action. Similarly, in regards to other pieces of this project the well will have to be 60 feet from any sewage system or wastewater disposal site; and 100 meters away from leach fields. Countermeasures for agricultural runoff will have to be taken into account, like locating the well uphill of any supplementary produce/aesthetic based agriculture that is done in the greenhouse off season. Additionally, due to the hands-on and incredible homemade work done
on the farm an extensive analysis of pipes and belowground development needs to be done before implementation.

**Results**

After looking at the topography and hydrogeology of Whiting Farm, a rough area estimate for well location would be about 100 meters (300 ft) to the Northeast of the 1st greenhouse system (red dot). This spot is the closest to bedrock according to topographic bedrock maps) of the area outlined by Kim. This would account for future slated development (additional greenhouse, education center, outreach housing, and farmhouse) and is located at a higher elevation than irrigation pond, fertilized fields, and where washing area/dry restroom located. Initially the yellow dot was another place to be considered for drilling, but the necessity of a restroom facility and the inconvenient distance has ruled it out (Hostmeyer et al. 2015). The well location and cost is pending a professional census, and all findings are superseded by local professionals. Based on topographic bedrock maps, and by tallying wells in the immediate area and their depth, the well itself would be in the range of 350-550 ft deep (106-170 meters) and 6-8 inches wide (16-20 cm). Additionally, utilizing well depth and yield maps old data on the Whiting Farmhouse Well, which is approximately 400-500 ft with an average yield of over 6-8 gpm (Appendix 2) and was able to power a larger more agriculture intensive farm, sets good parameters for future implementation of drilled bedrock wells. All estimates are based off Old Whiting Well in conjunction with surrounding farm and household depths/yields. The maximum needed yield to ensure Whiting Farm’s water security is 3.5 gpm, which would be a little over 5,000 gallons a day. In the lower estimation, the average price for the combined drilling and excavation cost is $23,529; on the other hand if the well has to drill even deeper and incur additional cost the price could be as much as $33,832 (Appendix 3). Establishing this well is the foundation for Whiting Farm’s future water security.
Farmstand Vegetable Washing

Introduction
Besides the flower crops, there are also a wide variety of vegetable crops grown at Whiting in the fields and smaller green houses. These vegetables are harvested and sold at a farm stand on site. Before being sold, the vegetables have to be washed to remove dirt, and currently, the vegetables are taken to a different location to use running water to wash them off. For this portion of the project, it is hoped that this process can become more efficient in terms of water use and transportation, searching for a location and source of water on site to wash the vegetables. This would allow the vegetables to be harvested, washed and sold all within the farm system.

Results
Initial research was conducted around the idea of searching for new sources of water on the farm to use to wash vegetables, examining the pond water, rain water, and the excess water from irrigation. After initial research around the standards set by the USDA and the Maine DACF for washing vegetables, it was determined that the water used in this case should be “potable water”, as specified by the Maine DACF (Newbegin 2016). After examining possible sources of water, it was determined that using any of the above listed sources would not qualify as potable water without complex and time consuming water filtration and purification. Switching in a different direction, it was decided that the best source of water would be from the new well that is proposed above.
Since a new well is likely to be built, this would be a ready source of potable water. To accompany the well to wash the vegetables, a washing station is suggested to be built in conjunction with the well site (Figure 2). This washing station would include a wash basin, hose from the well, and drainage, as well as areas to let vegetables dry. The washing station is totally customizable, and can range from very simple models, with just a basin and drying rack, to more complex, permanent models with multiple basins and space (see Appendix 4). The washing station can also vary in the amount of time and effort required to build it. Some models can be ordered online as a kit, while others can be built totally from scratch following a guide (see Appendix 5). Both of these factors affect the price of the washing station, with the more complex, pre-built models being more expensive. This would allow for a more efficient and cleanly place to wash vegetables, and would meet all state and federal requirements.

**Rainfall Collection**

**Introduction**

The Lewiston area receives about 3-4 inches of precipitation per month, meaning about 45 inches every year. With approximately 1 inch of rainfall collecting 0.6 gallons of water per 1 ft$^2$ of roofing, there’s the possibility of Whiting collecting over 50,000 gallons of rainfall per year off per greenhouse! The collection of rainfall is a simple way to reduce the amount of water being used from other sources—such as a well, and is regulated on a state to state basis. Maine has no regulations on rainfall collection, and the Portland water district actually provides a fact sheet about the benefits of installing rain barrels (pwd.org). Although there are quite a few greenhouses located on the farm property, this report will do collection and cost calculations per greenhouse, so as to provide Whiting with the option to choose accordingly to how much water they feel they need to collect, and to accommodate a budget. This reports calculations will use the dimensions of the majority of Whiting’s greenhouses, 34’ x 124’.

**Results**

After reviewing the structure of Whiting’s current greenhouses, the most efficient form of rainfall collection would be a gutter system (close up images located in Appendix 9). Gutters would be installed on the support beams located about
halfway up each greenhouses outer wall and run along the long side of each greenhouse, deposited into a holding tank. The suggested tank size would be two 550 gallon tanks on either side of each greenhouse with an installed rainfall collection system. This allows for the collection of the first ½ inch of any rainfall event, or 50% of annual rainfall, with the estimated annual collection of between 15,400 and 23,100 gallons (calculations detailed in Appendix 7), enough to water one greenhouse for 30 days. The estimated cost per greenhouse is around $1,600, an individual breakdown of cost in Appendix 8. All items can be purchased at the Auburn Home Depot except for two item noted also in Appendix 8. The gutter system will likely need to be removed for the months of November-March so as to prevent snow buildup and damage.

**Limitations**
This system does involved yearly maintenance, with the removal of the gutter systems so as to avoid damage due to snow collection. This is estimated to cost approximately $35-50 when adding up costs for new screws, nuts, wire, and gutter seal lubricant. This system, although simple to install, would still require a certain amount of manual labor to initially put up.

**Greenhouse Irrigation**

**Introduction**
The greenhouse watering portion of this project involves the way water is used within the greenhouses to water crops. Most of the greenhouses are used to grow Whiting Farm’s cash crops: mums and poinsettias. The greenhouses containing mums have already been equipped with a new, efficient drip watering system. However, this system is not suitable for watering poinsettias, and the three greenhouses housing poinsettias are the target area of this portion the project. When considering the time and water currently used to hand water and cultivate the thousands of poinsettias grown for sale (3.5 hours and several thousand gallons per day), a new watering method is imperative not only to establish efficient water use, but to cut down on manual labor. There are several methods for in-greenhouse watering, as well as ways to reuse water that is not directly absorbed into the plant. These methods include the use of spaghetti tubes, capillary mat irrigation, trough irrigation systems, and flood and drain trays.
Results

After considering the space and cost required for installation, water efficiency/reuse, and suitability use with poinsettias, as well as the capacity to be used by all abilities of workers coming to the farm, taking into consideration those with physical and developmental disabilities, it was determined that there were two methods that would be appropriate to implement: the ebb and flow method and the capillary mat system. Both methods are sub-irrigation systems, meaning water is supplied to the base of the pots and moves up through the soil medium. In addition, both methods are more water, nutrient and time efficient than overhead watering, like the hand watering. Each system has its pros and cons, between cost for installation, water efficiency, nutrient runoff, and maintenance required (summarized in Appendix 10). The ebb and flow system features a metal trough on the bench top which the potted plants are placed in (Figure 3), with a reservoir below the bench. The reservoir is connected to the trough through tubing and water is pumped from the reservoir into the upper trough to a depth of a few inches. Once the pots are saturated after several minutes, the water is pumped back out of the trough into the reservoir below. This can be done automatically with a timer, or manually by turning on a hose. This system can be purchased or built by hand, but is more costly because of all of the pieces required (Appendix 11) If the ebb and flow method is chosen, the excess water can be collected and fed back into the system to reuse for future
waterings, monitoring the quality of the water to prevent pH imbalance and contamination. Water quality monitoring could be achieved by doing simple pH, dissolved oxygen, phosphorous and nitrate tests of the reservoir water.

The capillary mat system features a porous, carpet-like material with several layers that is unrolled on the existing bench tops and the potted plants are placed on top (see Figure 4). Water is supplied to the mat through a drip line running alongside or underneath, and water moves through the mat into the potted soil through the capillary property of water. Water through the drip line should be applied frequently to keep the mat surface moist. The capillary mat system can be purchased in its entirety from several vendors (Appendix 12) and can be easily installed.

Overall, the ebb and flow method is much more water efficient and allows for reuse of water, but is more expensive to install and requires more pipes to be installed. The capillary mat system is very easy to install, but is less water efficient and requires more maintenance. It is hoped that the installation of this new irrigation system will significantly reduce the time required to water the poinsettias and reduce the amount of water used, and possibly reuse the excess water for future watering.

**Composting Bathroom Facility**

**Introduction**

Whiting farm currently lacks any sort of large scale bathroom facility on property, and with the averaged number of visitors being from 300-500 people per week, this is a problem that should be addressed if the farm sees any future of expansion. Prefabricated composting toilets are not designed to support more than the use of an average household, and any constructed system could cost anywhere from $10-25,000. Because of the high demands of Whiting, this study will refer to Horstmeyer et al. 2015 for results, outlining the benefits a septic system could have for Whiting.

**Results**

Because of the high cost ($10-25,000) associated with any sort of high demand compost facility, and high levels of maintenance involved in keeping the facility clean and operational, this report does not suggest the installation of a composting toilet system. Horstmeyer et al. outlines the benefits of Whiting installing a
septic system (Figure 5), and includes an Appendix in which many brands of composting toilets are laid out with detail, if this option is pursued.

Figure 5: Suggested location for installation of a septic system on Whiting farm property, more information can be found in Hostmeyer et al. 2015.

Qualifying grants for Whiting Farm

Introduction:
Financing water security at whiting farm is no small task, so here is a list of viable non-profit grants for the 2018 year. Other Grants and opportunities are located in Appendix 13.

1. SARE:
   a. **Research and Education Grant** $30,000-200,000
      i. application closed for 2017; due 18th of October 2017 qualifying for 2018
      ii. http://www.nesare.org/Grants/Get-a-Grant/Research-and-Education-Grant/Grant-overview/Grant-Description
   b. **Local Farm Partnership Grant** $15,000
      i. application closed for 2017; due 18th of October 2017 qualifying for 2018
      ii. http://www.nesare.org/Grants/Get-a-Grant/Research-and-Education-Grant/Grant-overview/Grant-Description

2. **Maine Conservation Innovation Grant** $75,000
   i. application open, due date is February 15th 2017
   ii. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/me/programs/financial/cig/?cid=NRCS141P2_002875

3. The Albertson’s Companies Foundation Grant: proposal dependent
   i. applications open for 2017, rolling admissions
Non grant option:

Barnraiser is a platform similar to kickstarter that specifically targets farms that are trying to expand or do more, projects have a set amount of time to achieve a goal, and if the goal is met 95% of the money goes to the farmer. This national website enables grassroots farmers to help specific projects on farms and has been incredibly successful in funding nontraditional farms. This could be a great way to kickstart Whiting’s experimental greenhouse.

https://www.barnraiser.us/projects/browse

Next Steps

In order for Whiting Farm to move toward better water security, and to ensure that the farm will have ample water for the next growing season, the addition of the new well is imperative. As this piece is extremely expensive to undertake, it is recommended that the grants should be looked into first in order to help offset the cost of the new well, or any of the other projects. If a grant can be awarded, the execution of the new well should begin, first meeting with topography experts and well diggers to ensure the best location. After drilling the well, excavating new pipelines is important to connect the new well to the old system. Be cautious of the locations of electrical lines and old piping underground when excavating, some of which the locations are unknown. Once this new system is completed, it is hoped that the new well will be able to sustain the water needs of the farm.

After the well is drilled, most of the other pieces recommended in this report are ancillary and mainly work to supplement the water supply or decrease the amount of water used. Therefore, these pieces can be added at your discretion and fund availability. For both the rainfall catchment and the greenhouse irrigation systems, grant options would be a great place to search for funding because these pieces help toward sustainability and are innovative, and there are many grants that look to fund farmers in these areas. Depending on which could receive funding sooner, the greenhouse irrigation systems could be great to try out in one greenhouse for the next growing season, to decrease the water use but to test out before going full scale. The rainfall catchment system could be an easy addition because it is easy to install and can quickly supplement the water supply during the rainy spring season.

Going into the future, the addition of a septic system and/or toilet to Whiting Farm is imperative. With the farm’s goals of expansion, education, and public outreach, it will be necessary to have a bathroom facility to accommodate an influx of new people. In addition, it would be great to add the septic system
instead of just a toilet because that could include sinks, showers, and other bathroom amenities for guests staying overnight or for a farm kitchen. Adding a whole septic system would be a big undertaking, but it is something to keep in mind when deciding on the location of the new well.
Works Cited


Newbegin, Michelle: Inspection Process Analyst Maine DACF. Water Quality for Washing Vegetables [E-mail to the author]. (2016, September 21)


Appendices

Appendix 1

Anatomy of the well:
Drilled bedrock wells rely on steel casing, a well head, and either a submersible or aboveground pump. This is powered by electrical wires running to the pump, and is connected to a grid. Drilled wells will also have gates, the one in the picture has two, one where the sanitary well cover is and one where the pitless adaptor is. This is purchased alongside piping.

IMPORTANT NOTE: because Kim Finnerty has a special connection with a well digging company through an employee I simply included these well drilling companies as a resource. These two were the most highly rated well drilling companies in the area.

Sun Co Drilling
280 Sabattus Rd, Sabattus ME 04280
Phone: 207-375-4661
Fax: 207-375-4687
Email: info@suncodrilling.com

Affordable Well Drilling
Bowdoinham Rd. Sabattus ME 04280
Phone: (207) 375-7204
Email: affordablewelldrillinginc@gmail.com
Appendix 2

Whiting Farm Potential Farmhouse Well:

For approximation of well parameters, in drilled bedrock well maps the space correlated to Whiting Farm’s Farmhouse it became evident that there was data on that piece. The most left hand clustered piece, which correlates to 300-400ft (100-133m) deep, with a yield of 6-8 gpm. This is marked in the figure by the small black dot. It could be any of the three wells, but all have same yield/depth estimate, so whichever it is is irrelevant.

Taken from maps available at:

Useful Resources For understanding Wells:

- Total Dynamic Head (TDH) http://www.marchpump.com/blog/how-to-calculate-total-dynamic-head-for-industrial-pump/

- How to size a pump

Part 2

http://www.flotecpump.com/residentialpage_resource_starthere_4inSub_SelPump.aspx

helpful slideshow overview: pump sizing

Helpful pump selection w/ parameters
Appendix 3

Whiting Farm Well Cost Breakdown:

Option 1: Assuming Well is 6 inches wide, 450 ft deep has a flow rate of 6 gpm, TDH of <250
This is very rough estimate, and the pump needed will be at least ¾ HP and 3 wire 240hz with a head of <250. Both wells assume 50ft after hitting bedrock.

option 2: Assuming Well is 8 inches wide 600 ft deep has a flow rate of 8 gpm. TDH of <250.

<table>
<thead>
<tr>
<th>Piece</th>
<th>Option 1 Cost</th>
<th>Option 2 Cost</th>
<th>Implementation Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling + Casing</td>
<td>10,000$</td>
<td>17,000$</td>
<td>+2,000-3,000$</td>
</tr>
<tr>
<td>Submersible Pump (4’-6”” ¾-1HP, head under 250ft)</td>
<td>977$</td>
<td>1,250$</td>
<td>included if well dug and implemented</td>
</tr>
<tr>
<td>Wellhead</td>
<td>325-1,250$</td>
<td>325-1.250$</td>
<td>+100$&gt;</td>
</tr>
<tr>
<td>Electrical Wiring (240)</td>
<td>250$</td>
<td>300$</td>
<td>+100$ (dependent on distance to nearest building)</td>
</tr>
<tr>
<td>Pressure Tank (81G)</td>
<td>507$</td>
<td>507$</td>
<td>+100$</td>
</tr>
<tr>
<td>Excavator</td>
<td>5,000$</td>
<td>8,000$</td>
<td>+2,000-5000$</td>
</tr>
<tr>
<td>Total Cost:</td>
<td>17,079$</td>
<td>27,382$</td>
<td>+4,700-8,200$</td>
</tr>
</tbody>
</table>

Total Cost Range:

Option 1: 21779-25,279= average 23,529$

Option 2: 32,082-35,582= average 33,832$

Keep in mind:

TDH is variable and calculations were done differently based on piping size and didn’t account for future development or moving it across the field to the farmhouse. This is because these calculations are important when figuring out what pump to buy, and this is going to give Whiting farm a range. Once the well is dug and you know many more factors, like the height of water when not being pumped as well as the ultimate depth of the well the contractor will be able to advise the Farm on the next best steps.

Appendix 9 includes resources and links to applicable pages regarding TDH/PRESSURE/GPM/future development.

Both these piping distances are overestimations of the depth of well, which would account for minimum additional piping.
Appendix 4

Price Determination:

Well Drilling: 30$ per ft for steel casing, once hit bedrock 25$. 400+50ft and 550+50 ft (150-200m) overestimate both of these margins. On average wells go as deep as 12 ft in bedrock, and these calculations assume 50 ft into bedrock. An overhead cost is also added so the numbers are rounded to accommodate unforeseen expenses (Affordable Well Drilling). The entire system cost will be bundled together by the company who drills and tests the well, so the estimates provided here are only to get a baseline idea.

Excavating: cost minimum 5,000, $3,000 for the equipment, but $2,000 for workers to come on site. This cost is highly versatile and was only a quote given over the phone. Contractor needs to see the area, (LP Poirier & Sons) price could increase or decrease. Electrical wiring would be included here as well $250-350.

http://www.lppoirier.com/
1331 Sabattus Street
Lewiston, ME 04240
207-782-3617

Other pieces were found on amazon/Lowes/Home Depot, but the contractor will give you the real costs and pieces once the well has been drilled and tested. These prices depend on that.
Appendix 5

Vegetable Washing Station models

Any model in between can be achieved by adding more sinks and drying racks

Features of the Simple Models:

- One basin to wash vegetables
- One drying rack to lay out vegetables
- Portable, moveable
- Connected to pipes to well water through a garden hose

Features of the Complex Models:

- Multiple wash basins for hands and vegetables
- Multiple drying racks for more produce
- Permanent, fixed into ground
- Overhang for weather
Appendix 6

Where to purchase wash stations

Types of the simple model can be purchased online from garden retailers.

Prices range from $200-$1000 for pre-built models. Cabela's Online sells a “Cleaning Station” ($200), as well as others from Home Depot and Walmart.

How to build a wash station

More complex models can be built following simple instructions.

The Leopold Center for Sustainable Agriculture at Iowa State University offers complete construction and design plans for several types of washing stations, with an itemized list of what to buy and how to put it together (see https://www.leopold.iastate.edu/files/page/files/WashStation.pdf).

The New Entry Sustainable Farming Project followed the Leopold Center design with a few modifications that can be followed. They also offer a complete price breakdowns, with the most complex model up to $2,000 (see http://nesfp.org/sites/default/files/resources/og_wash_station_notes_pdf_version.pdf).
Appendix 7

ucanr.edu & Iowa State University:
Each 1 ft$^2$ of rooftop will collect 0.6 gallons of water per 1 inch of rainfall
Collecting the first $\frac{1}{2}$ inch of rainfall events will capture $\sim$50% of annual rainfall

usclimatedata.com
Average of $\sim$3 inches of rainfall per month in the Lewiston area
Average of 45.77 inches of precipitation per year
2-3 rain events per month

Whiting greenhouses dimensions = 34’ $\times$ 124’ = 4,216’ for rainfall collection per greenhouse
Two 550 gallon storage tanks = 1,100 gallons of rainfall storage space

This amount of storage will collect slightly less than the first $\frac{1}{2}$ inch of each rainfall event.
(4,216’ $\times$ 0.6 gallons $\times$ $\frac{1}{2}$ inch rainfall = 1,264.8 gallons collected water)

1,100 gallons collected per rain event for 7 months per year

2-3 rain events per month, **between 15,400 and 23,100 gallons collected per year per greenhouse**
Appendix 8

Price Breakdown for Rainfall Catchment Installation per Greenhouse

Available at Home Depot in Auburn

- **vinyl gutter section**: $3.98 per 10’ section, 7 needed - $27.86
- **vinyl gutter brackets** (hidden hanger): $2.57 each, 28 needed - $71.96
- **gutter slip joints**: (1 per gutter section) - $4.30 each, need 7 - $30.10
- **gutter mounting screws**: (4 per 10’ gutter section) - $10.94 for a 10 pack, need 3 - $32.82
- **gutter seal lubricant**: - $4.97 each aerosol can, need 2 - $9.94
- **1.5” conduit clamps**: 96¢ for a 4 pack, need 4 - $3.84
- **vinyl high flow drop outlets**: $8.79 each, need 2 - $17.58
- **vinyl downspouts**: $8.34 each, need 2 - $16.68
- **downspout elbows**: $2.34 each, need 2 - $4.68
- **downspout connectors**: $1.95 each, need 2 - $3.90
- **vinyl gutter end caps**: - $6.96 set, need 1 - $6.96
- **lumber for gutter support**: - $4.35 for each 2in x 6in x 8ft piece, need 9 - $39.15
- **water storage tanks**: - $499 for 550 gallon tank, need 2 - $998
- **tank outlet valves**: - $15.48 each brasscraft compression inlet, need 2 - $30.96
- **hose adaptors to fit valves**: $3.49 each, need 2 - $6.98
- **small machine nuts**: - $3.82 per 100 pack, need 1 - $3.82
- **coated #9 wire**: - $10.98 for 50 ft non-coated, need 1 - $10.98
- **garden hoses**: - $15.47 each 25’ neverkink, need 2 - $30.94

**Available on Amazon**

- **inflatable childrens vinyl balls**: - $3.75 intex beach ball, need 2 - $7.50
- **115V industrial diaphragm pump**: - SHURflo $99.99 pump, need 2 - $199.98

**Approximate total cost per greenhouse = $1,750**
Appendix 9

Basic structure of Rainwater collection gutter system:

(all images sourced from Iowa State University Extension and Outreach)
### Appendix 10

**Comparison of ebb & flow vs capillary mat irrigation systems**

<table>
<thead>
<tr>
<th></th>
<th>Ebb &amp; Flow</th>
<th>Capillary Mat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Efficiency</strong></td>
<td>75-78% 12% of overhead sprinklers</td>
<td>50-55% 25% of overhead sprinklers</td>
</tr>
<tr>
<td><strong>Price of Installation</strong></td>
<td>$1000+</td>
<td>$200-600</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>Water quality checks (Water quality kit $40)</td>
<td>Replace mat once every 1-2 yrs ($50-100)</td>
</tr>
<tr>
<td><strong>Nutrient Efficiency</strong></td>
<td>Decent nutrient efficiency</td>
<td>Slightly more nutrient efficient</td>
</tr>
<tr>
<td><strong>Frequency of Watering</strong></td>
<td>3.4-3.5 days</td>
<td>1.8-2.0 days</td>
</tr>
<tr>
<td><strong>Ability to Reuse Water</strong></td>
<td>Yes</td>
<td>No, runoff = 24% of overhead sprinklers</td>
</tr>
</tbody>
</table>

All data based on study by Neal & Henley 1992. This study compared capillary mat and ebb & flow systems to overhead sprinkler system, which is similar to hand watering. Another study by Dole & Cole 1994 compared the same two systems to hand watering, but only used 16 plants which is not on the same scale as Whiting Farm.

**See for more information:**


Appendix 11

Purchase and installation of ebb & flow irrigation system

The ebb & flow irrigation system requires installing large metal troughs on the bench tops, with a large reservoir basin below the benches. The reservoir is attached to the top trough via a tube and water is pumped from the reservoir into the trough and back out.

The whole system can be purchased for $1000+ from a variety of retailers like Hydrobuilder or Innovative Growers Equipment Inc. ([http://hydrobuilder.com/active-aqua-4-x-8-ebb-flow-package-8-plants.html?utm_source=google&utm_medium=shopping&utm_campaign=4X8EBBFLOWPKG-GP&gclid=CNeBkf2N9NACFcO3wAodVWkPdw](http://hydrobuilder.com/active-aqua-4-x-8-ebb-flow-package-8-plants.html?utm_source=google&utm_medium=shopping&utm_campaign=4X8EBBFLOWPKG-GP&gclid=CNeBkf2N9NACFcO3wAodVWkPdw)).


Water quality checks of reservoir water is necessary to reuse water. Simple water quality kits (LaMotte) available for purchase at Walmart or Ben Meadows ($38-53).
Appendix 12

Purchase and installation of capillary mat system

The capillary mat irrigation system can be easily installed in the current greenhouses. The capillary mat can be purchased online and unrolled onto the existing bench tops. A drip line can also be purchased online and run alongside or underneath the mat. A full kit can be purchased from Agriculture Solutions (see https://www.agriculturesolutions.com/products/irrigation-and-watering/capillary-irrigation-matting).

Depending on size needed for bench tops, full kits can be $200-300. As mats become soiled (depending on algal growth), new matting can be purchased online in various sizes (Gardener’s Supply Company on Amazon or http://www.greenhousemegastore.com/product/capillary-matting/watering-supplies).

In addition, more complex kits with matting, better headers to wet the mats, filters, pressure gauges, as well as other features can be ordered online from Water Pulse (http://waterpulse.com/).

An estimate for a capillary mat system from Water Pulse for one greenhouse:

3 – 4ft x 20ft @ $2.00/square ft. = $240

3 – 4ft Header to wet mats = $150 ($50/ea.)

3 – Track Kits (includes filter, pressure reducer, and couplings) = $75 ($25/ea.)

1 – Shipping = $200 (estimated, actual will be provided at the time of ship)

Total = $665

Scott Kegerreis, the sales manager from Water Pulse, might also be willing to make a deal to forgive the minimum cost of $2,500 in exchange for information on any progress, results or pictures from the installation of the system, if you are interested in that. His contact information is SKegerreis@waterpulse.com.
Appendix 13

Grant Notifications and Mailing List

1. Water Development Grant: not currently taking any applications; but the administrator does have more information regarding water related grants in the future.
   Contact: Jessica Nixon at jessica.l.nixon@maine.gov

2. Maine Farms for the Future Grant: finished the 2017 grant process, but will start again in August, and be due in September. More information will come then.
   Contact: Stephanie Gilbert at stephanie.gilbert@maine.gov

3. Agricultural Development Grant: finished grant process but has newsletter for when the next grant process begins.

4. Orange Thumb Garden Grant: Finished 2016, but will start back up in June. More information to come then.
   [http://www2.fiskars.com/Community/Project-Orange-Thumb](http://www2.fiskars.com/Community/Project-Orange-Thumb)

5. Awesome Foundation Grant: sends $1,000 to anything they believe will make the planet more “awesome” and sustainable.