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Waste Disposal at Whiting Farm: Recommendations for Current Waste Removal and Future Recycling Systems

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Executive Summary

The goal of this report is to provide Whiting Farm in Auburn, Maine with an analysis of options and resources that will help the farm to make informed decisions for the removal and disposal of both existing and future waste, with a specific focus on recycling. Whiting Farm has never had an on-site waste disposal system. As a result, they have accumulated large amounts of agricultural plastic, which is stored mostly outside in three forested areas around the farm. Dealing with this waste is key in implementing the farm's goals of environmental and economic sustainability, as well as functioning as an educational model for youth and other farmers. In collaboration with Kim Finnerty, Whiting Farm's Manager, we have created this resource to inform waste removal and the development of a recycling system in order to mitigate future waste buildup.

We first compare different options, given commercial infrastructure, for both the removal and disposal of the existing waste. We considered factors such as cost, environmental effects, and feasibility. We conclude that working with Casella Waste Management will be instrumental towards achieving these goals given Casella's convenience, dumpster rental and waste disposal rates, and recycling capacity. We also discuss options for generating income by selling the metal, large machinery, and cardboard, which have also accumulated on the farm.

The information gathered in determining the best removal and disposal methods for existing waste informed our recommendations for a system to recycle future waste, both compostable and non-compostable. Given a lack of local commercial options and innovative technology in the field of agricultural recycling, recommendations for a future system were limited to suggestions regarding commercial partners, dumpster locations, and a list of Whiting Farm's recyclable waste. Additionally, options are given for compostable waste recycling, keeping in mind the specific practices of Whiting Farm.

Our report presents these practical recommendations in the main body, but much of this research was informed and influenced by additional information compiled in Appendices. Among topics considered are rationale for removal of existing waste, barriers to recycling agricultural waste, and case studies referring to other farms' disposal practices. Additionally, contacts for waste removal and disposal, model farms, as well as academics in the field of agricultural recycling are provided for future reference. This report aims to provide helpful and succinct recommendations for the implementation of a waste disposal system that is in line with Whiting Farm's practical needs, vision of environmental sustainability, and educational goals.

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SECTION 1: Removal and Disposal of Existing Waste

1.1 Introduction to Existing Waste

Due to a lack of infrastructure for agricultural recycling in Maine, Whiting Farm has never developed a system for the disposal of commonly produced agricultural waste. As a result, the farm has accumulated an excess of material that is currently stored at three outdoor sites in various locations around the farm (see Figure 1). These sites take up approximately 1.5 acres of land in total, and are made up of predominantly plastic waste (plug trays, seedling trays, plastic pots, and soil bags), but also contain small amounts of other waste including scrap metal, rubber tubing, old machinery, and a variety of other difficult-to-identify materials. This section of our report addresses barriers to recycling the existing waste, and outlines the different options we have determined (both recycling and otherwise) for the removal and disposal of the existing waste. These recommendations were based on the capacities of nearby disposal companies and the current market for specific materials given their compromised condition due to their long-term outdoor storage.

Waste Accumulation Sites at Whiting Farm
Auburn, ME

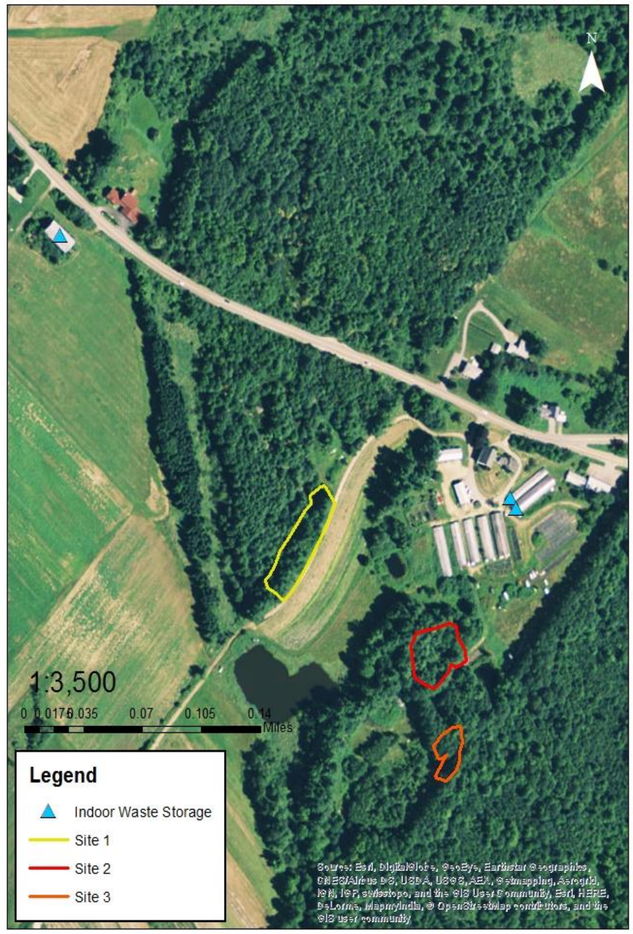

Figure 1. This map shows the various waste accumulation areas on Whiting Farm. Sites 1, 2, and 3 are outdoor dumping sites, covering about 1.5 acres in total. The indoor sites are greenhouses that have similar wastes in smaller quantities and a barn full of unused cardboard boxes.

1.2 Barriers to Recycling Existing Waste

The current condition and quantity of the build-up of agricultural waste on Whiting Farm makes recycling a challenging option. Whether materials on Whiting Farm can be recycled is dependent on the requirements of disposal companies, in terms of what they can accept for recycling and their standards for the conditions of recyclable material. As plastics in the Whiting Farm woods are not sorted or labeled, determining the length of their outdoor storage and exposure to chemicals is made challenging. It is possible that the plastics on Whiting have been exposed to environmental factors as a result of being stored outside that may deem them unfit for the recycling stream (see Appendices A and B). This determination, however, will need to be made by professionals in the business of recycling because waste disposal companies have individual standards for what they are willing to accept based on the market for the material, its condition, and the amount.

If recycling is not possible, there are other options for the disposal of Whiting's existing waste. The energy content of plastics can be recovered and redistributed in the process of plastic incineration.[1] This option has benefits in comparison to the landfill alternative (Appendix A), but does not reduce demand for raw materials used in plastic production, so it is considered less efficient than recycling.[2] Energy recovery does elicit public concern because of its possible addition of combustion gases to atmospheric pollution.[3] However, the use of plastics for the generation of new energy does allow them to act as a source of renewable energy and lessens the need for landfills. Each of these options comes at a cost (both for transportation of the materials, and the act of disposal itself), which differs depending on the company and the waste disposal method (recycling vs. incineration vs. landfill)—the most environmentally sustainable option is often not the most cost effective.

In addition to plastics, there are also significant amounts of scrap metal, cardboard, large machinery, and Styrofoam on the farm. Our initial sense was that most of the materials that are currently accumulated on Whiting Farm might be fit for the recycling stream, but after conducting our research, it has become clear that a large portion will need to be landfilled.

1.3 Options for Removal of Existing Materials

Removal of the vast array of current materials on the farm presents a unique and complex challenge, especially given our goal of finding a method that is both cost-effective and environmentally friendly. In gathering information from recycling or trash agencies we considered costs (Table 1), feasibility, and sustainability, keeping in mind many of our contacts are for-profit businesses with an eye for the bottom line. Thus, the information we received regarding the recyclability of materials was often contradictory. Considering this dynamic, we have worked to compile a list of possible

Table 1. Table of Options and Costs for Waste Removal and Disposal. This table lists the different options considered for waste removal and disposal on Whiting Farm with the corresponding prices for each.

Removal:	Cost:
- Independent Contractor:	Variable
- Dumpster Rental (30-40 Ft.):	
- Delivery	$60
- Haul	$180
- Disposal	$80/ton
Disposal:	
- Casella:	
- Recycling	$25/ton
- Mid-Maine Waste:	
- Transfer Station (Landfill)	$96.29/ton
- Incinerator	60.78/ton
Future Waste Pick-Up with Casella (Pine Tree Waste):	
Any size roll-off can:	
- Delivery (one-time fee)	$65.00
- Haul	$135.00
- Disposal	$85/ton

[1] Thompson, R. C., et al. "Plastics, the Environment and Human Health: Current Consensus and Future Trends." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364.1526 (2009). Print.
[2] Ibid.
[3] Briassoulis, D., et al. "Experimental Investigation of the Quality Characteristics of Agricultural Plastic Wastes Regarding Their Recycling and Energy Recovery Potential." *Waste Management* 32.6 (2012): 1075-90. Print.

options (Figure 2) for removal and disposal of the waste at Whiting. A compiled list of contacts discussed in this section, that will be useful once a course of action is decided upon, is located in Appendix D.

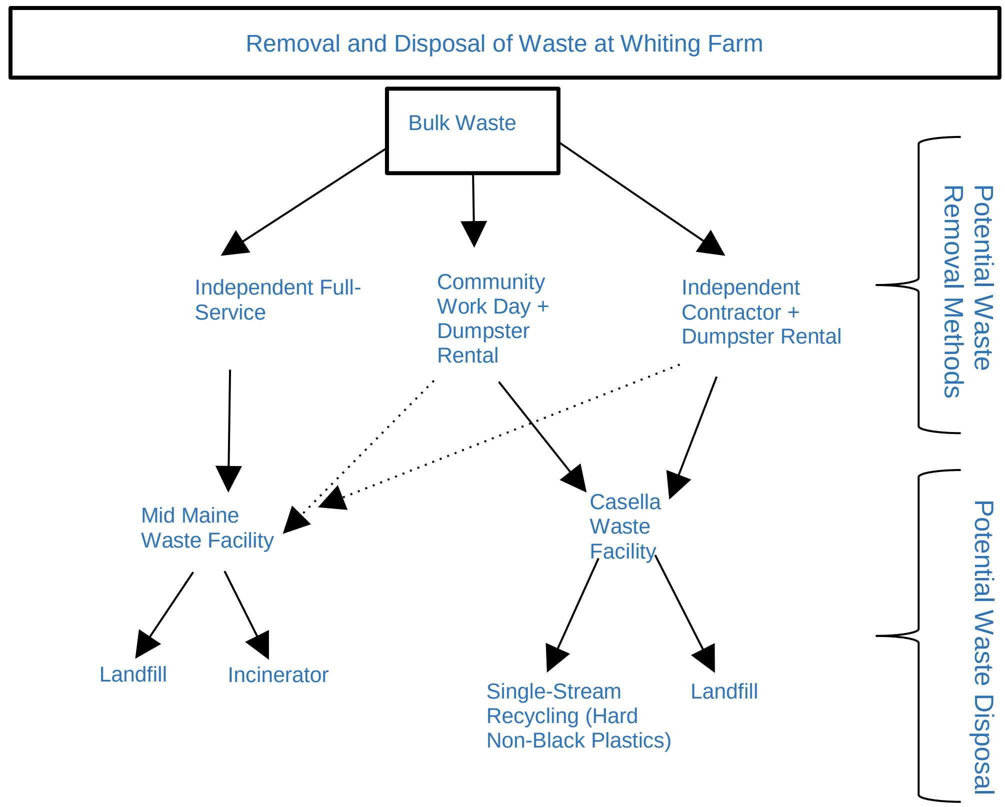

Figure 2. Removal and disposal of bulk waste at Whiting Farm. This figure lays out the potential options for dealing with current bulk waste (excluding metal, cardboard and large machinery). Dotted lines indicate that the option is less feasible due to the need for an outside (non-Casella) dumpster rental, while bold lines represent more realistic options for how to proceed.

The removal and transportation of waste from the dump sites will likely be the most costly part of project implementation. We have determined three feasible options for removal:

a. Independent Contractor + Casella: Casella offers the most convenient and accessible local dumpster-rental service, but does not deal with the manual labor of removing the waste. Some of the existing waste has been stored outside for so long that it is buried. Thus, one would need to hire an independent contractor to dig up the material and deposit it in a rented dumpster (Table 1 and Contact List in Appendix D).

   i. The level to which the independent contractor is willing to separate and sort the material into recyclable and non-recyclable waste will determine the kind and number of dumpsters to be rented from Casella.

b. Community/Staff Work Day(s) + Casella: Given the high cost of hiring a company to remove the waste, a second, more time consuming option is to arrange a community/staff work day to remove the materials and place them into Casella dumpsters to be hauled away.

   i. This method could provide some additional profit since, in the absence of per-hour contracted payment, the Whiting Farm community/staff could more feasibly separate metal from the rest of the waste. Separating out metal would reduce the weight of landfilled waste, resulting in decreased disposal tipping fees.

ii. This method is potentially more cost-effective if community and staff were to take additional time to separate recyclable from non-recyclable material, given the lower fees of recycling as opposed to landfilling waste.

iii. Important to consider if choosing this option is the need for personal protective equipment and risk-mitigation in handling potentially sharp or heavy objects. We believe that the existing waste does not present any chemical hazards,[4] but steps should be taken to ensure the safety of community and staff.

c. Full-Service Independent Contractor: There are a number of contractors willing to remove all the buried and free-standing waste using whatever means possible. These contractors would need to visit the farm to give an accurate quote, but they are generally more expensive than other options. Their service offers removal from the site as well as waste disposal at various local waste companies, and the charges from whatever waste disposal method is mutually decided upon would be included in the fee.

1.4 Options for Disposal of Existing Materials

There are a variety of options for how and where to dispose of Whiting's existing waste. We have divided the waste into relevant sections to be considered separately. The waste disposal method will be contingent upon which removal method is selected.

a. Bulk Waste: Given that we have determined that the majority of the waste is ineligible for recycling, we suggest three existing disposal options for the bulk waste; this includes black plastic as well as the rest of the non-recyclable materials such as rubber, Styrofoam, carpeting, and wood.

i. Mid-Maine Waste: MMW is the closest waste treatment plant to Whiting Farm, and operates both a landfill and a Waste-to-Energy incinerator that is a more sustainable disposal option than landfilling. While the cost of incineration per ton is slightly lower than Casella's per ton landfill rate, MMW has indicated that, given the outdoor storage of materials at Whiting, the waste will likely be ineligible for incineration unless the soil is removed using a vibratory screen. This equipment may be borrowed or rented from other farms or local companies, but we have not found this information easy to obtain, further reducing the feasibility of incineration. If Whiting decides to work with MMW, a dumpster-rental service (other than Casella, which will not deliver dumpsters to MMW) will need to be hired to remove and deliver waste to MMW. Incineration at MMW presents an environmentally-friendly alternative to landfills, but MMW was unable to specify how much plastic, if any, they would accept for incineration. Thus renting an additional dumpster to send to MMW seems inefficient given the marginal cost difference between landfilling and incineration.

ii. Large-Scale Commercial Recyclers: Discussions with out-of-state, large scale recycling companies such as Ultra Poly-Pro (Appendix D) who oftentimes purchase and repurpose bulk plastics, have suggested that the condition of the waste at Whiting disqualifies it for this option.

[4] R. Washburn, Casella Auburn.

iii. Casella (Auburn) Recycling and Landfill: This Casella plant offers both recycling and landfill services. Representatives from this Casella plant have examined the material on the farm, concluding that some of Whiting's existing hard plastic waste could be recycled in their facility. Recycling is considerably cheaper than landfilling, and thus could be a cost-cutting measure. The remainder of the material would need to be landfilled, and the Casella landfill is well-equipped to handle its large quantity.

b. Hard Plastics: Hard, rigid plastic of any non-black color can be recycled at Casella Auburn facilities if the dirt is removed. Recyclables would need to be separated from the landfill waste in a second dumpster. Dealing with hard plastics in this manner is of course only an option if Whiting Farm chooses to work with Casella for both the removal and disposal aspects of the project. Given the large amount of plastics on the farm, the environmentally friendly approach would be to recycle as much of this material as possible—recycling would also reduce costs because of the lower price per ton of recycling as opposed to landfilling. Mid-Maine Waste is not equipped to handle bulk recycling—hard plastics would, however, have potential to be incinerated, which costs significantly more per ton than recycling.

c. Cardboard: The cardboard in the barn is of value to local recycling agencies given its good condition and large quantity. Cardboard currently has a low market value;[5] however, its price per ton changes every month.[6] Despite instability of cardboard's market value, most research indicates that transportation and removal costs would at least be covered by the profits gained from recycling the cardboard. Since the price of cardboard per ton is set and stable across geographic location, using a local disposal options will reduce transportation costs and increase total net profit. Below are three options for the removal of the cardboard.

i. Casella Auburn: The Auburn Casella is unwilling to buy the cardboard; however, they will accept it for free.

ii. Casella Scarborough: The Scarborough Casella is willing to pick up, purchase, and transport the majority of the boxes that are in good condition. As of November 19, 2015, this option is already being implemented.

iii. Local Muscle Movers: Local Muscle Movers (Lewiston-based moving company) has expressed interest in taking a small number of the boxes but will not compensate.

d. Metal: The large amounts of scrap metal at the waste sites present the potential to generate profit or at least offset transportation costs. Unfortunately, the metal market is at an all-time low with no expected rise in value.[7] Returns are not often greater than $40/ton. Given this low value, the transportation costs of bringing metal to a specialized facility (see Appendix D) as well as the cost of an additional container to remove metal could outweigh the profits. Three options for metal removal are detailed below.

i. Rent a dumpster specifically for scrap metal and deliver to a specialized facility (see Appendix D). This option is time-consuming and would likely yield a small net profit; however, there is a cost advantage in keeping heavy metal material separate from the rest of the waste, the disposal of which is priced by the ton.

[5] J. Kazar, Mid-Maine Waste.
[6] R. Washburn, Casella Auburn.
[7] Ibid.

ii. Mix metal into a rented recycling dumpster and deliver to recycling plant at Casella. This option would decrease dumpster rental costs and labor but increase cost of disposal due to the heavy weight of metal. Additionally, some scrap metal is ineligible for recycling.
iii. Deposit metal into rented dumpster for disposal as "demolition" waste. This option is time efficient; machinery can move large amounts at one time if separation is a non-issue, but will raise costs of disposal given the heavy load.

e. **Large Machinery**: There are a number of large machines in various conditions at the existing waste sites. Perusal of online farm-equipment sales as well as conversations with our contacts at Casella suggest that these machines have market value within the nearby community—a much greater value than if they were disposed of as scrap metal. The most feasible and efficient way to profit from these items is to post them on the Lewiston/Auburn Craigslist page. There are a number of additional Farm-specific sale websites that operate under similar models, but Craigslist was suggested as the most effective.[8]

1.5 Recommendations for Removal and Disposal

In light of the above information, we can offer a set of suggestions for the most efficient and cost effective method for removal and disposal of the waste. Our interactions with persons at Casella Waste Management have been especially positive, and the company offers services which will be helpful throughout the entire scope of the project from the removal of existing waste to the disposal of future waste (see Section II). **To remove the current waste, we recommend hiring an independent contractor or planning a community workday and depositing the waste into Casella dumpsters to be transported to their Auburn facility, which is capable of dealing with both bulk landfill waste and recycling.** If time and funding allows, separating out metal and plastic into a single-stream recycling bin during this process will reduce tipping fees and is generally more environmentally friendly. Working with Casella seems the more feasible option, for in order to transport to MMW one would need to arrange an additional dumpster rental, and would not have the option of recycling any material.

In considering cardboard removal, we recommend working with the Scarborough Casella in order to profit from the cardboard, and perhaps donating damaged or leftover boxes to Local Muscle Movers. ***Implemented as of 11/19/2015.***

We additionally recommend paying special attention to large machinery or other metal items that could be sold for a profit.

[8] R. Washburn, Casella Auburn.

SECTION 2: Recycling and Disposal of Future Waste

2.1 Introduction to Future Waste

In order to prevent re-accumulation of waste at Whiting Farm, it will be important to design an efficient and easy-to-use system to dispose of day-to-day materials. While the systems of trash and recycling are undoubtedly linked, we are primarily concerned in this section with the development of an on-site recycling system that will function well alongside the current trash system. The main factors we considered in making our recommendations were: type and volume of produced materials, their potential to be recycled given pesticide use, best management practices, location and size of on-site dumpsters, and potential waste removal services. The major materials of expected use going forward are mostly plastics—seedling trays, four- and six-packs, pots, and soil bags. Unfortunately, all of the black plastic including seedling trays and mulch is non-recyclable at local plants. Although there were various factors at play, our research led us to the same recycling solutions due to limited recycling infrastructure and options for removal. Local recycling companies have, for the most part, simplified the system via single-stream recycling and convenient pick-up options. To tailor our suggestions to Whiting Farm, we thus compiled relevant best management practices and included a list of what can and cannot be recycled at the farm, as well as options for recycling-related educational material.

2.2 Suggestions for On-Site Recycling

Given the limited number of local waste management agencies who are capable of dealing with bulk recycling, **we recommend that Whiting continue its relationship with Casella Waste Management in designing a system for future recycling**. Casella has examined the site at Whiting and suggested placing an additional small dumpster next to the existing trash dumpster. This dumpster is already hauled away by Pine Tree Waste (a subsidiary of Casella), so adding a recycling dumpster managed and billed by the same company seems the most reasonable option. The dumpster would be single-sort, meaning that any recyclable material regardless of type could be deposited. The recycling could be hauled away whenever the dumpster is full, or Whiting could schedule a weekly or monthly pick-up.

2.3 Recyclable and Non-recyclable Material

The following list was compiled from discussions with Casella Waste Management and may not be accurate for other waste management services.

Recyclable

- Cardboard
- Paper
- Non-black plastic containers (types 1-7)
- Large rigid plastics
- Glass
- Most metal

Non-Recyclable

- Black plastic mulch
- Seedling trays
- 6-packs
- Plastic grocery bags
- Window glass, mirrors, light bulbs
- Paper towels
- Paints, oils,
- Recyclables contaminated with food waste

2.4 Next Steps: Recycling Initiatives and Educational Material

After the removal of existing waste and implementation of a recycling plan for future waste, there are a number of ways that Whiting could further this project. Firstly, Whiting could take initiative and collaborate with local farms to collect the bulk black plastic seedling trays, 6-packs, and mulch and send it to independent companies capable of recycling these materials, such as Ultra-Poly Corporation in PA. After a relationship is established with other area farms, Whiting could spearhead the movement to work with these farms and other local recycling companies to create a sustainable and efficient countywide agricultural plastics recycling program. The Cornell Recycling Agricultural Plastics Program offers many valuable resources for starting such programs and the contacts we have provided are very willing to advise this process.

On Whiting Farm itself, the extra wood (barrels, crates, pallets, etc.) and windows can be up-cycled in educational and/or artistic ways. Additionally, the Farm could work towards adopting more sustainable materials for agricultural production, such as woven ground cover instead of black plastic mulch and biodegradable seedling planters instead of six-packs, as these materials become cheaper and therefore more feasible for use at Whiting Farm. Utilizing these materials would help make Whiting a cutting-edge and more environmentally friendly model for other farms.

The implementation of a recycling system at Whiting Farm will allow the farm to serve as an educational resource for students, gardeners, farmers, and others. An easy way to inform Whiting's visitors about their recycling practices is to post signs by the recycling dumpsters and compost piles. The sign on the recycling dumpster could detail which materials it can and cannot accept, where they go, how they are recycled, and what new materials they are used to produce. The compost sign could detail what kinds of materials can be composted, how they are decomposed, and what the compost is used for on the farm. These signs could also be printed out as handouts for farm visitors.

2.5 Best Management Practices

These best management practices are a list of recommended methods designed to promote economically viable agricultural production while minimizing negative effects on human and ecosystem health, with a focus on preparing plastics for recycling. These BMPs were sourced from a variety of state government and university publications and chosen specifically with Whiting Farm in mind. Voluntary adoption of BMPs will improve aesthetics and perception of the farm, help compliance with local and national laws, and minimize waste sent to landfills.

Plastics		
Reduce • Only order pots and soil when necessary. • Keep good records of how much was ordered and used per season to accurately make orders next season.	*Reuse* • Stack pots and trays, knock out loose soil, keep dry. • Reuse all pots, trays, six-packs, etc. until they crack. • Substitute woven ground cover that can be reused for black plastic mulch. • Use cardboard instead of mulch, it is biodegradable and keeps weeds down.	*Recycle* • Brush and shake off dirt, stack broken pots, all plastics but black plastic can be recycled in Maine. • Cut larger plastics like mulch and hoop-house covers into smaller pieces. • Collect all used plastics in a clean, dry storage place so they can be taken away easily.

Pesticides/Fertilizers
• Time fertilizer applications in conjunction with rainfall or irrigation. If heavy rain is anticipated do not fertilize as nutrients will be flushed from the lawn into drain ways and low areas. • Avoid broadcast application of herbicides after laying of black plastic mulch. • Containers must be empty and triple-rinsed or pressure-rinsed to remove all residue. Be sure there is no residue that can be smeared or will flake off when touched with a glove. The interior surfaces of containers must be dry. • NON-high-density polyethylene (HDPE) parts such as caps, metal handles and rubber linings cannot be recycled, and should be disposed of as normal solid waste. Do not put a cap back on a rinsed container.

SECTION 3: Recycling of Compostable Materials

3.1 Why Compost?

Alongside the recycling of plastic and paper material at Whiting Farm, the introduction of composting infrastructure will further serve to reduce the volume of landfilled material as well as produce useable soil amendments that can be spread on fields and gardens. The existing literature on composting options is extensive and provides easy-to-access, user-friendly information regarding the science, benefits, best practices, and different composting procedures. Since developing a composting system is not dependent on outside waste management companies or existing infrastructure, the options are far more extensive. This section of the report will focus on distilling available literature and making recommendations specific to Whiting Farm given the volume and type of materials produced.

3.2 Composting Methods

a. Vermiculture: Vermiculture, or “worm composting” uses worms to recycle organic materials, which pass through their digestive tract to create “vermicompost." Worm composting is most efficient with raw produce. Meats, oils, and dairy products are harder for worms to break down allowing them to last longer within the compost bin attracting pests. Worm composting can be contained within glass, metal, or plastic bins, and requires bedding (newspaper), darkness, warm air, and food. Worm housing can be as simple as plastic storage bins, but requires a breathable lid that allows air into the bin. With optimal worm growth-conditions, in three to five months the compost will be ready to harvest. Compost can be mixed with soil as a soil amendment, adding beneficial nutrients.[9]

b. In-vessel: In-vessel composting refers to a method in which all composted materials are contained in a walled and capped bin. This method contains bad odors, eliminates possible issues with weather, and allows for temperature control. The bin method requires some type of forced aeration, in order to provide oxygen to highly compacted materials at the base of the pile. The occasional turning of materials can accelerate the composting process. Most in-vessel systems that are commercially available have built-in pressure aeration and a biofiltration system for processed air. Vessels available for purchase are more expensive than other options because they have built in rotation or agitation systems that maintain porosity and break up larger pieces of organic material.[10]

c. Pallet-structure: Creating a pallet-structure to hold compost is a fairly straightforward “do-it-yourself” method that will save money in comparison to more sophisticated in-vessel systems but uses the same general principal. Compost in a pallet-structure still requires the correct temperature, adequate oxygen, and moisture. This method uses three structures that hold compost at various stages of decomposition. In the first section, a pile of raw materials is started,

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[9] Fong, Jenn, and Paula Hewitt. "Cornell Composting: Composting In Schools." *Worm Composting Basics*. Cornell Waste Management Institute, 1996. Web. 11 Nov. 2015.

[10] Misra, R. V., and N. R. Roy. "On-Farm Composting Methods." *Food and Agriculture Organization of the United Nations* (n.d.): 1-26. Web.

alternating green layers (leaves, weeds, grass clippings) with brown layers (manure, dirt). A pitchfork can be used to turn piles between sections in order to supply oxygen. The alternation of green and brown material is a good supplement to traditional fruit or vegetable scraps in providing a balanced diet for microbes, limiting smells, and thereby reducing the risk of attracting critters.[11]

d. **Windrow:** Windrow composting involves the stacking of raw compostable materials into long rows (typically on a field), and is often used in situations where large amounts of raw material (i.e. manure) are being constantly produced. Dense materials like manure require a smaller windrow than light materials such as leaves, because a lack of pores makes aeration difficult in heavier compostable waste. The rows must be periodically turned with buckets, a front-loader, or a compost-turner, in order to provide decomposing microbes with necessary oxygen for the breakdown of organic material. This method requires a high initial investment, and tends to be the most efficient for bulk compostable waste.[12]

3.3 Whiting Farm Specific Recommendations

Taking into account the many different methods of composting as well as discussions with Kim, **we recommend that two different composting methods be utilized on Whiting Farm: pallet-structure composters and vermiculture**. Pallet structures could be built behind the greenhouses and in the field. These composters are easy to build and maintain, and are a good size for the amount of compostable waste expected to be produced at Whiting, at least in the initial composting process. In addition to vegetables and weeds, chicken manure and flowers can be added pallet-structure compost piles. Chicken manure has an especially high nitrogen content and makes great compost. Vermiculture could be used at the farm stand and the greenhouses, and would provide an exciting educational opportunity for school groups that visit the farm. There are minor initial costs associated (for the bins and worms), but it is an engaging educational opportunity and a great way to compost food scraps or other small amounts of compostable waste that might be generated at the farm stand.

3.4 Pesticides and Composting

There are various physical and chemical factors that determine the persistence of pesticides in compost. Often, composting provides an optimal environment for the breakdown of pesticides, allowing the pesticide to become inactive throughout the composting process. There are three factors that make compost a good setting for pesticide degradation. First, the elevated temperatures that occur during the composting process create faster biochemical reactions. Second, some microorganisms co-metabolize with the pesticides, meaning that they break down the pesticides with energy retained from consumption of the composting materials. Third, the diversity of active microbes, each with different capabilities, increases the likelihood of pesticide breakdown. Despite the likelihood that the composting process will break down a pesticide and render it harmless, there are various factors that lead to the persistence of

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[11] "How to Compost: Composting 101p." *Planet Natural RSS*. Planetnatural.com, 2015. Web. 12 Nov. 2015; K. Dussault, St. Mary's Nutrition Center, Lewiston ME.
[12] "Center for Integrated Agricultural Systems: Windrow Composting (Research Brief #20)." *Center for Integrated Agricultural Systems*. University of Wisconsin, Madison, 1996. Web. 12 Nov. 2015.

pesticides in and around a composting environment. The pesticide toxicity after decomposition is complex and varies among different pesticides. The potential of a pesticide to remain in the environment depends on the pesticide's chemical structure. For example, the creation of pesticides with chemical structures not found in nature can result in the persistence of that pesticide in the environment. Another danger is presented when water-soluble pesticides are washed away through leaching and runoff, as they can potentially move into groundwater, threatening the surrounding ecosystem. This is especially important to keep in mind given that Whiting Farm is on two major watersheds. Mixing compost with agricultural soils is a preventative measure that can reduce the possibility of pesticide leaching. Due to the possibility that pesticides can persist throughout the composting process at damaging levels, Whiting Farm should take further steps to understand the ways in which their specific pesticide chemicals break down in the composting process.[13]

[13] Singer, A., and D. Crohn. "Fungal Degradation of Pesticides."*Mycoremediation* (2006): 181-214. *Persistence and Degradation of Pesticide in Composting*. California Waste Management Board. Web. 16 Nov. 2015.

Appendix A: Justification for Removal of Existing Waste

Aesthetics

One of the major motivations for the removal of accumulated waste on Whiting farm stems from its appearance. With the goal of becoming an educational facility that will teach not only youth, but other farmers and community members about the farming process (and theoretically, sustainable and cost-effective agricultural waste disposal methods), the current method and location for waste disposal will not be suitable. Determining methods for removal of outdoor waste and returning these wooded areas to their natural state will improve the aesthetics of the farm, demonstrating Whiting's commitment to the environment. Additionally, with suggestions for the implementation of a new waste disposal system, the educational goals of the farm can be met through display or explanation of the new aesthetic and disposal waste disposal process, and why it is beneficial or important in comparison to the old waste storage system.

Environmental/Health Concerns

Plastics are made of a diverse set of polymers, and are widely used because of their incredible versatility. Plastic polymers, however, are rarely used without the addition of outside chemicals that enhance certain plastic properties. These additives include carbon, silica, plasticizers (which make plastics more pliable), flame-retardants, coloring, thermal stabilizers, and more.[14] Many polymers contain small molecules (including additives) that are able to diffuse through the material and into the surrounding environment.[15] Diffusion of these molecules in combination with rainwater creates leachate (common in landfills), which exposes the particles to the environment and often results in runoff to nearby waterways.

The field of plastic research is booming with the increasing awareness of possible adverse health effects on humans and animals due to the leaching of plastic additives. Phthalates and bisphenol A (BPA) are of particular concern because of their leaching properties due to their lack of molecular affinity within the chains of raw plastic, rendering them less stable within plastic products.[16] The outdoor storage of plastic (in landfills, or in the case of Whiting farm, in the woods) is an environmental concern because of the possible health effects that result from the breakdown of these materials. Plasticizers and various additive chemicals have been shown to leach from landfills in various amounts depending on surrounding conditions including pH and amount of organic matter.[17]

Plastic additives that are lost to the environment through leaching or plastic decomposition have been shown to cause reproductive and developmental issues in a variety of animals.[18] These disturbances include alterations in the number of offspring, reduced hatching success, disruption of larval development, and delayed emergence in insects.[19] Phthalates have been found to be carcinogens,

[14] Thompson et al., 2009.
[15] Lower, Stephen. *States of matter, polymers and plastics: an introduction.* Creative commons attribution 3.0., 1 September, 2009. Web.
[16] Oehlmann, Jörg, et al. "A Critical Analysis of the Biological Impacts of Plasticizers on Wildlife." *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 364.1526 (2009): 2047-62. Print.
[17] Thompson et al., 2009.
[18] Ibid.
[19] Oehlmann et al., 2009.

teratogens, and mutagens as well as endocrine disruptors.[20] As plastic leaching is still a relatively new area of study, explicit health impacts are not concretely known, however it is clear that the range of biological systems that are susceptible to negative effects from plastic additives is extensive. The effects of phthalates and BPA have been studied most in aquatic ecosystems, but less is known regarding their impact on terrestrial organisms.[21] Research has shown that species are differently sensitive to these leachates, and the impact on reproductive systems, for example, may vary greatly between phyla.[22] Accumulation within biological systems (when substances are absorbed by an organism at a rate faster than they are lost) is also a health risk caused by the outdoor storage and resulting breakdown of plastic products.[23] BPA and phthalates have both been shown to bioaccumulate in organisms, but the rate of accumulation differs between species and as a result of the type of plasticizer.[24] The accumulation of these additives within organismal bodies is especially concerning, as the long-term effects of plasticizers have not been greatly studied.

It is clear that as a fairly new area of study, the effects of leached plastic chemicals are not concretely known. Most research on this subject has been conducted in marine environments, and effects on human health are not as easily studied. This research, however, does show that generally, outdoor plastic storage is not beneficial to the surrounding environment, and *may* result in degraded health in certain species. The safest option in order to prevent these possibly harmful effects, is to dispose of plastic with known methods. Landfills are enclosed and protected systems which tend to have methods with which to collect plastic leachate, and while landfilling may not be the most sustainable waste removal option, it at least provides more educated and safer waste storage than lack of protection between the plastics and the ground.

Appendix B: Limiting Factors for Recycling Agricultural Waste

Many factors associated with plastic treatment and the outdoor storage of plastic waste can limit the recyclability of these materials. The physical condition of plastics is the most visible issue in recycling. Plastics with soil build-up cannot be recycled because soil, gravel, and sand particles can damage the blades of recycling machinery.[25] Plastic additives including pigments, thermal stabilizers, and more may produce gaseous waste upon recycling.[26] The effects of ultraviolet (UV) exposure on plastic degradation were studied for a growing season, and it was determined that this amount of time was not long enough to severely degrade the plastic to a point where it is unfit for recycling. UV exposure results in the breakdown of plastic molecules, and light exposure for extended periods of time leads to this process of plastic photodegradation, at which point plastics can no longer be recycled.[27] Despite literature on photodegradation, Casella Waste Management is still willing to accept clean plastics which have been exposed to UV for long periods.

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[20] Ma, Ting Ting, et al. "Phthalate Esters Contamination in Soils and Vegetables of Plastic Film Greenhouses of Suburb Nanjing, China and the Potential Human Health Risk." *Environmental Science and Pollution Research Environ Sci Pollut Res* 22.16 (2015): 12018-2028. Print.
[21] Oehlmann et al., 2009.
[22] Ibid.
[23] Ma et al., 2015.
[24] Oehlmann et al., 2009.
[25] Briassoulis et al., 2012.
[26] Ibid.
[27] Lower, 2009; Briassoulis et al., 2012

Additionally, pesticide use on plastic can cause plastics to fall under the category of legally hazardous waste, which requires different disposal techniques.[28] Moisture in plastics (another unavoidable issue with outdoor plastic storage) can cause an increase in the amount of energy lost by gasses in the heating process of recycling, furthering inefficient energy use.[29] Site visits with Casella Waste Management indicated that pesticide hazards were not of large concern in the waste disposal process; however, due to the amount of time the pesticides have had to break down.

The recyclability of agricultural film plastics, which are the long sheets of mulch usually consisting of a blend of low and linear low density polyethylene, is dependent upon the state of its contamination after it is used in the fields.[30] Mulch film can have contamination of up to 50 percent by weight, which is a large percentage in comparison to other agricultural plastics.[31] This contamination mostly comes in the form dirt, sand, moisture, and vegetation. The contamination can also be from pesticide residue, although the low concentrations and low quantities of pesticides used, along with the speed at which the pesticide breaks down in the presence of UV and moisture, decreases the likelihood that pesticide contamination will be problematic for reclaiming this black plastic. However, there are several factors that influence the recyclability of black plastic in regards to pesticides, including the different types of pesticides applied, the pesticide concentration, etc. Regardless of the condition of black plastic, local recycling companies are not equipped to handle it; however, certain out-of-state recycling agencies will accept it in bulk. The barriers specific to recycling agricultural film arise from its extreme levels of contamination, in addition to difficulties in baling, transportation, high tipping fees at recyclers for very contaminated material, and a lack of facilities to handle ultra-contaminated film. The issues with black plastic reflect the barriers affecting other types of plastic including seedling trays and pots.[32]

The contamination barriers to recycling agricultural plastic are combined with significant logistical barriers. The distance to the disposal site, the high cost of transportation, local landfill tipping fees, low volumes and the low market value of materials decrease the practicality of recycling these materials.[33] A survey conducted by California's Integrated Waste Management Board, asking California vegetable growers about their recycling practices, determined that distance from recycling facility to farm production site and the numerous restrictions to recycling were the biggest barriers to recycling for these farmers.[34] Furthermore, the irregular seasonal generation of recycled materials on farms creates inconsistency in the accumulation of these materials. This makes it difficult for farms to logistically coordinate a pick up-service with the businesses that transport these materials from the farm to their disposal sites. A farm's lack of balers to adequately condense and prepare materials for collection can decrease the likelihood of finding a local or out-of-state recycling facility willing to take the materials. Farms also face barriers when there is a lack of demand for recycled end products, local disposal sites do not have the advanced technology needed to use recycled material in products, or lack a financial incentive to recycle.[35] To echo this, another report found that the main obstacle for recycling agricultural

[28] Briassoulis et al., 2012.
[29] Ibid.
[30] Amidon Recycling. "Use and Disposal of Plastics in Agriculture." *American Plastics Council*, (1994): 1-95. Print.
[31] Amidon Recycling, 1994.
[32] Ibid.
[33] Ibid.
[34] Hurley, Sean. "Postconsumer Agricultural Plastic Report." *Integrated Waste Management Board* (2008): 1-100. Print.
[35] Amidon Recycling, 1994.

plastic comes from the high cost of collecting, transporting, and cleaning plastic.[36] In summary, the main barriers to recycling agricultural plastics are cost, polymer breakdown, UV exposure, contamination, collecting adequate volumes, and transportation to and availability of recycling facilities.

Appendix C: Case Studies

The following list represents the most responsive farms from an extensive list of contacts. These case studies serve as examples for how other farms handle agricultural waste, and reflect the barriers to recycling we also encountered in the literature and at Whiting Farm.

Morning Glory Farm

Morning Glory is a non-organic farm on Martha's Vineyard started in 1975 by James and Deborah Athearn. It has 60 acres of vegetables and small fruits. Although Morning Glory is a for-profit farm and has different educational interests than Whiting Farm, it similarly places an emphasis on sustainability and therefore is very conscious of its use and disposal of agricultural materials. As an overall policy and ethic, they try to limit plastic use and reuse as much as possible, to ultimately reduce the amount of materials entering the waste stream. The measures listed below are some examples of the ways Morning Glory limits their agricultural waste:

- Greenhouse trays are used over and over until they crack.
- Soil bags, such as those used to grow hydroponic vegetables in a soilless mix, are used several years and only used in one greenhouse, limiting the amount collected.
- Black plastic mulch, which is more economical than other types of mulch, is supplemented with cloth fabric mulch that can be reused.
- Reusable Plastic Containers (RCPs) are used in place of cardboard to store and transfer produce.

Morning Glory Farm aims to send its collected agricultural waste to the most sustainable disposal sites, and values recycling over incineration, and incineration over landfilling, but has difficulty in living up to its sustainability ethics due to high costs and a lack of local recycling infrastructure. Although, Morning Glory is located in a different state than Whiting Farm, and therefore has access to different disposal option, it faces similar issues in regards to agricultural plastics. Here are some of Morning Glory Farm's practices for recycling and disposal of agricultural waste:

- The greenhouse trays go into the recycling dumpster only after they crack.
- The black plastic mulch goes to a transfer facility that brings it to an incinerator in Rochester MA, SEMASS, where it is burned or separated.
- Cardboard and soil bags go into a mixed recycling dumpster.

Little Ridge Farm

Little Ridge Farm is located in Lisbon Falls, Maine, approximately 13 miles from Whiting Farm. Although Little Ridge Farm differs from Whiting in that it is smaller, USDA organic, and is a for-profit

[36] Hussain, I and H, Hamid. "Plastics in Agriculture." *Plastics and the Environment edited by Anthony Andrady, John Wiley & Sons, Inc*., (2003): 185-210. Print.

farm, it is located within the same county and thus has access to similar recycling and waste disposal infrastructure. Little Ridge Farm also emphasizes reuse and reduction methods. Listed below are some measures that Little Ridge Farm takes to limit their agricultural waste:

- Plug trays are reused over and over—even the ones that technically are not supposed to be reused—until they crack or breakdown.
- Organic waste is used as compost or to feed their animals.
- Drip tape is reused when possible.

Little Ridge Farm, like Whiting Farm, is looking for alternative options to deal with their agricultural waste more sustainably because their current disposal system is limited to local or other available options. Here are some of Little Ridge Farm's practices for their recycling and disposal of agricultural waste:

- Plug trays, greenhouse plastic, drip tape, and soil bags all go to the dump and are incinerated if possible.

Appendix D: Contacts

The contacts listed below represent additional sources that have provided us with a wealth of relevant information, especially for the more practical aims of our project. The following does not represent a complete list of persons with whom we have spoken, but are the contacts who have been most helpful and responsive.

The contacts list was removed in order to post this report to the public domain. If you would like to reach out to any of the people we worked with in creating this report, please contact the Program in Environmental Studies at Bates College.

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