Introduction:

Background

LaFarm is a portion of Lafayette college that is dedicated to bringing together students and faculty from various departments across campus with the objective of sustainable food production. It is currently a 3 acre plot of land located directly next to the Metzgar field complex, placing it roughly 2 miles away from Lafayette's main campus. The farm has grown significantly since it was started in 2009 on a single acre of land. It has grown 2 acres while adding an irrigation system, a large perimeter fence, several sheds and storage buildings, and a rain catchment system. This growth has allowed LaFarm to diversify its core produce which includes asparagus, beans, beets, cabbage, eggplants, garlic, and herbs while simultaneously increasing crop yields. Fiscally, the expansion has allowed LaFarm's harvest retail and wholesale value to grow to roughly $9,000.00 in 2017. With LaFarms recent success, the food and farm club, LaFFCo, was able to secure funding in order to restore the bee program at the farm, which further expands the capabilities of the space (2017 Capstone) . In addition to these successes, LaFarm has recently received a new farm manager, Lisa Miskelly, who has been working on the farm since the start of 2018 and is looking forward to helping LaFarm continue to prosper (Tropp, 2018).

The farm acts primarily as an educational tool for students at Lafayette College. As the farm itself is only 3 acres, and as such not very large for a farm, the educational element to the farm is critical. Along these lines, the farm operates as a laboratory for student and faculty learning and research. It is key to bring in cross disciplinary students to the farm to facilitate conversations about sustainability, agriculture, and business (Education, 2013). This learning extends beyond simply observing what is happening at the farm and required increased student and faculty involvement there.

Lafarm additionally provides Lafayette college dining services with sustainably grown produce that is served in a number of the on campus dining halls (LaFarm Annual Report, 2013). This gives students healthy eating options that they can have a hand in growing and developing. There is also an educational component as students see a focus on locally grown produce for consumption on school grounds. The farm also creates a sustainable food loop with Lafayette by taking wasted food and using it as fertilizer in order to grow more produce, in turn reducing the amount of waste produced (LaFarm Annual Report, 2013). This is another example of Lafayette students learning by the example provided by Lafayette.

Lastly, LaFarm serves as a connection between Lafayette College and the surrounding communities through a series of community-based partners. LaFarm is partnered with groups within the city of Easton, such as the Easton Urban Garden, in order to donate produce and provide support through the exchange of ideas (Landauer, 2015). This is an educational example for Lafayette students of the school beneficially impacting communities in Easton through the provision of healthy food access to such communities. It also works to strengthen the relationship between the college and the local community.

Our Project:

Currently LaFarm contains no cold storage space for harvested produce. This creates a problem of environmental as well as harvesting inefficiency. Any produce that is ready to be harvested must be packaged and shipped to its final destination immediately and then stored on site there, whether that is at Lafayette College or one of LaFarms community partners. Since not all produce can be harvested at the same time, it requires a large number of trips between the farm and its partners which uses and excessive amount of fossil fuels and is simply inefficient. Lisa Miskelly has expressed the need for a storage facility on site due to scheduling issues she has when it comes to harvesting produce. Currently, when a pick up is scheduled either Lisa or a group of students must be present in order to harvest the produce and then package it for delivery on the day it is scheduled. If Lisa or a student cannot be present to perform the harvesting then she has to reschedule the pick up. When dealing with asset like crops, the time to harvest is a crucial and time dependent aspect in terms of maximizing yield. If crops are not harvested before they ripen and stored right away, or harvested when they are ripe to then be consumed soon after, they will be wasted.

The creation of a cold storage space, in the form of a root cellar, would be ideal as a method to decrease the previously stated inefficiencies of LaFarm. Creating a carbon neutral storage space at LaFarm would improve environmental and harvesting efficiency of the production of fresh produce with a reduction in wasted crops. Lisa/other LaFarm workers would be able to harvest the crops before they ripen and then store them on sight. From there, the crops could finish ripening at a slower pace in the root cellar, to then be shipped to their final destinations once they are ready. Once the produce is stored in the root cellar, it would take longer to ripen, giving more time for produce transportation. Less produce would be wasted through inefficiencies in the transportation of the produce not aligning with ripening times at the field.

The root cellar would also serve to further Lafayette's climate action plan by creating a storage space that wouldn't require energy to stay cool. Rather than all plants at LaFarm needing to be sent directly to powered storage, they would be stored in the natural cold storage of the root cellar. Lastly, the root cellar would serve as a teaching point for students on how to live sustainably simply through providing an example of an additional real life example of sustainable living.

LaFarm also faces issues that arise from being located almost 2 miles away from Lafayette's main campus. Based on personal experience, due to this distance many students are unaware that LaFarm exists, or know it exists but have had no experience actually at the farm. The lack of usable classroom space at the farm reduces reason for classes to travel there because there is no usable space for them besides the farm itself. The result of this distance and lack of practical space for a classroom at the farm leads to many students never visiting LaFarm in their time spent at Lafayette College. An additional strapulation we make here is that this lack of contact with LaFarm reduces the amount of people who know about volunteering opportunities at Lafarm, or who are willing to volunteer there.

A solution to this lack of use of Lafarm as an educational space is through constructing a multipurpose classroom adjacent to the farm. Having a space that can be used by students located at LaFarm would firstly increase academic use of the space. Once such an increase is established, in suit would follow an increase the number of people who are willing to visit and become involved at the farm. In addition to these uses of the classroom, Lisa Miskelly has also expressed interest in hosting events at LaFarm in order to show its progress and further integrate it into the Lafayette community. The classroom would be a perfect space for such events. In addition to these uses, the classroom could also potentially facilitate an opportunity for local public schools to visit a small, but crop diverse, farm.

The multipurpose outdoor classroom will be situated at the plateaued area above the hill semi-adjacent to the root cellar, yielding an ideal teaching environment that overlooks the farm in its entirety. This combination will deliver an ideal blend of both educational and environmentally sustainable benefits to both Lafarm and Lafayette College as a whole.

Social Context:

Intro:

LaFarm is part of a much larger social movement that can be seen gaining steam around the country. This movement is the Farm-to-table movement, and subsequently the college farm movement, that has started a change from commercially farmed foods to locally sourced sustainable agriculture. The evidence of this change can be seen in the establishment of sustainable food loops between public K-12 schools, who partner with local distributors, as well as private colleges who are establishing their own farms. The sustainable food loop that exists between Lafayette College and LaFarm can be strengthened by improving the efficiency of LaFarm. The best way to go about improving LaFarm is to add a root cellar that can be used as a carbon neutral, cold storage area to increase the farms harvesting capabilities through the utilization of the Earth's geothermal cooling. By using this carbon neutral method of food storage LaFarm will work towards furthering Lafayette's goal of becoming more environmentally friendly and eventually fully carbon neutral. In order to highlight the impact that sustainable farming and carbon neutral storage can have on the environment, a classroom space located at LaFarm could be used as an educational hub to highlight these points.

Farming Movements Impacting LaFarm

A small farm in the United States is defined as a working farm with a gross cash flow of income less than $250,000.00. As of 2010, small farms make up 91 percent of the total number of farms in the United States. Consumption from small scale farming operations is decreasing and ultimately leading to an increase in consumption at the commercial level (Hoppe et al., 2010). This movement has resulted from a decrease in produce prices in the commercial sector as well as the increase in convenience for the average consumer.

From the 1950s through the 1970s the small and mid-sized farmers that generally produced locally sourced food shut down and were replaced by megafarms (Pirog et al., 2014). These megafarms are delivering a perceived convenience among consumers by providing out of season produce at the expense of the environment and all the relative negative impacts associated with these conveniences. Three sectors where this is most prevalent is food production, food transportation, and non-organic farming. Large scale food production has far more detrimental effects to the farmed land, causing "environmental degradation, loss of biodiversity, loss of ecosystem services, [and] emergence of pathogens" (Tilman et al., 2002). Once produced, the transportation of food within large scale food supply chains accounts for 11% of US household greenhouse gas emissions (Weber & Matthews, 2008). The aforementioned forms of environmental degradation are equally important when considering the question of organic vs. nonorganic foods. Organic farming is shown to cause lower soil nutrient losses as well as less biodiversity loss when compared to non-organic farming (Tuomisto et al., 2012). Over the past twenty five years, the public's attention on food production has increased to where consumer prefer locally sourced organic foods to other types of produce (Hempel & Hamm, 2016). These preferences have grown with the popularity of two movements focused on developing and maintaining small organic farms: the farm-to-table movement and the organic movement.

A defining characteristic of LaFarm is the farm-to-table movement, which emphasizes the need for locally sourced food sold direct from producer to consumer. This movement has taken a number of forms including locally sourced restaurants, farmers markets, and Community Supported Agriculture (CSA). CSA is the provision of prepaid "shares" of farmed product for local community members to receive food product once it is available. Since 1994, the number of registered farmers markets has increased from 1755 to 8700. In addition to this, there are an estimated 3000 CSAs operating in the United States as recorded by the USDA (Woods & Ernst, 2017). There has also been a significant increase in the amount of locally sourced foods being used in the restaurant industry (Inwood et al., 2009). The increase in the popularity of CSAs, farmers markets, and farm-to-table restaurants shows an upward trend in supporting local sources of produce rather than obtaining it from distributors. LaFarm continues to uphold similar practices through the produce it sells to Bon Appetit at Lafayette as well as local farmers markets throughout the greater Easton area (LaFarm Annual Report, 2017). Part of Lafarm's mission is the intent to train students day-by-day to become more sustainable individuals (Lafarm Annual Report, 2014). Through students "getting their hands dirty" at Lafarm, they are both participating and learning essential aspects of the localized farm-to-table movement. With this newfound knowledge of environmentally friendly practices, students can continue aiding in the future development and capabilities of small scale farms throughout the U.S. (Brown & Miller, 2008).

Parallel to these beneficial trends seen in small scale farming movements, the organic movement shares an equally strong position while maintaining similar ideals. Studies show that planting in soil untouched by any man made chemicals is far better for biodiversity and the maintenance of healthy soil (Rigby & Cáceres, 2001). Farming with pesticides and other chemicals can have strong detrimental effects on the local ecosystem by entering local water sources through runoff and ultimately damaging the overall aquatic ecosystem as well as any other systems that rely on this clean water (Pimentel, 2005). Moving toward organic farming is better for the environment, and the societal growth in understanding this has been positive, even though more action still needs to be taken. Concerning LaFarm, all produce grown is done so with certified organic seeds, and a program called LaSeed Library was developed to extend the use of organic seeds beyond the farm itself. LaSeed now has over 120 plant varieties of certified organic seeds that Lafayette community members, including students, can "check out" for use (LaFarm Annual Report, 2017).

LaFarm draws many of its ideals from both the farm-to-table and the organic movement while still possessing a unique identity seen in many small scale farms throughout the U.S. The motivations of becoming increasingly more sustainable, accessing fresher produce located closer to home, and farming organically aligns with the motivations of these two movements. The difference lies in that LaFarm is also an educational farm, integrating these aforementioned objectives into principles to teach students through practical experience rather than only book work. Through the addition of both a root cellar alongside a classroom at LaFarm, the farm will be in greater alignment with the sustainability initiatives it has been pursuing. It will also be more capable of teaching about such sustainability initiatives in a more direct fashion.

Sustainable College Farms

The LaFarm initiative at Lafayette College is not unique to Lafayette. The creation of farming programs has become popular across the country as an increasing number of colleges and universities are taking on sustainability initiatives in order to reduce their impact on the environment and provide students with more educational opportunities. These college programs are an extension of the farm-to-table movement as they remove the middle man that is often present when obtaining produce from large scale commercial farms. The college farm program is a newer part of the farm to table movement that is fueling " '... the growth of more sustainable food chains'..." as well as developing ties between the school and the surrounding community

(Izumi et al. 2010). These college farms are also similar to the farm-to-school movements that have been occuring in public K-12 institutions which encourages the use of locally grown produce in school lunches (Izumi et al. 2010). Many of these programs have been in place for decades while some are rather young and still developing within their college and local communities, similar to the LaFarm program.

An example of a well established program is the Hampshire College Farm, which is located at the Hampshire College in Amherst Massachusetts. This farm was started in 1970 as a research tool for students at the college, but in 1992 it was expanded to produce crops for the college itself as well as the surrounding communities by a group of students (Hampshire College Farm). In comparison to LaFarms small acreage and low yield, the Hampshire College Farm has 15 acres of crop producing land, and 65 acres of livestock pastures. In total, it produces 75,000 pounds of produce per year (Hampshire College Farm). The goal of the Hampshire College farm is to support “teaching and research opportunities for faculty and students” as well as a model for sustainable land development for the college’s students and the surrounding community (Farm Mission and Vision). The Hampshire College Farm shares similar, if not the same, goals as LaFarm at Lafayette College but it has been established over a much longer period of time and has greater resources at its disposal.

Another example of a college that is using a farm as an interdisciplinary teaching tool as well as a source of food on their campus is Bowdoin in Brunswick Maine. The organic garden at Bowdoin was started in 2005 and recently moved in 2014 to a half acre plot located on its campus (Organic Garden). This small plot of land also has a medium to large sized barn located next to the property that is used as a gathering place for students and faculty who are taking part in events that the garden is hosting or using it for one of their classes (Organic Garden). The barn located at the organic garden is instrumental in its ability to host events and keep students involved as well as host classes. Although the Bowdoin Organic Garden is on a smaller scale than Lafayette college’s LaFarm, it is able to act as an integral part to the curriculum to a number of different disciplines and host events that make it a relevant to the college community as a whole.

LaFarm and the Community

In addition to a strong connection with the Lafayette community, LaFarm also shares strong ties with several third party groups outside of the college. While Bon Appetit is the largest consumer of LaFarm’s seasonal produce, the farm also provides some produce and services to the greater Easton Community. LaFarm is partnered with groups within the city of Easton, such as the Easton Urban Garden, in order to donate produce and provide support through the exchange of ideas (Miskelly, 2018). This relationship very accurately depicts the benefits a program like LaFarm can have on communities in Easton through the provision of healthy food to surrounding communities. It also works to strengthen the relationship between the college and the local community. The thoughts and concerns of the people of Easton and Forks Township must be considered as well because LaFarm is located within their community. As such, regulations must be abided by, and the know-how of members of the community needs to be considered. The members of the community that live directly around LaFarm may not want to see it expand due to problems such as noise and less undeveloped land that they may see as increasing the value of their community. LaFarm has a strong partnership with the Easton Urban Garden and they would likely be able to provide input on both of these additions to the farm. They would also receive a large benefit in the increase in LaFarms efficiency that would result from the root cellar project (Miskelly, 2018).

Lafayette College and LaFarm

The idea for LaFarm was created in 2009 by two students, Jen Bell (10') and Mickey Adelman (10'), in hope to use this land that Lafayette owned for an educational purposes by integrating engineering and the liberal arts through the environmental studies curriculum, scholarly research, and community engagement (LaFarm Advisory Board, 2016). This sparked the movement to a small scale farm for produce provided to the college and donating to other outside sources. In its early stages, it was mainly Ms. Bell running the farm with the help of Professor John Wilson, a geology professor that also owns his own farm. Together, with the help of other volunteers, Ms. Bell was able to grow the farm to the point of the school offering her a job as Manager of LaFarm (LaFarm Annual Report, 2015). The farm then developed further to partner with Bon Appetit dining services in ways that were not possible with Sodexo, the old dining services, for providing the farm to table of the produce from LaFarm. The farm has now grown in size and popularity with volunteers from students, greek organizations, and professors. LaFarm in particular has become central to the College's many greening initiatives and a leading example of Lafayette's commitment to environmental health.

From the LaFarm's first annual report in 2013, the farm was only a two-acre community garden and working farm practicing in natural food production in order to grow food for the Lafayette College community. The goals of LaFarm at this time include to sustain a food loop at Lafayette, encourage outreach from students and faculty, and provide academic integration between LaFarm and educational practices of the college. Between the 2013 report and the 2017 report, the farm was able to grow in many successful ways with the help from professors, volunteers, classes, and donors. These advances include: Metzgar Irrigation & Swale Project, Crop Planning, Bon Appetit Partnership, Campus Market and Holiday Market, Solar Powered Irrigation System, Donations to the Easton Community, compost implementation with Green Mountain Earth Tubs, Soil Replenishment, LaSeed - Community based Seed Library, new fencing project, Bee Program (LaFarm Annual Reports, 2013, 2014, 2015, 2016, & 2017). The farm has come a long way in just 10 years from Jen Bells original idea, but we believe there is two major places where the farm is lacking are food storage and a larger enclosed structure.

We propose that the LaFarm nexts efforts should be towards implementing a root cellar for storage and a classroom that can also be used as an event space for many of the community activities that take place there. A root cellar would act as site storage for some of the produce such as carrots, potatoes, beets, parsnips, rutabagas, and turnips. This cool environment is also ideal for storing jars of pickled vegetables and the bulbs or rhizomes of perennial flowers as well (Newton, 2003). This would be profitable for LaFarm because carrots and potatoes make up 19% of the vegetable are produced at LaFarm and the addition of pickling vegetable could bring a new market to the farms growth (LaFarm Annual Report, 2015).

Lafayette dining services could be affected by LaFarm in a number of ways. Currently, the food must be transported from the farm directly after harvesting and is stored in refrigerated units on Lafayette's campus. This is not a very efficient way for food to be stored, even though the college is only roughly 3 miles away, there should be a more convenient place that the food could be stored at the farm (Miskelly, 2018). One such way is through the root cellar, thus possibly increasing total yield of the farm by providing more storage space for the farms root vegetables. Less produce from the farm would be wasted, and then less produce would have to be purchased from alternative suppliers for dining services. Lisa Miskelly expressed that the lack of storage space hinders the harvesting of crops because it has to be done on the day that the produce is scheduled to be picked up and brought to dining services. Since crops ripen at different times, the result is that multiple trips must me made to and from LaFarm, but with storage on site the food can be transported in large quantities to the college or Easton Urban Farm for food preparation and sale (Miskelly, 2018). The farm makes some of its profit by selling organic produce outside Gilbert's on Wednesdays and with more storage of root vegetables, this could scale up, improving organic food growth in the area.

Lafayette College has a goal of being as sustainable and environmentally friendly as possible while keeping the college's ideals of providing as many educational opportunities to its students as possible. This can be seen in their actions of signing the climate action plan to reduce the colleges carbon footprint as much as possible (Climate Action Plan, 2011). Currently, LaFarm is using an inefficient method of transporting and storing food, but there is possibly a more environmentally friendly option that would go directly with the institutions' overall sustainability goal. The creation of a carbon neutral storage unit will show that the school is living its environmental ideologies, rather than just stating them. This project will give the community a physical example of the college moving towards sustainability.

The Lafayette students would profit from the addition of a root cellar through educational experience of learning on sight at LaFarm. There is a possibility to add a course that could be directly related to the farming and genetic manipulation of plants for the either biology or environmental science departments. In the past, professors such as Professor Brandes used his Hydrology class (CE 421) with the Art department to develop the Metzgar Irrigation & Swale Project (LaFarm Annual Reports, 2014 & 2015). The implementation of more classes based on LaFarm's growth would bring students to the farm to work on improving their knowledge on effective farming practices, the benefits of organic farming, and the advantages of the root cellar. In addition to the root cellar as an educational tool, the goal is to build a classroom a the top of the hill for classes to meet, even in poor weather conditions. This way, students can conduct lab work with LaFarm to help it move toward it future goals. They would receive first hand experience rather than learn through models in a textbook. Specific to the root cellar, it also provides a learning experience for students through them seeing it in use and understand how the college is moving towards a more carbon neutral future.

Lisa Miskelly expressed the need for an event space at LaFarm for when the weather isn't fair for being outdoors. This is why we believe that the addition of a classroom space that could double as an event space would be extremely beneficial for LaFarm moving forward in its progression. Professors who want to teach about subject matter relevant to LaFarm can also make use of the classroom space that would be made available, teaching while in close enough proximity to the farm that students would get more first hand experience. These addition would give students and faculty direct access to a storage unit where they can keep any produce they harvest on sight and an enclosed structure for education purposes.

Intro

Our standards for the construction of the root cellar will abide by a series of food safety regulations that are based on those provided by the Food Safety and Modernization Act (FSMA). It is essential that food safety is a priority, and abiding by these regulations will be key to ensure both the preservation of produce and prevention of foodborne illness in the root cellar. The classroom space has its own set of laws and regulations that it will be using as guidelines for its construction. Rather what must be considered are the building codes, both federal and local, for construction of the educational facility at LaFarm.

In addition to abiding by these expectations and codes, when considering the creation of a root cellar and a classroom at LaFarm it is important to consider all the stakeholders involved. The stakeholders know the most about LaFarm, are the greatest supporters of LaFarm, and will be impacted the most by any projects carried out at LaFarm. Likely the most important "stakeholder" is LaFarm itself. The ideologies of Lafayette College may vary from those of other organizations, such as other schools or even the federal government, so these unique values should be understood and taken into account when conducting this project.

Federal Policy

The most fundamental policy which must be followed in the construction of the root cellar is the Food Safety Modernization Act. Signed by President Obama, this act's primary purpose is to shift the FDA's focus from responding to foodborne illness outbreaks and towards preventing them in the first place (FDA Food Safety Modernization Act, 2018). Due to the size of LaFarm and its low level of production it is actually exempt from FSMA regulation. With a profit of around $9,000 this past year, the farm falls below the exemption limit of selling less than $25,000 of goods over the previous three years (LaFarm Greenhouse Capstone, 2017).

Despite the exemption regarding the FSMA, a strong incentive still exists to follow the guidelines set out for food storage by the FSMA. The specific regulations relevant to the root cellar concerning the FSMA are detailed within the *Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption: Guidance for Industry* (2018). A few examples of these standards are that “food storage facilities must have a record of dates corresponding with the storage of separate batches of food” and “food within food storage locations should be protected from cross-contact as to prevent cross contamination”

In addition to the FSMA regulations, guidelines formed by both the FDA and the USDA act as additional standards to insure the highest degree of safety is kept. Based on good handling practices as outlined by the FDA, the primary handling fundamentals include an expectation to check water for contaminants at least once a year, active effort to prevent contamination, and an expectation that handlers are trained regarding health and hygiene standards (FDA Food Safety Modernization Act, 2015). All of this applies in the washing and care for produce before and after it is stored. In addition to following these guidelines, smaller farms such a LaFarm can go through voluntary audits which verify that the meet standards in preventing microbial food hazards. These audits are called Good Holding Practices alongside Good Agricultural Practices (U.S. Department of Agriculture, 2014). In order to ensure that the root cellar is properly used, these guidelines should be followed alongside those listed by the FSMA. There are many instances of repetition, but following all verifies that all safety standards are met. By following these guidelines, which have been proven to help prevent the spread of foodborne illness, LaFarm will be able to supply the highest quality of food to Lafayette College and anyone else who may be eating its produce. The main goal of any food producing operation is to ensure that all of the food is safe to consume and in its healthiest form.

Since LaFarm is a subsidiary unit of Lafayette College, the primary purpose of anything done on LaFarm is to add educational value for current and future students. Through abiding by FSMA, FDA, and USDA regulations, the farm is showing students the industry standard. When students participate in courses that include conversation about the root cellar, the adherence to these regulations can be referenced. A root cellar that adheres to a very strict level of safe food handling practices will serve as an example to students of the proper way food should be handled.

Besides regulating food safety, the USDA helps to ensures that sustainable agricultural practices are being promoted across the US and have helped the farm-to-table movement to develop even farther. One way that the USDA did this was to amend laws in order to change where food in K-12 public institutions was obtained from. The National School Lunch Act was created in 1946 by the USDA in order to regulate school lunches and in 2002 an amendment was added that encouraged public schools to buy and use locally grown food in their cafeterias. Since this change was implemented, many different states have enacted their own laws and regulation that support this change in food at public schools (Izumi et al., 2010). Although these laws do not have an impact on private colleges like Lafayette, they serve as an indication that movements, such as the farm-to-table movement, are becoming more popular and are actually being supported by both the federal and state level governments. These federal and state programs can be used as examples for higher learning institutions in that they should be sourcing their food from local growers rather than buying it from large distribution companies that are partnered with commercial farms.

In order to ensure that our classroom space was able to provide the necessary amenities for students at Lafayette. To ensure that this happens we based our ideas on the Pennsylvania Public School Codes of 1949 to include all features that are necessary for a functional classroom. The Public School Codes are more based on grants given by the state based on costs, but we focused more on the processes and overall need additions that are important on building a classroom space. Under section 751.a.2, the regulations states that all construction of any school buildings must include the introduction of plumbing, heating and ventilation, electrical works, and lighting systems must be prepared with the appropriate detailing in size and materials of the structures (Public School Code, 1949). In 1972, it was added to the that under Section 703.1 that all constructed building spaces with educational purposes must comply with the standards and regulations established by the State Board of Education and the Department of Labor and Industry.

Stakeholders

In order to make the addition of both a root cellar and an outdoor classroom as effective as possible, we must take into account all of the people who will be affected by the project. The first group of people to take into account when it comes to LaFarm are the students who are part of the Lafayette College community. In order to do so, we must consider what will be the most beneficial for the students at the LaFarm site. The addition of both a root cellar and an outdoor classroom will increase the educational opportunities for the Lafayette students in a non traditional setting. This will increase the overall experience that they have while learning at the college. By creating an outdoor classroom at LaFarm it will also provide students with an extension of campus that they can use in any way that they see fit.

LaFarm is managed by an advisory board, made up of several professors from different departments, as well as a farm manager, Lisa Miskelly. The LaFarm staff and advisors are the people on campus who are most aware of the areas in which the farm is lacking. In order to effectively implement the root cellar as well as the classroom the input from the board as well as the farm manager will be influential. In order to ensure that these thoughts are taken into account we met with Lisa Miskelly in order to hear her concerns and needs regarding the root cellar and the classroom. She was able to provide us with her needs for size of both of the additions as well as the ideal locations for both.

Lafayette College is likely the biggest stakeholder that must be taken into account when any changes are being made to LaFarm. This is because the success of the farm reflects back on the school so they want it to be as productive and efficient as possible. The farm provides their students with the opportunity to get off of campus and get involved in volunteering and both the classroom and the root cellar would enhance this experience. The creation of a sustainable food loop for the schools dining services is also a major selling point to prospective students as well as step towards their sustainability goals. The development of a sustainable food loop between the college and LaFarm will help to create a food system that is completely independent from the global An increase in the efficiency and production of food at LaFarm will greatly benefit dining service's ability to serve sustainably sourced food in the dining halls. The storage of food at LaFarm will also decrease the amount of food waste that is produced by dining services. The increase in sustainably sourced food and the decrease in food waste as well as the reduction of emissions producing storage will help the school further its climate action goals.

Since LaFarm is not located on the main Lafayette College campus, the community members located directly around LaFarm must be taken into account because they are affected by any development projects taken on by LaFarm due to their proximity. This includes things such as construction noise, increased traffic from students, and the decrease of undeveloped land in their community. There are also positive impacts from the donation of food from LaFarm to their community partners, such as the Easton Urban Farm, as well as the selling of organic seeds.

Easton/Forks township and Lafayette College

In this project, we must consider the overall goals that Lafayette College has for its campus. One of the main goals that Lafayette carries throughout its campus and the activities that it conducts is sustainability. One example of this the Grossman House dorm located on campus which has a LEED gold certification. In order to keep sustainability at the forefront of everything that it does, Lafayette created its own Campus Energy Policy. This policy states that all new construction and development will strive for LEED certification, this should include structures at LaFarm. Although we likely will not be working towards LEED certification, we aim to build carbon neutral facilities in order to carry out the colleges ideology of sustainability. The addition of a root cellar at LaFarm will be a perfect example of a carbon neutral storage unit for produce. Additionally, the root cellar will reduce the amount of waste food that comes from LaFarm since there is not on site storage currently available.

LaFarm is located with Forks Township, thus before moving to the technical planning we must have an understanding of the zoning laws and building permits of Forks, Pennsylvania. After looking at the zoning maps for Forks Township, the location of LaFarm lays on top of REM (Recreational/Educational/Municipal) land according to Township of Forks Ordinance 331 Code § 200. Based on the zoning and the Pennsylvania statewide zoning laws, this land can be used in a variety of purposes which includes agriculture or educational. Moreover, the Pennsylvania Uniform Construction Code exempts any agricultural building on agricultural land from building codes. This is important information to know for our project because it means that according to the zoning laws, LaFarm will be a very feasible location for building of the classroom along with the root cellar. The LaFarm classroom and root cellar project will require permits in order to be built. This could prove to be a problem if permit applications are denied due to the township disapproving of the project or if they believe that the building project will create a disturbance for the surrounding community. In order to properly apply for permits the help of the Forks Township will be required to ensure that the designs adhere to any and all requirements of building projects in the township.

<u>Technical Context:</u>

Introduction:

In the world of today, the primary technology used in order to store food is a refrigerator or which uses electricity to maintain a constant cold temperature that creates a healthy environment for food storage. This method of storing food is the most effective and helps to keep food safe in both individual consumers homes as well as commercial settings. The most prominent issue with this particular method of storing food is that it uses large amounts of electricity. For example, in 1999 a survey was conducted in California to determine the break down of electricity use in the residential and commercial sectors. This survey showed that in California alone, 3% of commercial electricity and 5% of residential electricity use was purely refrigeration of food (Brown, R. E., & Koomey, J. G., 2002). Although this data is almost 20 years old, it reveals that the refrigeration of food uses large amounts of electricity. This electricity use may not seem like an issue but it connects directly to generation of greenhouse gas emissions. In order to put this into perspective, we can look at the UK where around 5% of all greenhouse gas emissions come from the refrigeration of food (Garnett, T., 2007). This example from the United Kingdom can be used to create a generalized portrait of a majority of the first world nations around the world.

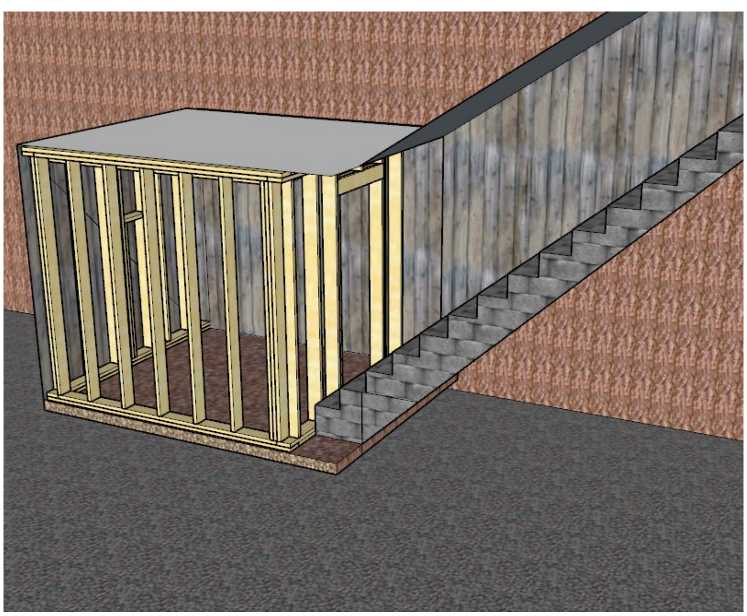
In the case of Lafarm, the use of a root cellar is a step back in the development of technology from this electricity based technology of modernity. Root cellars are an age old method of food storage that harnesses the geothermal properties of the Earth. The layers of soil create a thick layer of insulation that helps to maintain a constant temperature below the surface. By creating a room below the surface that is almost completely cut off from the varying temperatures of the surface, we can harness the constant lower underground temperatures to create a natural refrigerator. This specific geothermal property of the Earth is what made root cellars a feasible method of storing food without generating any carbon emissions.

In the case of LaFarm, the specific classroom environment we hope to develop is one which that conveys outdoor, environmentally focused education. The current stance is that the classroom should be fully enclosed but have large windows which let light in, delivering a full view of the farm. Through this, the classroom will both be usable year round and also remain well connected with LaFarm. In addition to this, it is possible that the classroom will be combined with a greenhouse, and as such be a multipurpose facility.

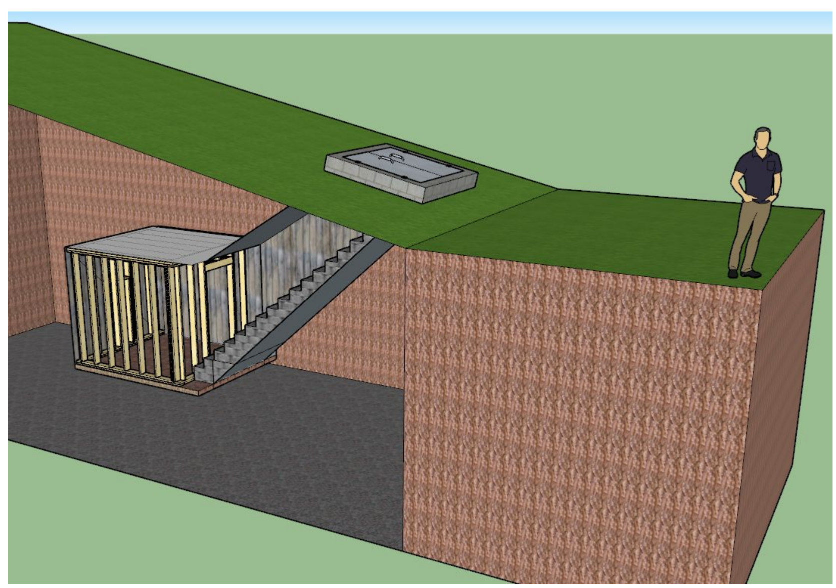
Root Cellar:

The root cellar must be able to safely store food products in order to ensure that they are usable in the dining halls at Lafayette or sold to other community members. This means that the cellar must be properly placed within the ground in order to maintain a constant temperature, ideally around 50 degrees Fahrenheit. Another necessity of safe food storage in a root cellar is the humidity levels. The root cellar requires a high level of humidity to properly store the food but cannot reach the point at which condensation is formed. In order to ensure the proper levels of humidity a ventilation system will be installed to give the LaFarm staff an improved control of the air flow throughout the cellar. In addition to this, the use of specific materials for the floors and shelves will be chosen to promote the ideal atmospheric conditions needed for storage.

We propose a 10'x8'x8' root cellar room located 7 feet below the top of the hill located directly next to LaFarm. The size of this underground structure was chosen after speaking with Lisa Miskelly, the current farm manager, about the farms needs for the cellar. The entrance will be a set of stairs located on the slope of the hill in order to reduce the length of the staircase as well as its steepness. A rough estimate of the slope of the hill is 11-13° and for the most part uniform to the apex of the hill. Building the cellar into the hill will allow us to minimize the amount of excavation required to reach the subsurface temperatures required for the root cellar to be functional. However, due to this shallow slope a fairly significant staircase must be excavated for the entirety of the root cellar to be within this constant ground temperature threshold.



3D Rendering of Root Cellar with Shelving Framework
-Austin McKee



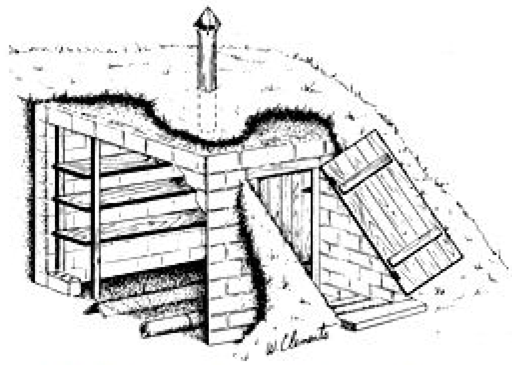
3D Rendering of Root Cellar in Relation to the Hill
-Austin McKee

The floors will be made up of a 4 inch layer of all purpose gravel, which is a basic decorative stone that helps to repel bugs and can be found at a local HomeDepot, in order to promote the flow of air and moisture that is so crucial to a root cellar. In order for a root cellar to be successful, it needs a very high level of moisture, around 90-95 percent humidity, and the use of gravel as flooring promotes this (Bubel, M., & Bubel, N.). The gravel is also a very cheap and easily maintained flooring option. In conjunction with this, a simple ventilation system made up of several metal chimney pipes will be added. In a small scale storage operation like the one we are proposing, this is all that is required to allow air to flow in and out of the root cellar. Users of the root cellar at LaFarm will have the ability to open and close to ventilation duct at the access point within the root cellar. Through the addition of a psychrometer, both the temperature and humidity levels within the storage space can be measured accurately with zero energy use. The psychrometer uses both a wet-bulb and dry-bulb thermometer to measure the atmospheric conditions within the space. The difference between the two yields the atmospheric humidity at any given time. The shelving units used for storage will be made up of slatted wood in order to promote the flow of air between the produce. In such a moist environment, if air is not able to flow properly then the produce may build up mold. The wood is also a cheap shelving option and will not rust or break down in the high moisture environment. In addition to this, the adjustable, slatted wood shelving will allow Lisa Miskelly and the LaFarm team to change storage layout within the root cellar if need be. Depending on the crop yield or the physical size of the crops, an adjustable storage layout could be very beneficial in terms of maximizing the root cellars use at LaFarm.

Classroom:

We had originally theorized an outdoor classroom space built into the hillside adjacent to or as a part of the root cellar. This outdoor space would have been an entirely open setting with seating, desks, and some form of whiteboard space to work. This would then be complemented by an overarching gazebo to protect the classrooms infrastructure from the elements. After talking with Lisa from LaFarm, we developed a more feasible structure that would satisfy the needs of both LaFarm and most academic classroom essentials. The structures design shifted toward that of an entirely closed and multipurpose educational space. Lisa had emphasized that we shouldn't limit the classroom to a strictly a Lafayette College classroom. By developing an enclosed space for which to work, LaFarm can then utilize the classroom for event hosting and educational seminars to further it's educational efforts in the surrounding community.

The classroom itself will be built in a typical rectangular design, spanning 45x60 feet, in terms of the perimeter dimensions, with a ceiling height of 10 feet. This tends to represent a very similar design to that of a typical lecture based classroom, around 25x30 feet, one might find throughout Acopian Engineering Center here at Lafayette. The additional space will allow for storage, restrooms, and excess space that increases the overall capacity of the multipurpose class space. This classroom will differ from these rooms with a large, foldable glass facade that faces



A root cellar needs to breath, and a ventilator is necessary. It should be 4 to 6 inches square, extend 3 or 4 feet above the dirt that covers the cellar and must have a rain cap. Plug the vent with rags or paper in extremely cold weather.

southwards towards LaFarm in order to bring the outside in and make it feel like the classroom is open to the elements as well as highlight its focus, the farm itself. With this design the classroom will be able to open an entire wall towards LaFarm and make it feel connected to it rather than cutting it out altogether. The foldable glass facade will allow the optional exposure to the outside elements, which in turn will still deliver the added benefits previously discussed regarding immersive teaching. In compliance with the Pennsylvania Public School Codes of 1949, section 751.a.2, the building will include plumbing, heating and ventilation, electrical works, and lighting systems (Public School Act, 2012). In 1972, it was added under Section 703.1 that all constructed building spaces with educational purposes must comply with the standards and regulations established by the State Board of Education and the Department of Labor and Industry. The space will include two gender neutral restrooms in addition to full heating and lighting amenities throughout the entirety of the multipurpose classroom. The furnishing of the classroom will be lightweight and easily movable. In doing this, we can guarantee LaFarm and Lafayette College the ability to reorganize the room for whatever classroom or event based environment necessary.

<u>Geo-technical:</u>

General geology:

When developing a project that alters the land by development, it is important to include a geologic index to the local geology. Different rock types can affect what type of materials should be used for construction. LaFarm lays in an area made of dolomites that make up part of the Beekmantown Group Formations. The geology of LaFarm lays on two subgroups within the Beekmantown, which are the Rickenbach Dolomite and Epler Formation. Rickenbach Dolomite (Or) is the older of the two groups and mainly consists of various types of dolomite. Dolomite is a fine grain anhydrous carbonate mineral, typically composed of calcium magnesium carbonate ($CaMg(CO_3)_2$) and if a rock type is termed as dolomite when it makes up a large enough portion of the bed. In this case, the Rickenbach is made of varying sizes of dolomite with abundance of silt and sand grains and some conglomerates (Beekmantown Group). Overall, in outcrop, this mix of grains gives the rock a "dirty" look, but the upper portion of the formation is more finely grained, which is what we will have to handle when it comes to building. However, due to the nature of the farm laying over two beds, we cannot confirm this until we dig down to it. The contact between the Rickenbach Formation and the Epler Formation is transitional, meaning there is a more gradual change between the two, rather than an abrupt transition. The Epler Formation (Oe) is similar to Rickenbach, which is why they are group together within the Beekmantown Group together. The Epler Formation is made up of interbedded limestone and dolomite. The individual beds are often found finely laminated, meaning thin beds of limestone and dolomite varying between the fine beds. This information leads us to believe that fine grain dolomite and limestones lay beneath the soils. This can make more difficulties for building due to the fine grains and possible sinkholes due to the rocks being carbonates and more susceptible to weathering (Drake, 1965).

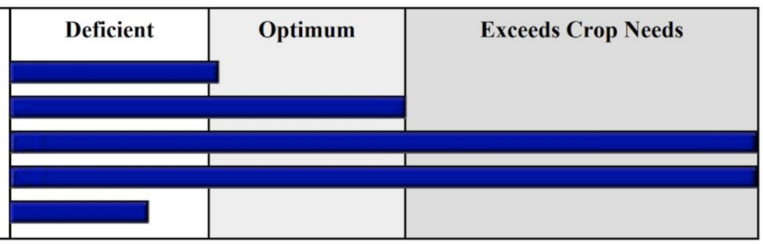
Soils:

In order to build on or into the land, it is required survey for the land development to be conducted prior to any form of construction. The soils below LaFarm are Washington silt loam (Wab) soil. Each letter in the identification of this soil has meaning behind it, along with the multiple soil horizons tell how the soils change with depth. In this case the W means well graded bedding soil, where beds of different size sediment are well separated through the soil. The horizons within the soil are labeled as Ap, Bt, and C (Northampton County Soil Maps). Ap symbolizes the top layer of the soil is a silt loam that can vary from 0-9" and the p stands pasture land, causing disturbance at the surface. Bt symbolizes the accumulation of clay silicate in someway, likely by water table in the subsurface, but can make challenges for building. The final layer in any soil horizon is almost always C, meaning parent material, which is the deposit at Earth's surface from which the soil developed. The b of Wab symbolizes the hydrologic soil group B where water passes through the subsurface at a 10-50 micrometers per second. The soil itself is healthy, received a 85.8% - Rated higher quality on the NCCPI (National Commodity Crop Productivity Index) scale. With further data collection we may be able to learn the exact distance to the bedrock using the auger machine to dig vertically down approximately ~ 61 inches to bedrock (60-99") before hitting the bedrock. (Whether we do this or not is dependent on the new GPR data which is still being processed). This is important knowledge to know before construction because of the nature of the soil being a mineral soil can reveal problems. The mineral characteristic makes the soils more susceptible to weathering, like the rock below, making building difficult more difficult during the construction process (Northampton County Soil Maps, 2018).

A soil analysis was done at LaFarm in 2011 to test soil quality for mixed vegetable crops. A major point that came out of this study was where the farm was lacking in some nutrients while others that were exceeding the needs of the farm. The notes from the report go on more detail for LaFarm practices to try and balance out these values to become more optimum for growing vegetables at the farm. One of the major lacking qualities were in the nitrogen to be able provide for a higher crop yields. The first suggestion was for the correct amount of manure to be place across the land to supply the crop's nitrogen requirement, stating, "For most vegetable crops apply about one ton per acre of moist crumbly poultry manure or 7 tons per acre of cattle manure for low N-Crops such as beans and peas and up to 4 times this amount for high-N crops such as broccoli, cauliflower and fresh market sweet corn." (Soil Test Report, 2011). The other suggestions includes lime, boron, and fertilizers, but each has different effects on the soils that are both good and bad qualities for bringing the soils to the optimum conditions.

LABORATORY RESULTS:										Optional Tests:		
[1]pH	[2]P lb/A	Exchangeable Cations (meq/100g)					% Saturation of the CEC			Organic Matter %	Nitrate-N ppm	Soluble salts mmhos/cm
		[3]Acidity	[2]K	[2]Mg	[2]Ca	[4]CEC	K	Mg	Ca			
6.6	150	2.2	0.6	2.6	5.0	10.5	6.1	25.2	47.6	2.3	9.6	
Test Methods: [1]1:1 soil:water pH, [2]Mehlich 3 (ICP), [3]Mehlich Buffer pH, [4]Summation of Cations												

SOIL NUTRIENT LEVELS			
Soil pH		6.6	
Phosphate	(P_2O_5)	344	lb/A
Potash	(K_2O)	600	lb/A
Magnesium	(MgO)	1049	lb/A
Calcium	(CaO)	2769	lb/A



Ground Penetrating Radar (GPR):

For this project, we used Ground Penetrating Radar (GPR) to understand the subsurface. GPR allows a client to know when you dig, you will have a safe assumption of what might be in the subsurface to see any unknown utilities. Other methods, such as x-ray, electric locating, and magnetic locating, but GPR will always pick up structures other machines may not. The GPR is actual safer than X-ray procedures, no harmful materials are emitted, thus no limit tot is use on a site (CLU-IN Technologies - Ground Penetrating Radar, 2018). The GPR works by transmitting electromagnetic energy to pass information from two antenna: transmitter and receiver. There is a direct wave through the air and ground, while a indirect wave goes into the subsurface. The differences in return time transportation into the deeper earth materials is what the machine is reading by the actual by having the noggin sensor sitting against the bottom of the cart. The system reads the subsurface based on pulses of electromagnetic energy going into the ground (CLU-IN Technologies - Ground Penetrating Radar, 2018). These pulses send out energy in a cone like way, to see both in front and behind where there a cart is at a certain point. This is reason that the resulting figure will contain multiple hyperbolas due to the approach and retreat of driving over the object. The information is then sent in real time to the computer to be able to move back and forth anomalies over a straight line. This allows the surveyor to marked on the ground the location of these anomalies, so the client knows before they begin digging. Interferences that can affect GPR readings is the dielectric value of the medium we are trying to pass through, based on their conductivity. The air is the best conductor and has the lowest dielectric value, while water has one of the highest dielectric value of 81. GPR systems work best with lower dielectric values because of the high conductivity, but in the event of rain the accuracy of the data collection is weakened.

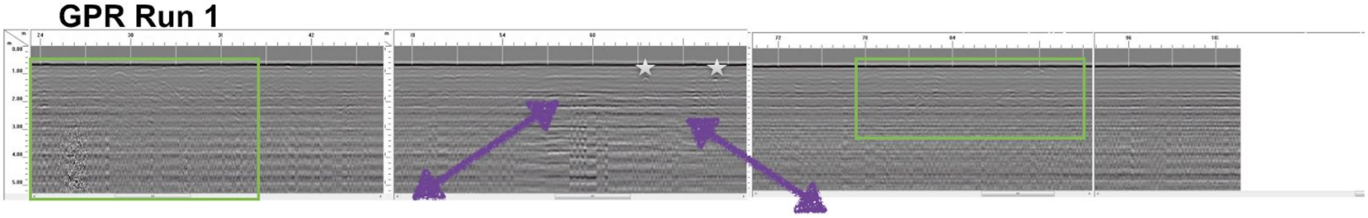
The preliminary data below was captured from a GPR unit, representing three passes over the hillslope. In turn, we were able to detect possible disturbances in the subsurface of the area intended for future excavation. Each run starts at the top of the hill and runs down slope, turning at the base of the slope to walk approximately 10 meters before turning back up the hill. The stars indicate object disturbances, in the case the first run of the two stars indicate fence posts that run along the base of the slope, at the edge of LaFarm. The third run has a star at another disturbance and we believe that it is a possible root from the top of the slope, but we say this with less confidence than the posts. The purple arrows indicate lines a horizon, possibly bedrock underneath the hill. This was a big clue into how the hill was formed because we originally thought it was the natural topography of the land, but the horizon runs in the opposite direction of the slope of the hill. This leads us to believe the hillslope is man-made and consists of fill.

The second trip to LaFarm we set up a grid system to cover a larger area of land to try and decide to try and decide where it was best to place the root cellar. Unfortunately, after the figures did not come out as clear as the preliminary data because the saturation of the soil along with using a higher frequency to try to see deeper into the ground. The saturation of the soil affected these readings because it decrease the conductivity of the soil for the electromagnetic waves trying to pass through the medium the electromagnetic waves. With more saturation, the soil becomes less conductive because water is a poor conductor. Conductor mediums are given a dielectric values based on conductivity of the medium, for example air has a value of 1 while water has a value of 81. Clay soil dielectric values varies depending on the saturation greatly having a value from 2-6 when dry and 15–40 when wet (Martinez & Byrnes, 2001). This impacted the data, but we still saw the linear artifact showing up in the data and that the soil is very likely to be a clay fill at the site.

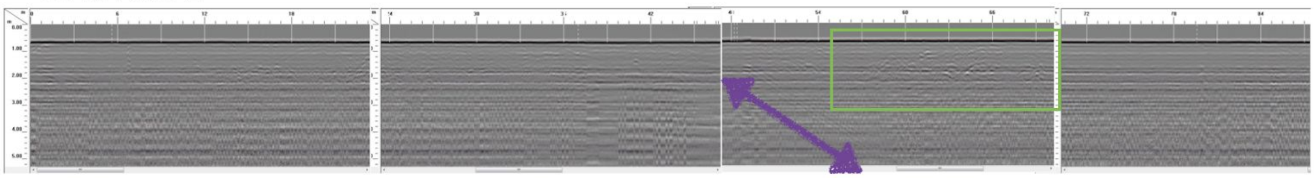
This could lead to difficulties when it comes to building for building depending on the type of fill and whether or not it’s fine or coarse grained rock or clay. It is unclear whether or not the this will affect building, but if there is more larger cobbles of rock instead of finer grains it

GPR DATA

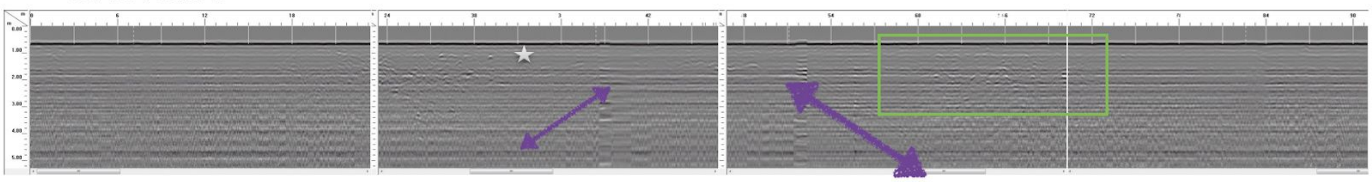
GPR Run 1



GPR Run 2



GPR Run 3



could lead to more difficulties in building. The green boxes are to highlight unknown noise in the data, this is found at the top of the slope so it shouldn't cause problems of the project. The possible source could be fill with larger rocks due to more fill would have been needed at the top of the slope opposed to the slope itself. This data is important to our project because we now know there is an impermeable layer at 1.5 meters and greater as the hill slope increases in elevation. With this data we have found that there is no unknown utilities or obstructions laying under the hillslope. This means that excavation cost will not vary depending on where on the hillslope the final. location of the root cellar is placed, based on the larger grid system we set up for confirmation of the preliminary data collected.

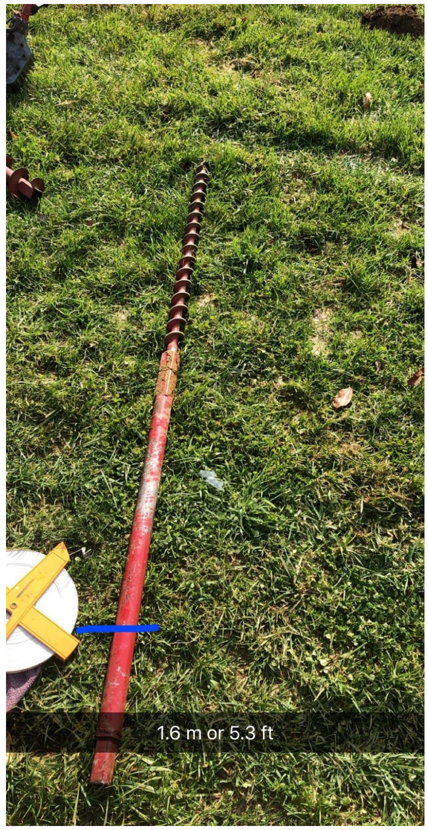
Auger:

After running our preliminary runs for GPR we wanted to confirm the depth to our supposed bedrock layer we saw closest at the base of the slope and lowering as we moved up the hill slope. We used an auger drill with a rotating helical screw blade from the Lafayette Geology Department and the assistance of John Wilson. We dug a total of three holes, two at the base of the slope and one 5 meters up slope. The purpose of the auger to dig into the ground until we hit a solid layer that we believe is the bedrock. The first two holes at the base of the slope verified there is a solid layer at 1.55-1.60 meters deep. The third hole was 5 meters up slope from the the second hole and we chose to do this to verify that the solid layer does get deeper to 1.85 meters.

Overall, we can conclude that there is a solid layer the auger could not drill through at 1.55-1.60 meters deep at the base and increases in depth the farther we move up slope.

Auger Site 1 -
Impermeable Layer
Hit at 1.55 meters

-Justine Perrotti



Auger Site 2 -
Impermeable Layer
Hit at 1.60 meters

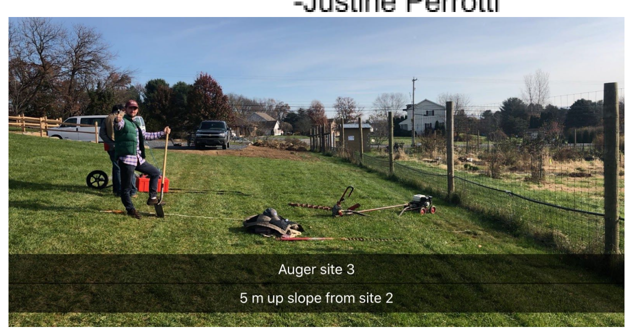
-Justine Perrotti

Auger Site 3 -
Impermeable Layer
Hit at 1.85 meters

-Justine Perrotti

Location of Auger
Site 1 - 2.7 meters
from the fence

-Justine Perrotti



Location of Auger
Site 3 - 5 meters
from the fence

-Justine Perrotti

Economic Context:

Introduction:

In the agricultural industry, small scale farms are at an economic disadvantage to large scale commercial farms and this barrier must be overcome in order for these operations to be successful. Large commercial farms provide a much cheaper product to consumers, due to their use of less labor intensive farming methods, and many have become accustomed these low prices (Reynolds p.10, 2015). Although the prices are higher for locally sourced sustainable grown produce, they provide an environmental benefit that some consumers have a hard time putting a dollar value on and are often unwilling to pay for. In order to combat this issue there are some programs that are compensating farmers for the environmental value they are adding by using sustainable farming practices (Reynolds p.10, 2015). Although it seems that small scale farms are not as economically viable as large commercial farms, the environmental benefit that they provide does in fact make them viable. LaFarm faces this same struggle of economic viability but because it is an educational farm that is backed by a collegiate institution it does not factor into its success.

LaFarm is a small operation that occupies roughly 3 acres of land whose primary goal is to promote the educational mission of its partner Lafayette College. Overall, the farm maintains a yearly budget of $11,000 (Sarah Edmonds, LaFarm Capstone, 2017). This budgeted capital comes from a combination of donations in addition to produce sales to Bon Appe'tit and several other parties outside Lafayette College. The economic capabilities of the farm are limited so financing both the root cellar along with the classroom isn't a likely option without some form of outside support. This outside support will have to be sourced from external grants, donors, or funding from the College. With the absence of a predetermined budget from the College or outside donors, the economic feasibility of the project cannot be fully ascertained. However, through a basic cost estimate siting costs of labor and materials we have delivered a financial proposal outlining the funding necessary for the implementation of these designs. By doing so we have laid the economic groundwork for future students to move past the economic analysis and focus on the actual securement and approval of the project in the years to come. A future class will be able to take what we have done and create a more detailed estimate in conjunction with the administration to determine if the project is doable or not. Following this we have outlined a more comprehensive analysis of cost estimates, operations and maintenance costs, and economic incentives for constructing both projects. In addition to this, a rough outline has been developed for a possible Senior Design Project in the near future.

Cost Analysis of Root Cellar/Classroom:

We analyzed the economic aspects of the aforementioned root cellar design with our proposed dimensions of 10'x8'x8' room located 7' below the surface. In order to determine the costs of such an excavation project, we used data from RSMeans. RSMeans is a series of universal construction standards that are used for cost estimation across the US, and even the globe. Although the actual costs will vary depending on where the project is located and who is doing the work, RSMeans provides a concrete base that can be used to decide whether the project is worth undertaking or not. The bare material, labor, equipment, and totals are all standards for the usage of a 1 cubic yard bucket for the excavation of basic soil that were taken from RSMeans. The total item cost utilizes all of these numbers along with the quantity of soil needed to be removed in order to calculate a total cost for the item. Based on the data, the bare excavation would cost roughly $1,189.50 and be able to be completed within a day. This cost estimate is derived from the amount of raw material, in this case soil, that can physically be excavated by a 1 cubic yard bucket. The cost of excavation includes the renting of the actual excavator and the labor costs necessary for the removal of material. These labor costs, as seen in **Table 1** and **Table 2** are based on an hourly operating wage for the individual operating the excavator. In order to properly determine the cost of this project, a multiplier must be used to accomodate for costs in the Lehigh Valley region, also provided by RSMeans. Cost multipliers are used in the construction industry to more accurately estimate the cost of projects throughout the U.S. These cost multipliers are geographically distinct due to the varying price of materials and transport of said materials in the respective area of construction. When the local cost multiplier, 1.047x, of the Lehigh Valley is applied the final item cost increases slightly to $1,245.41. In order to account for the overhead and profit (O&P) of the company that will be doing the job, a standard O&P of 20% is used in order to obtain an accurate estimate (Building Construction Costs with RSMeans, 2017). After O&P are taken into account, the cost of the excavation becomes $1494.49. The inclusion of the overhead and profit will provide the college with a more accurate estimation of how much the excavation will cost and be more helpful when determining if they will be undertaking the project or not. This cost might be subject to change depending on the contractor that will be performing the work but this is a good starting point .

Crew	1 CY Bucket
Material Line Number	31 23 16.16 6040
Quantity (B.C.Y)	65
Bare Materials	0
Bare Labor	7.1
Bare Equipment	6.85
Bare Total	13.95
Total including O&P	18.3

Table 1: Equipment Costs

Bare Item cost	$906.75
Total item cost	$1,189.50
Total Cost w/ Multiplier	$1,245.41
Adding O&P	$1,494.49

Table 2: Adjusted Equipment Costs

The basic labor costs, including an hourly and daily rate for each trade, as seen in **Table 3**, were taken directly from RSMeans for the standard trades that will be needed to perform the work for both the cellar as well as the classroom. All of the trades as well as the hourly and daily rates are listed in the table below. Although the labor costs do not provide a total cost for the project, it provides a basic idea of how much it would cost to run the project on a daily basis. These costs can vary depending on whether the laborers are union affiliated or private contractors or if they deem that more tradesmen are required to perform the work. With a project of this size, we do not foresee the project timeline exceeding more than a month or two, depending on any unforeseen delays or issues that have to be resolved before the project can be started or finished. A deeper analysis would be needed to determine exactly how long the timeline of the project would be and this would be somewhere the next class could pick up where we left off. This would also entail direct coordination with a contractor to outline and compare both timelines and budgets. However, if this project can be formatted into a larger interdisciplinary design project for a future class the timeline would shift to be more accommodating to the classes potential syllabus.

Position	**Hourly Rate**	**Daily Rate**
Equipment Operator (Med)	$53.75	$430.00
Laborer	$39.85	$318.80
1 Backhoe (48 HP)	N/A	$643.80
Labor Foreman (Outside)	$41.85	$334.80
Carpenters	$50.70	$405.60

Along with the labor costs that will be needed to perform the work, a basic outline of the costs of materials for both the root cellar and the classroom is necessary to understand the economic needs of the project. In the **Table 4** and **Table 5** below, a list of basic materials needed for both phases of the project are listed along with standard unit costs for those items. All of the prices have been taken from the Home Depot website to help build a basic understanding of the costs for the materials for the project. These costs may vary depending on where the contractor performing the work gets its materials from but we used Home Depot as a standard. A future capstone should look into actual quantities for these materials in order to formulate a total cost for the project, as well as any specialized items such as furnishings and technology needed for the classes that will be held there.

Item	**Size**	**Units**	**Unit Cost**
Cinder Blocks	16"x12"x8"	EA	$2.50
All purpose gravel	.5 Cu. Ft.	Cu. Ft.	$4.50
Oriented Strand Board (Plywood)	7/16”x4’x8’	EA	$10.85
Studs (Shelves)	2”x4”x10’	EA	$2.84

Table 4: Root Cellar Material Costs

Item	Size	Units	Unit Cost
Concrete	80 lb bag	EA	$3.97
Studs	2”x6”x10’	EA	$6.42
Oriented Strand Board (Plywood)	7/16”x4’x8’	EA	$10.85
Windows	41.5"x53.5"	EA	$242.04
Roof Truss	2"x10"x16"	EA	$22.17
Sheet Rock	1/2"x4'x8'	EA	$9.57
Insulation (Foam Board R-13)	2"x4'x8'	EA	$39.74

Table 5: Classroom Material Costs

Along with the costs of labor, materials, and excavation, the cost of the ground penetrating radar survey must also be taken into account. According to the EPA, the GPR equipment can be rented for $1,000.00 dollars per week along with a mobilization charge of 300 dollars (CLU-IN Technologies - Ground Penetrating Radar, 2018). Alternatively, a technician can be hired to perform the survey along with all of the required reports at a cost of $1,000.00 to $2,000.00 per day (CLU-IN Technologies - Ground Penetrating Radar, 2018). Although there are professors at Lafayette college, such as John Wilson, who could conduct the GPR survey, we wanted to provide the potential costs to have a professional perform the work in order to show an alternative to having it done by a member of the faculty. The best option for this project is to hire a technician to perform the work to ensure that the survey is conducted properly and the reports are interpreted in the most appropriate way. This professional GPR survey will be necessary to either support or contradict the survey that was conducted by our group and will provide Lafayette College with a better understanding of the feasibility of the root cellar and classroom at the proposed site.

After analyzing the cost estimates and further discussing some of the logistics with Lisa Miskelly, the group came to the conclusion that the actual construction of the root cellar could be a feasible senior design or capstone project in the future. In accordance with LaFarms educational practices, Lisa suggested keeping the majority of the project internal to Lafayette College’s Engineering and Science departments. Students would in no way be sufficiently qualified to operate heavy excavation equipment or install the subsequent support structures within the root cellar, however it could offer an exceptional learning experience. We believe the further design and construction of the root cellar could be supervised by a faculty member for an Engineering Senior Design Project that would encompass not only several engineering fields of study, but also other scientific fields being pursued by students here at Lafayette College. Those individuals seeking degrees in Engineering Studies, Mechanical Engineering, Civil Engineering, Geology, Environmental Studies, or any field that could benefit from this design process could come together to participate in a truly interdisciplinary project. By framing this project as an educational process in which students come together and participate in a small scale construction operation, we believe there would be a stronger incentive for the college to aide in its funding. Clearly expanding the actual excavation and construction of the root cellar over the course of an entire semester would be very fiscally inefficient. However, further geotechnical analysis, planning, coordination, acquisition of supplies, and a further development in design could be assessed over the majority of the semester. This would leave the excavation and construction of the root cellar coming into fruition toward the latter portion of the semester, or whenever weather permits.

These economic capabilities won't necessarily payoff the initial expenses of both the root cellar alongside the classroom. The reality, though, is that such improvement is not the primary purpose of either of these builds. The key benefits are not economic-centric, but rather focused on improving the environmental sustainability alongside the teaching capabilities of LaFarm. These benefits are not directly quantifiable, but more so subjective. As such, weighing costs and benefits of the root cellar and the classroom can't be done in a spreadsheet. The expected educational and environmental benefits of the root cellar and the classroom must be projected based upon examples seen at other locations and use cases developed by asking faculty and students how much they could see these locations add to their interaction with LaFarm. We didn't conduct such analysis, but see it as potentially relevant to the project. As such, a future EGRS project or capstone should be focused on conducting such research to improve the overall study of the cost-benefit analysis of the root cellar as well as the LaFarm classroom.

Funding:

With the small yearly budget of $11,000 for LaFarm there is a need for external funding to carry out the construction of the root cellar, the classroom, or both. The options for acquiring this funding include school funding, grants, and alumni funding. School funding is possible, since the school does have an environmental initiative that can be further promoted by the carbon neutrality and sustainable food loop the root cellar will add to LaFarm. External grants are also possible from organizations or funds that provide support for environmental initiatives. Of these three possibilities alumni funding is the most probable. An alumnus with an environmental/farming specific background would likely be interested in providing the capital to build these projects and further the development of the farm, ultimately enhancing an experience relevant to their career path. Our goal is to lay the groundwork for this project so that a future capstone can take what we have done and continue to build on it.

Conclusion:

We believe that implementing this project at LaFarm will be beneficial to the Farms infrastructure as well as its core values of education and sustainability. There are some clear infrastructural issues regarding on site storage that LaFarm continues to work around that ultimately causes them to sacrifice both efficiency and sustainable practices in the process. An on site root cellar would solve these key issues regarding storage and promote the sustainable ideals LaFarms continues to uphold in the process. The classroom will bring an additional educational element to LaFarm that far exceeds the kinesthetic learning currently ingrained in their sustainable farming techniques being taught. The dynamic nature of the multipurpose classroom will provide a venue in which Lafayette College and LaFarm can further develop their educational efforts regarding the green initiatives each is striving to improve upon.

As detailed in the report, Lafayette College and the greater Easton community will see strictly benefits from the implementation of these projects. With locally sourced farming and the Farm to Table movement on an upward trend, now is a better time than ever to follow this trend with the continuation of environmentally sustainable practices. Specifically in Easton, PA, operations like the Easton Farmers Market and the Easton Public Market that promote the sale of locally sourced products are continuously gaining popularity throughout the community. With this upward trend actively present in both the Lafayette and greater Easton communities, we believe the root cellar and classroom could add to this by providing an additional educational outlet for all those interested in this growing community.

Economically speaking, this project requires very few resources from the citizens of Easton and students of Lafayette College. With funding for the project likely coming from outside donors or the college itself, we predict little to no opposition in terms of the approval of these two facilities. The carbon neutrality of the root cellar limits funding to strictly excavation and construction costs with little to no upkeep required. This places its future development in a very feasible position due to its relatively inexpensive upfront costs. In terms of the classroom, Lafayette is currently in an expansion phase that will affect the college and subsequently the surrounding communities. The near completion of the Rockwell Integrated Science Center and its tentative LEED certification provides an ideal example of sustainable direction Lafayette is heading. While the classroom space is not fully developed at this point in time, we believe a future class can take the reigns and design a facility that mirrors the green initiatives present at the College.

Moving Forward:

Our report provides an extensive amount of preliminary data and research necessary to one day bring this project from its planning stages to its actual implementation. The basic cost estimates we've conducted provide an early budget estimate for a future group to utilize as a baseline. With this preliminary economic research, we recommend future capstone groups develop a more comprehensive cost estimate that will ultimately aide in an economic proposal to either the College or outside donors. Additional research in this field should include direct coordination with one, if not several, outside contracting firms to retrieve cost estimates beyond the scope of figures presented in RS Means. If a group in the near future wishes to develop or pursue the actual construction of these projects in the form of a Senior Design project, contact with several outside companies would be incredibly beneficial. We recommend specifically reaching out to Lafayette alumnus involved in the construction industry. It is our belief that these individuals would be more receptive to taking on this project as an educational opportunity and place monetary incentives second.

Due to the large quantity of geotechnical data collected over the course of the project, we believe there is a very minimal scope of work to be completed in this field to fully confirm the geotechnical feasibility of both structures. We do however recommend some additional GPR data collection on the site in a dryer portion of the Fall season. This will yield more accurate data and may reveal subsurface artifacts not detected in our data collection. In addition to this, seismic testing can be utilized if weather conditions prove to be a continuous issue during data collection. These resources are both available for use in the Geology department here at Lafayette with the accompanying assistance of one of the many Professors.

In regards to the design of both the root cellar and classroom, we believe each offer distinct opportunities for further development. The root cellar design we've offered in the report offers a solid starting point for future groups to create a more comprehensive structural analysis of the design. Using ANSYS, which is commonly utilized to analyze strength and deformation of load bearing materials and structures, future groups can expand upon the root cellar design. Discretional factors like materials, structural design and implementation of the ventilation systems can all be tested through this software. Design options for the classroom offer additional opportunities for students to continue the down Lafayette's path toward carbon neutrality. We recommend capstone students pursue strictly environmentally friendly aspects that could even yield a LEED certified structure. These aspects could include, but are not limited to, environmentally friendly lighting options, grey water sewage systems, reclaimed or recycled building materials, and possibly an onsite renewable energy source for the building's amenities. While our report is the first step in the hopeful construction of these two additions to LaFarm, Lafayette College, and the greater Easton community, we believe the preliminary work laid out here offers an essential baseline for groups to come.

Bibliography:

Beekmantown Group (PAOb;23). USGS. Retrieved from https://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=PAOb;23

Brown, C., & Miller, S. (2008). The impacts of local markets: a review of research on farmers \ markets and community supported agriculture (CSA). *American Journal of Agricultural Economics*, *90*, 1298-1302.

Brown, R. E., & Koomey, J. G. (2002). Electricity Use in California: Past Trends and Present Usage Patterns. *Energy Policy, 31(9).*

Bubel, M., & Bubel, N. (Aug./Sept. 1991). The Fundamentals of Root Cellaring (Ogden Publications, Inc. Ed.). Retrieved from https://www.motherearthnews.com/real-food/root-cellaring/fundamentals-of-root-cellaring-zm0z91zsie

Building Construction Costs with RSMeans (2017). Rockland, MA: The Gordinian Group.76th ed.

Christensen, L. O., Galt, R. E., & Kendall, A. (2018). Life-cycle greenhouse gas assessment of Community Supported Agriculture in California's Central Valley. *Renewable Agriculture and Food Systems*, *33*, 393-405.

Climate Action Plan (2011) Lafayette College. Retrieved from http://hdl.handle.net/10385/1618

CLU-IN Technologies - Ground Penetrating Radar. (Sept. 7, 2018) Retrieved from https://clu-in.org/characterization/technologies/gpr.cfm

Coffey, C. (2011, Feb 1). The Efficiency of Beef Production. Noble Research Institute, Retrieved From: https://www.noble.org/news/publications/ag-news-and-views/2011/february/the-efficiency-of-beef-production/

Drake, Avery Ala, Jr. (1965) *Carbonate Rocks of Cambrian and Ordovician Age Northampton and Bucks Counties, Eastern Pennsylvania and Warren and Hunterdon Counties, Western New Jersey*. Contributions to Stratigraphy Geological Survey Bulletin 1194-L. United States Government Printing Office, Washington. Retrieved from: https://pubs.usgs.gov/bul/1194l/report.pdf

Farm Mission and Vision. (n.d.) Hampshire College Farm. Retrieved from https://www.hampshire.edu/farm/farm-mission-and-vision

FDA Food Safety Modernization Act. (2018, November 15). US Food and Drug Administration. Retrieved from: https://www.fda.gov/food/guidanceregulation/fsma/

Garnett, T. (2007). Food refrigeration: What is the contribution to greenhouse gas emissions and how might emissions be reduced. *Food Climate Research Network, University of Surrey*.

Hampshire College Farm. (n.d.). Retrieved from https://www.hampshire.edufarm/hampshire-college-farm

Hempel, C., & Hamm, U. (2016). Local and/or organic: a study on consumer preferences for organic food and food from different origins. *International Journal of Consumer Studies*, *40*(6), 732-741.

Hole, D. G., Perkins, A. J., Wilson, J. D., Alexander, I. H., Grice, P. V., & Evans, A. D. (2005). Does organic farming benefit biodiversity?. *Biological conservation*, *122*, 113-130.

Hoppe, R. A., MacDonald, J. M., & P. K. (2010). *Small farms in the United States: Persistence Under Pressure.* United States Department of Agriculture.

Inwood, S. M., Sharp, J. S., Moore, R. H., & Stinner, D. H. (2009). Restaurants, chefs and local foods: insights drawn from application of a diffusion of innovation framework. *Agriculture and Human Values*, *26*, 177-191.

Izumi, B. T., Wright, D. W., & Hamm, M. W. (2010). Farm to school programs: Exploring the role of regionally-based food distributors in alternative agrifood networks. *Agriculture and Human Values,*335-350. https://link.springer.com/content/pdf/10.1007%2Fs10460-009-9221-x.pdf

LaFarm Annual Report (2013): *LaFarm & The Lafayette College Sustainable Food Loop*. Lafayette College LaFarm. Presented by Sarah Edmonds

LaFarm Annual Report 2014: *Growing Impact for a Sustainable Future*. Lafayette College LaFarm. Presented by Sarah Edmonds

LaFarm Annual Report (2015): *Growing Lafayette College's Sustainable Food Loop*. Lafayette College LaFarm. Presented by Sarah Edmonds

LaFarm Annual Report (2016): *LaFarm is the cornerstone of the Lafayette College Sustainable Food Loop*. Lafayette College LaFarm. Presented by Sarah Edmonds

LaFarm Annual Report (2017): *Looking Back and Gearing Up*. Lafayette College LaFarm. Presented by Sarah Edmonds

LaFarm Community Garden (nd.) LaFarm Community Garden Plots. Accessed at: https://garden.lafayette.edu/lafarm-community-garden-plots/

LaFarm Greenhouse Capstone. (2017). Capstone Seminar in Engineering and Society. Retrieved https://sites.lafayette.edu/egrs451-fa17/greenhouse/

LaFarm Advisory Board (July 2016). *LaFarm Phase II: Background and Rationale for Expansion.* Lafayette College.

Menus of Change: The Business of Healthy, Sustainable, Delicious Food Choices. (2018). Local Food and the Farm to Table Movement, Retrieved From http://www.menusofchange.org/principles-resources/issue-briefs/local-food-and-the-farm-to-table-movement

Miskelly, Lisa (Oct. 29, 2018) Personal communication.

Newton, Sandy. (2003) *ROOT CELLARS: TYPES AND STORAGE TIPS.* The 2003 Old Farmer's

Almanac Canadian Edition. Retrieved From:
https://www.almanac.com/content/root-cellars-types-and-storage-tips

Northampton Soil Map (2018) Web Soil Survey from United States Department of Agriculture (USDA) and Natural Resource Conservation Service.Survey Area: Version 11, Sep 19, 2018. Tabular: Version 11, Sep 19, 2018. Spatial: Version 4, Sep 18, 2018. Obtained from: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Organic Garden: The Bowdoin Organic Garden has been an integral part of the College's sustainability mission since 2005. (n.d.). Bowdoin College, Dining. Retrieved from: https://www.bowdoin.edu/dining/organic-garden/index.html

Pimentel, D. (2005). Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems, *BioScience*, Volume 55, Issue 7, Pages 573–582, Retrieved from https://doi.org/10.1641/0006-3568(2005)055[0573:EEAECO]2.0.CO;2

Pirog, R., Miller, C., Way, L., Hazekamp, C., & Kim, E. (2014). The local food movement: Setting the stage for good food. *MSU Center for Regional Food Systems. WK Kellogg Foundation*.

Public School Code (1949, Mar. 10) Act of 1949, P.L. 30, No. 14Cl. 24. Section 751.a.2.
Retrieved From:
https://www.legis.state.pa.us/WU01/LI/LI/US/HTM/1949/0/0014..HTM
751.a.2 added June 30, 2012, P.L.684, No.82

Reynolds, Kristin. (2015). Small Farm Economic Viability.

Rigby, D., & Cáceres, D. (2001). Organic farming and the sustainability of agricultural systems. *Agricultural systems*, *68*, 21-40.

Soil Test Report (Oct. 31, 2011) Agricultural Analytical Service Laboratory. The Pennsylvania State University. University Park PA 16802.
Retrieved from: https://sites.lafayette.edu/lafarmblog/files/2010/06/soil-test-2011.pdf

Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption: Guidance for Industry. (2018). US Food and Drug Administration Retrieved from: https://www.fda.gov/downloads/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/UCM623178.pdf#page=83

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature*, *418*, 671.

Tuomisto, H. L., Hodge, I. D., Riordan, P., & Macdonald, D. W. (2012). Does organic farming reduce environmental impacts?–A meta-analysis of European research. *Journal of environmental management*, *112*, 309-320.

U.S. Department of Agriculture. (2014). *USDA Good Agricultural Practices Good Handling Practices Audit Verification Checklist.* USDA, AMS, FV, Specialty Crops Inspection Division. Retrieved From: http://www.ams.usda.gov/services/auditing/gap-ghp/audit

U.S. Food and Drug Administration. (2015). Current Good Manufacturing Practice, Hazard

Analysis, and Risk-Based Preventive Controls for Human Food. Retrieved from https://www.federalregister.gov/articles/2015/09/17/2015-21920/current-good-manufacturing-practice-hazard-analysis-and-risk-based-preventive-controls-for-human#p-2862

Weber, C. L., & Matthews, H. S. (2008). Food-miles and the relative climate impacts of food choices in the United States.

Woods, Timothy & Ernst, Matthew (2017, April) *Community Supported Agriculture: New Models for Changing Markets.* University of Kentucky Debra Tropp, USDA. Agricultural Marketing Service. Retrieved from: https://www.ams.usda.gov/sites/default/files/media/CSANewModelsforChangingMarketsb.pdf

Martinez, Alex & Byrnes, Alan P. (2001) *Modeling Dielectric-constant values of Geologic Materials: An Aid to Ground-Penetrating Radar Data Collection and Interpretation.* Kansas Geological Survey, 1930 Constant Avenue, Lawrence, KS 66047. Retrieved from http://www.kgs.ku.edu/Current/2001/martinez/martinez.pdf