Sustainable Food Systems Design and Education at a Multi-Use Site

Site Design for the Kalamazoo Valley Community College Food Innovation Center

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Project submitted in fulfillment of the Masters Opus Requirement at the University of Michigan's School of Environment and Sustainability.

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ABSTRACT

The Kalamazoo Valley Community College Food Innovation Center (FIC) is an institution dedicated to urban farming, sustainable agriculture, food systems education, and local food advocacy. They currently have a warehouse office, food processing center, greenhouse, and raised beds on their 5-acre campus. The FIC wishes to design the rest of that 5-acre site so that it can be an educational site that coordinates with KVCC’s food-related educational programing while also serving model for sustainable site design techniques. The FIC has enlisted the help of a team of landscape architecture master’s students at the University of Michigan to undertake this design. Utilizing precedent studies and site inventory and analysis techniques, the Design Team created a design for the FIC campus that minimizes maintenance practices that lead to greenhouse gas production, maximizes ecosystem services including habitat creation, pollinator support, and stormwater management, addresses existing environmental contamination, supports the FIC’s mission and educational programming plan, prioritizes stages of implementation in accordance with the FIC’s access to resources and capacity for expansion, and reflects the FIC’s vision for their campus.

ACKNOWLEDGEMENTS

The Design Team would like to thank everyone who helped us with this project and guided our design process. We would specifically like to extend our gratitude to:

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Professor of Landscape Architecture at the University of Michigan School of Environment and Sustainability

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Director for Sustainable Food Systems at Kalamazoo Valley Community College Food Innovation Center

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Background

The Kalamazoo Valley Food Innovation Center (FIC) at Kalamazoo Valley Community College is an institution dedicated to urban farming and local food advocacy across multiple communities in southwestern Michigan. It is also an educational facility that embraces formal, and informal programming, as well as serving as a social enterprise job training site. KVCC has culinary classes that interact with the FIC and utilize the site to grow foods for use in those courses. The FIC also serves as a demonstration site for sustainable agriculture best practices. Currently, the FIC operates out of a warehouse office building on their 5-acre site that also has a greenhouse and four raised growing beds. They wish to design the rest of their site so that the site design reflects the FIC's mission and coordinates well with their academic and educational programming. The FIC is also interested in developing content for interpretive signage around the site that can contribute to the educational value of the site for both guided and self-guided tours. Overall, the FIC intends to serve as a model of sustainable site design techniques across its campus, such that the premises will more-closely reflect the environmental and educational values of the organization.

The new site design must utilize techniques to reduce resource use, adapt to climate change, and provide ecosystem services such as pollinator habitat. Additionally, the FIC would like the site to provide additional growing spaces that can be flexibly adapted to their academic programming. Finally, the FIC site is currently a brownfield, so they need to address bioremediation if they intend to grow any food directly in the soil.

The FIC faces difficulty in implementing their visions for sustainable site design due to the unique challenges of maintenance and limited staff training, due to public misunderstanding and resistance to the appearance of installations such as native prairie and wetland areas, and due to administrative conservatism (FIC Director for Sustainable Food Systems, personal communication). Fears of increased maintenance costs in a time of shrinking education funding can limit creativity and encourage continued use of conventional, more resource-intensive approaches to site design and maintenance (KVCC facilities representative, personal conversation at stakeholder meeting). The site plan and toolkit requested as part of this project will provide the justification for a shift toward sustainable site design at their school, and create a model that other institutions can replicate for amplified impact.

Currently, there are several precedents for both educational farms, urban farms, and teaching agricultural centers, as well as precedents for sustainable site design.

However, there is very little precedent for designs for the exact type of site that the FIC has. Most Food Innovation Centers are food processing centers that don't have an external educational component, but food processing is only a small part of what the FIC does. Additionally, most teaching farms are true farms in that they are sprawling and relatively rural, but the FIC site is distinctly urban. There are plenty of urban farms in the state and country, although there are select few *educational* urban farms that the team has been able to identify. Specifically, many urban farms will teach their employees how to run the farm, but we were unable to identify any urban farms that tied in university or certified coursework to their model that was similar to the model at the FIC. As such, the design team will be undertaking a process of exploring all of these precedents separately, and integrating them into a unique design that reflects the unique character of the KVCC FIC.

Site plan development for the KVCC FIC will prioritize minimizing GHG-emissions associated with the maintenance needs of the site, maximizing human wellness, addressing existing environmental contamination, and maximizing ecosystem services and/or food production. Existing environmental contamination will be evaluated and assessed using historical soil testing data provided by the site owners, interpretations of the construction documentation (in particular, the grading plan), and independent soil testing at key locations throughout the site. These methods will ultimately lead to a richer understanding of the spatial distribution of environmental contaminants.

Site history and context is a critical component to understanding the cultural, financial, and economic context of the site, as well as its current relationship with the surrounding communities that are most directly impacted by the project. Community engagement workshops will be organized for better local knowledge of the site and the community that will use this space. This historical and contextual analysis also helped us interpret the site's environmental data, thereby aiding in the siting of pollinator and permaculture-based garden designs.

Team Composition

The design team is comprised of four landscape architecture students, and as such, there is significant overlap in skill sets and there were significant overlap in responsibilities. For example, all members of the design team were responsible for site inventory and analysis. Because site design is an iterative process where ideas are constantly tested, discarded, and reformulated, the actual process of designing the site was shared among all members of the design team, with each team member making contributions to most components of the design.

Although there is significant overlap in skill sets, there are also significant areas in which team members stand out and were likely to take the lead. Evan Granito excels in design visualization including 3d rendering of the analysis and design materials, and led these aspects of design communication. Derell Griffin has a particular interest in therapeutic gardens is also trained in construction management, and had significant responsibility in calculating design costs and making relevant materials decisions. Ian Bernstein has a particular affinity for planting design utilizing native plants, and led on the planting plan and related design activities. Zonghao Li has a specific interest in urban site design, and contributed to many of the significant site layout decisions including paths for vehicle and pedestrian circulation and installation of various site elements.

Design Process

Our design process consisted of an extensive site analysis phase that included site visits and client meetings, aerial mapping of the site, soil tests, and GIS data analysis. The preliminary phases also included community and stakeholder meetings and precedent analysis to guide the final design. Throughout the design process we held bi-weekly meetings with our clients to ensure that our visions remained aligned.

Site Analysis

Preliminary Inventory of Existing Assets

The first step was to assess everything on-site. This was accomplished through an initial site tour and client meeting.

1. **Main Office**
    a. Classrooms, Offices, Visitor's Center
    b. Flexible Indoor Growing Space
    c. Food prep and storage facilities
2. **Pervious Parking Lot**
    a. Massive stormwater management benefits
3. **Greenhouse**
    a. Sustainable agriculture demonstration techniques
4. **Raised Beds**
    a. Coordination with culinary classes
5. **Wetland**

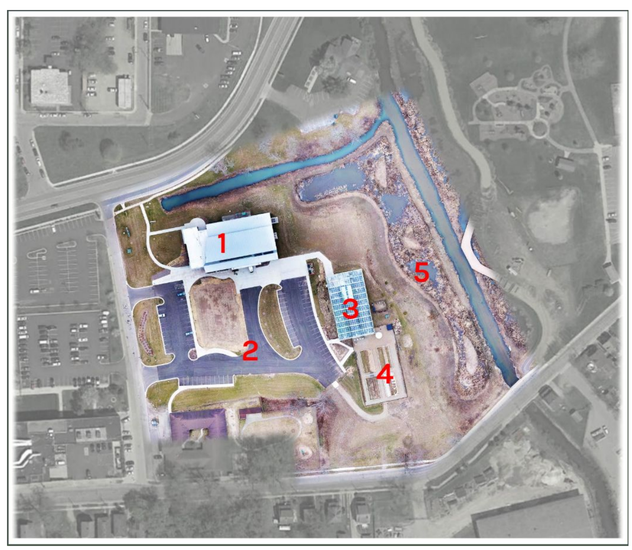


Fig 1. Existing Site Assets

Site Visits

Site visits are a critical phase of the design process, as they allow us to become familiar with the human experience of the site and collect data that might not be otherwise available. Designing without a feel for the human experience is ill advised, and to that end we conducted several site visits throughout the design process to collect data and ensure that our design decisions were appropriate for the site.

<u>UAV (Drone) Aerial Mapping</u>

Aerial imagery of the site was available through public sources, but the available photos were taken before the FIC was built. Thus, we needed to generate our own aerial imagery. Using a Mavic Pro 2 drone to fly over the site, we were able to record site photographs, elevation data, normalized difference vegetation index (NDVI) of existing plants, and contour lines that would all be used to inform the final design.

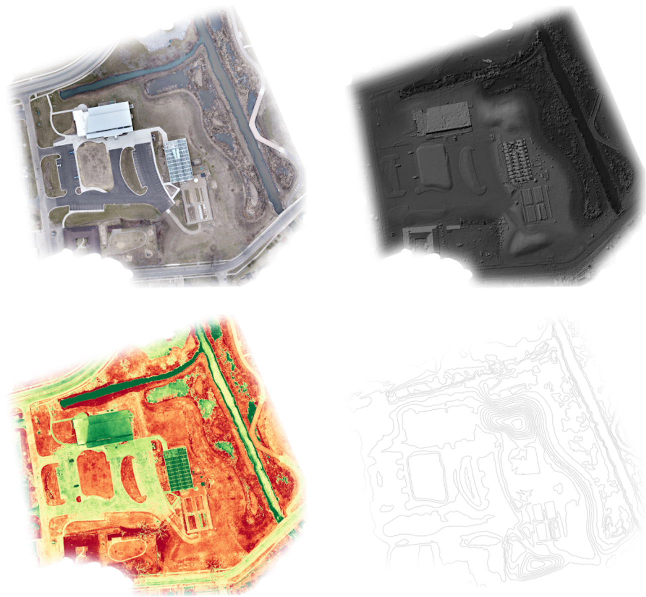


Fig. 2. Drone Generated Aerial Site Maps

<u>Soil Testing</u>

The FIC was built on top of a brownfield, so we needed to figure out if any areas were suitable for growing food. Contaminated soil was piled into two mounds and the site was supposedly capped at 3’, but we found fencing as shallow as 6” in some places. Only one area sampled (marked in red below) returned prohibitively high lead levels, but we were worried about the inconsistent depth of the cap. Accordingly, it was decided that raised beds would be a requirement for any new gardens that yielded food intended for human consumption (Mitchell et al., 2014)(EPA, 2011).

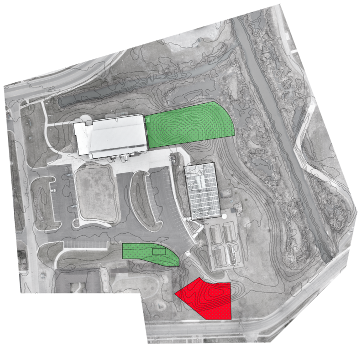
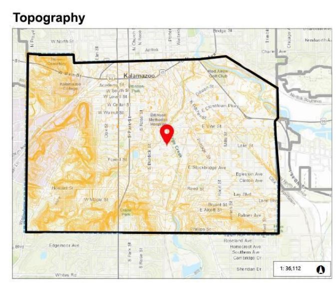


Fig. 3 & 4. Soil Test Locations (left) and results (right)

GIS Mapping

Understanding demographic, topographical, geological, and hydrologic factors interacting with the site is a critical aspect of the design process, as it is important know the context in which a design exists. To accomplish this, we examined GIS layers made available to us by the Kalamazoo County Planning Department, GIS layers for Kalamazoo are not publicly available and must be requested from the planning department. The GIS demographic data informed us on the who the future users of the site could be, with that information we were to be certain we speaking to the right stakeholders within the community to develop a site they would use.



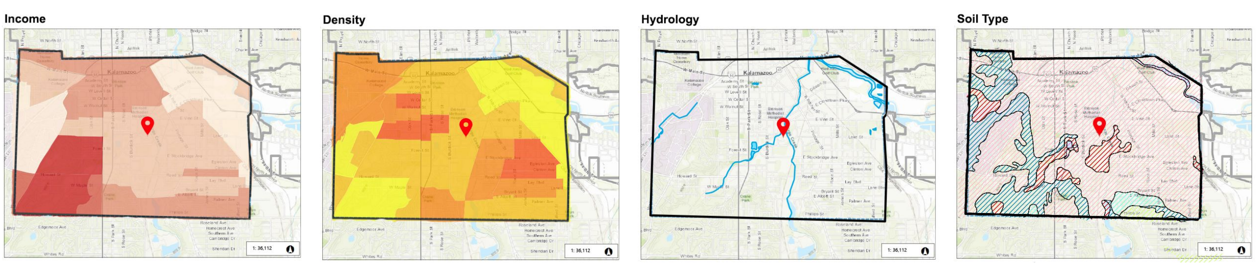


Fig. 5. GIS layers for contextual site analysis

Precedent Analysis

A preliminary precedent search revealed surprisingly few sites and facilities that encapsulated all of the functions of the FIC. Thus, our precedent review focused on drawing insight from various outdoor education, sustainable agriculture, and urban agriculture settings. Organizations such as Big Green that create schoolyard gardens and educational programs offered some insights. Two common themes emerged from this review:

- The need for informal outdoor seating and gathering space is critical
- Signage that explains site installations and growing spaces greatly enhances public interaction with urban agricultural sites

Fig 6. Schoolyard garden and classroom (Big Green)

Growing Hope, a community-based sustainable agriculture organization in Ypsilanti, Michigan is the closest existing model that resembled the client's vision for the site. Growing Hope has significant outdoor growing space, and partners with community members and local farmers markets to bring sustainable and equitable agricultural practices to the Ypsilanti community. A review of Growing Hope's model suggested the need for:

- Expanded outdoor growing space
- Opportunities for community engagement with the site through educational programming
- On-site features that encourage community outreach and support public events

Fig. 7. Photos from growing hope. Entry community garden (left) and expanded outdoor growing space (right)

Stakeholder and Community Meetings

Stakeholder meetings were an integral part of the design process, as it was critical for us to understand the needs and interests of people who interact with the Food Innovation Center and with the site. To that end, we held meetings with stakeholders from KVCC, the City of Kalamazoo, and representatives from the neighborhoods adjacent to the site on 5/4/18, and citizen meetings with residents of those neighborhoods on 8/7/18.

KVCC and Kalamazoo Stakeholders

We held an early focus group and information session with representatives from various KVCC departments, as well as from local food-sustainability organizations. The purpose of this meeting was to explain the scope of the project and identify what kinds of features interested parties might want to see at the site. We followed up this initial meeting with individual meetings with representatives from the groups with the most interaction with the FIC site. These groups were Bronson Hospital Group, KVCC facilities, Kalamazoo Parks and Recreation, and the City Planner. These meetings yielded a few critical insights and design guidelines.

- Create a restorative and restful space within walking distance of the hospital to aid Bronson Hospital Group’s wellness initiative for patients and staff in this high stress environment
- Encourage connection between nearby parks and the Kalamazoo Farmers Market, both within a 5-minute walk
- Encourage public engagement with the FIC site through inviting streetscapes and entryway features

Vine and Edison Neighborhood

The FIC site is situated directly in between Kalamazoo's Vine and Edison neighborhoods. We felt it appropriate to meet with the heads of the Neighborhood Associations for Vine and Edison.

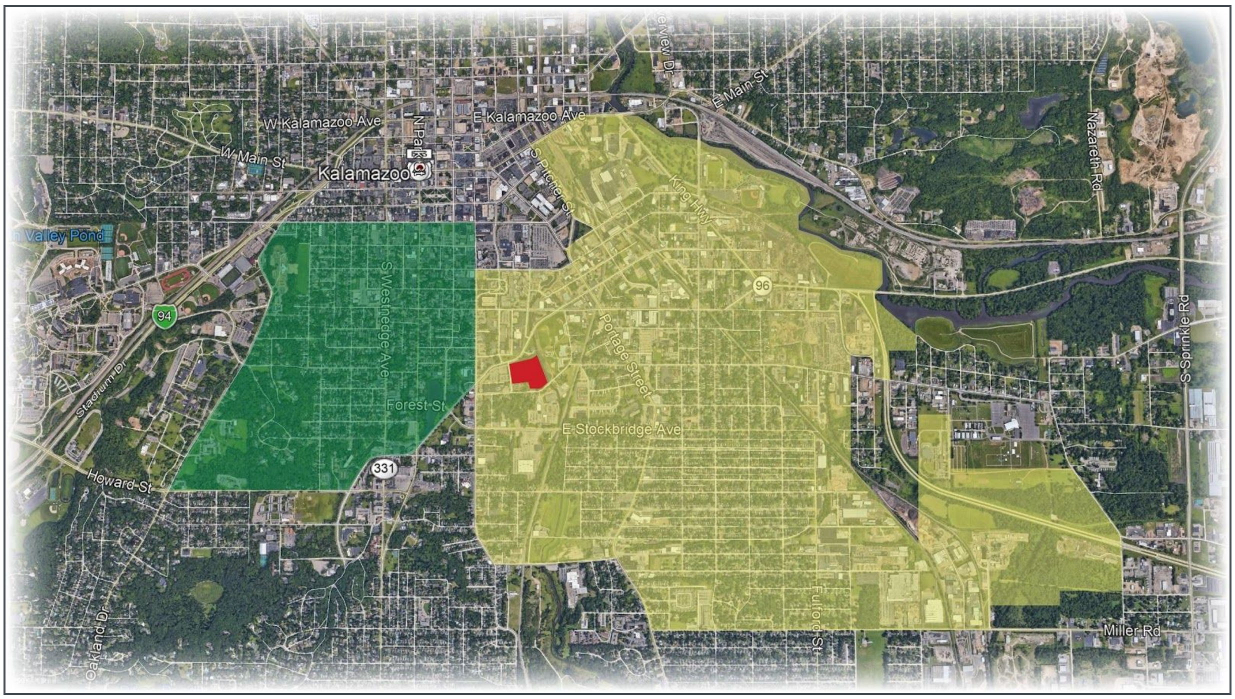


Fig. 8. The FIC (red), the Vine Neighborhood (Green) and the Edison Neighborhood (Yellow)

The heads of the Neighborhood Associations generally expressed similar desires for the site as the KVCC and Kalamazoo stakeholders. Additional insights gained from these meetings include:

- Build community gardens, and use them for educational programming for the community
- Make the site inviting with colorful landscape features and high visibility

Edison Neighborhood Night Out

Residents of the Edison Neighborhood would have the highest level of interaction with the FIC site, and we wanted the opportunity to get a sense of their perceptions of the site. The Edison Neighborhood Association was kind enough to provide us with a table for their Neighborhood Night Out, an evening where community organizations and residents had an opportunity to interact and celebrate their community. We set up an informal information session where we asked residents about their familiarity with the site, before allowing them to write their ideal site features on a whiteboard and vote on site features that had already been written down. We interacted with approximately 75 residents.

Fig. 9. Community engagement photos from Edison Neighborhood Night Out

The most common community desires for the FIC site echoed the information from meetings with the heads of the neighborhood associations, and included:

- Community gardens
- Flowers and colorful landscape features
- Inviting and educational signage placed around the site

Fig. 10. Word cloud generated from public input at Edison Neighborhood Night Out

Design

Site Plan Overview

This site plan illustrates our final design. Major design features include improved hardscape pathways for increased circulation around the site, expanded and formalized entrances in the north and south of the site, new gathering spaces, the addition of community gardens, the installation of an experimental food forest, the removal of turf grass in favor of native plant landscaping in all non-food-growing areas, and a boardwalk connection to the existing boardwalk and park on the west side of the site. The next section of this report will walk through these specific decisions and highlight key features of the design.

Fig. 11. Site plan overview with key features labeled

Pedestrian Circulation

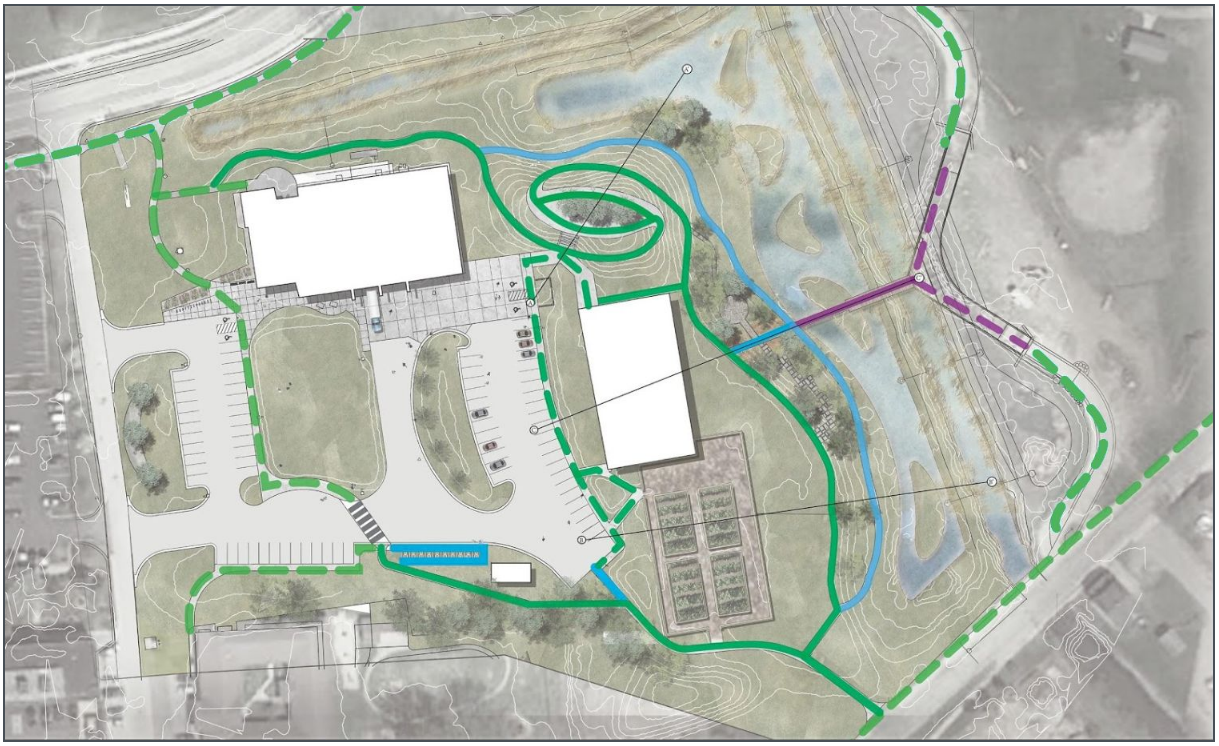
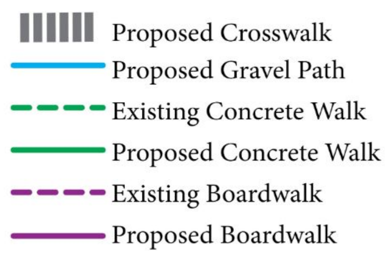


Fig. 12. Pedestrian circulation and surface treatment

This map details the proposed pedestrian pathways and surface treatment of the design. Connectivity and a simple walk through the site were prioritized when designing the pathways. New poured concrete and crushed aggregate pathways are proposed to improve circulation around the site, as well as to divert foot traffic away from the loading dock on the main building.



Key Design Decisions

Major design choices were made in five locations. Specifically:

1. The northern entrance
2. The existing hill in the northeast
3. The eastern hill adjacent to the wetland
4. The southern entrance
5. The southern border of the parking lot

Fig. 13. Site plan with major design change locations highlighted

The next section will walk through those five major decisions and discuss the changes made.

Northern Entrance

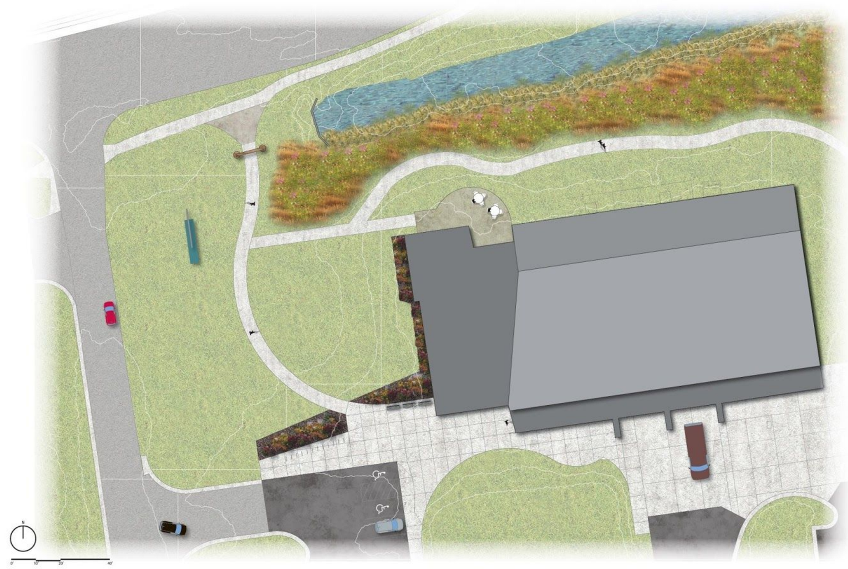


Fig. 14. Northern entrance detail

The entrances to the site were incredibly important for us to consider, because they are critical for inviting pedestrians into the site. Our major design decisions for the Northern Entrance were to create an entry archway and sign, ideally with KVCC’s construction class that has already built some site features for the FIC, expand the hardscape at the entrance To encourage entry into the site, and to replace existing turf grass and juniper beds with native plant prairie and native plant gardens, respectively, to create a colorful and visually stimulating entrance to the site.

Fig. 15. Northern entrance perspectives

Hilltop Gathering

Fig. 16. Hill gathering space detail

The existing hill on site provides the perfect opportunity for gathering and seating space. The ADA accessible hardscape gently winds to the top of the hill where it expands into a concrete platform with built-in seating and the space for movable furniture, if desired, before continuing back down and easily connecting to walkways to the rest of the site. We recommend planting the areas between the paths with fragrant herbs and flowering plants to serve as a sensory and meditative garden.

Fig. 17. Hill gathering space perspective

Food Forest

One of the most exciting design recommendations is the experimental food forest. Food forests are planned, food-producing landscapes that are comprised of fruit and nut bearing canopy trees, and understory food-bearing plants planted in guilds that optimize plant species interactions. The mature form of this landscape feels aesthetically similar to any other forest, with the added benefit of being a food-producing ecosystem (Permaculture Research Institute). Permaculture, a landscape design philosophy that emphasizes closed waste cycles and a food-growing philosophy that returns nutrients to the landscape can inform the design of a food forest (Permaculture Research Institute). KVCC has expressed interest in establishing a food forest, and we used guidelines from permaculture to generate this experimental design. The food forest will feature fruit and nut trees, as well as shrubs and groundcover plants that all yield food of some kind. It will additionally boast seating and gathering spaces that are shielded and serene. Due to concerns over soil toxicity, all yields from the food forest will be submitted for testing by KVCC to determine the level of toxicity transferred to the edible parts of the plants. The research team found no relevant literature on the subject after a thorough search of the University of Michigan library database resources, and KVCC is eager to have this experimental food forest contribute to the literature on food growing on remediated brownfields.

Fig. 18. Food forest detail

Fig. 19. Food forest perspectives

Southern Entrance

The southern entrance to the site will receive a similar treatment to that of the northern entrance. This symmetry promotes continuity and the idea that the space has a formal beginning and end. Expanded hardscape to the street, entry signage to match the northern entrance, and native wildflower prairie installations create this continuity and provide inviting cues to pedestrians that there are destinations to be explored within the site.

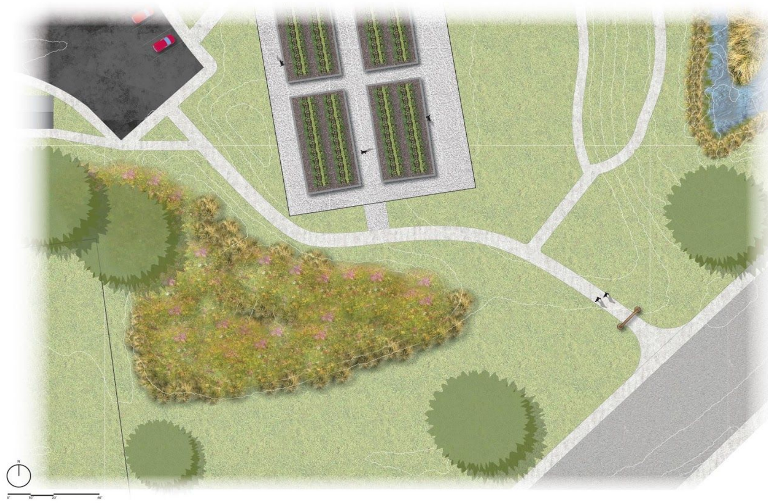


Fig. 20. Southern entrance detail

Fig. 21. Southern entrance perspective

Keyhole Gardens

These gardens are a take on a community garden space. Keyhole gardens are very easy to build, and bring an engaging design aesthetic to the traditional raised beds. This space has an ADA accessible crushed gravel base, and the gardens have attachable trellises that serve both as a growing opportunity for vining plants, as well as a privacy buffer to create a sense of separateness from the parking lot. This space can be used either as traditional community gardens, or as educational growing space to experiment with different plant combinations and growing techniques.

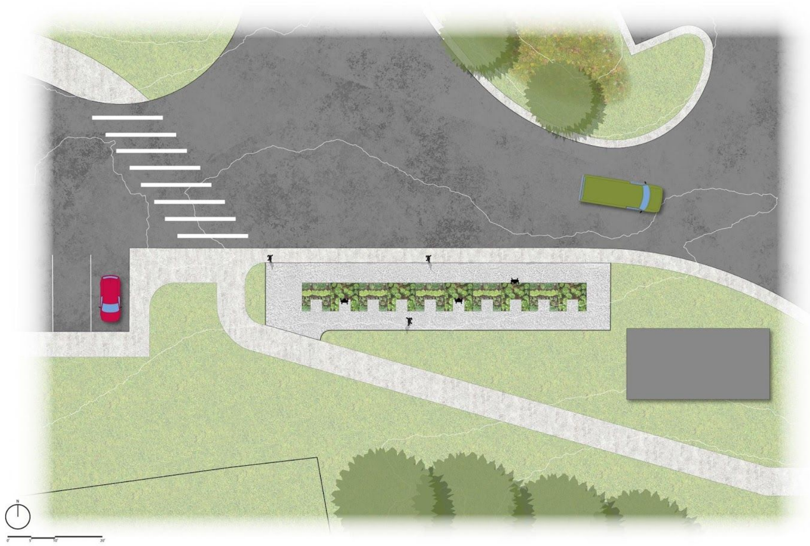


Fig. 22. Keyhole gardens detail

Fig. 23. Keyhole gardens perspective

Timeline for Prioritized Phases of Development

The FIC asked that the design be split into phases, so as to coordinate with their annual funding cycles. We recommend that the FIC begin to build the gravel paths and keyhole gardens immediately, as they have expressed the willingness to do this on their own, independent of their requests for funds. We recommend that the concrete paths be poured next, as establishing the site's circulation patterns will be crucial to developing the remaining design features. The FIC has expressed that the most construction-intensive features will be built last, so we recommend that the boardwalk connections and hilltop gathering space are built in the final phases of development.

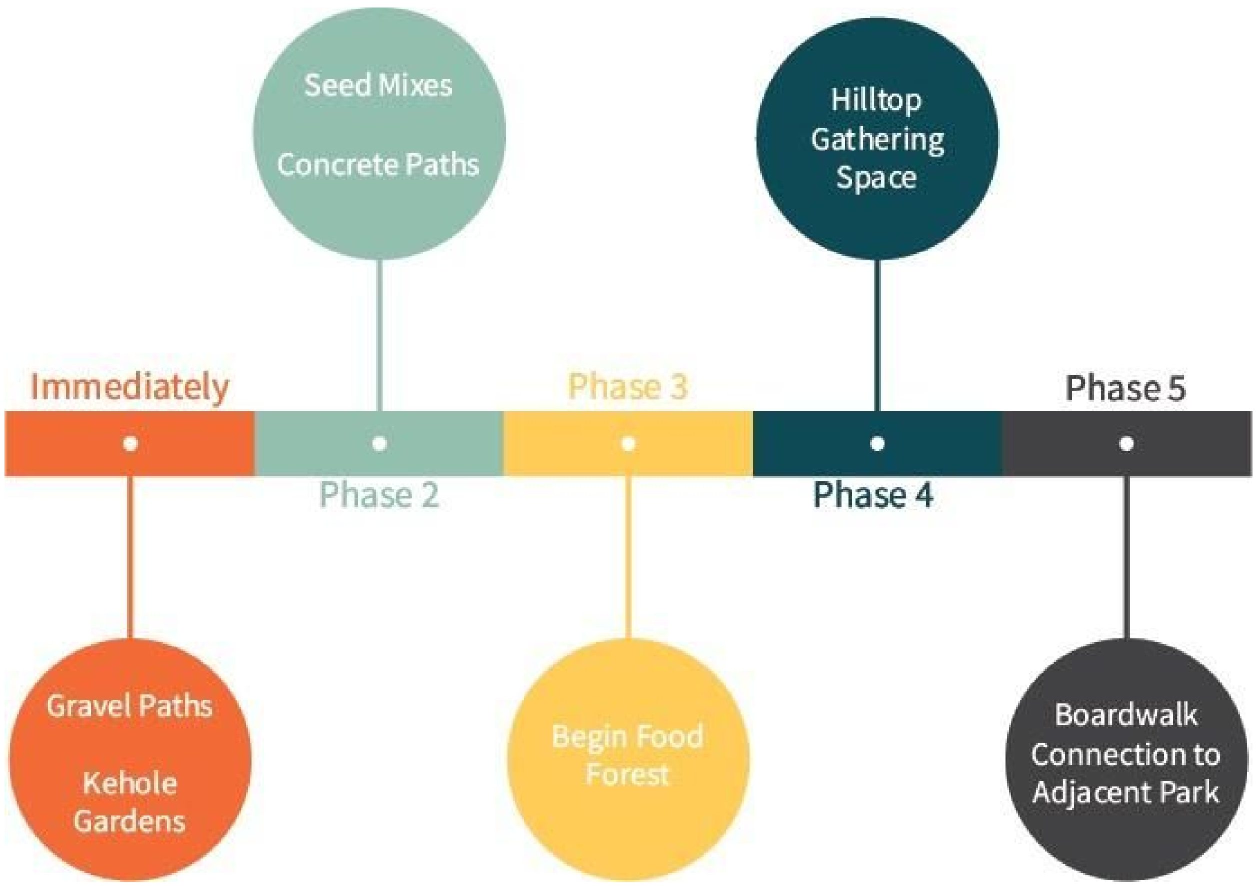
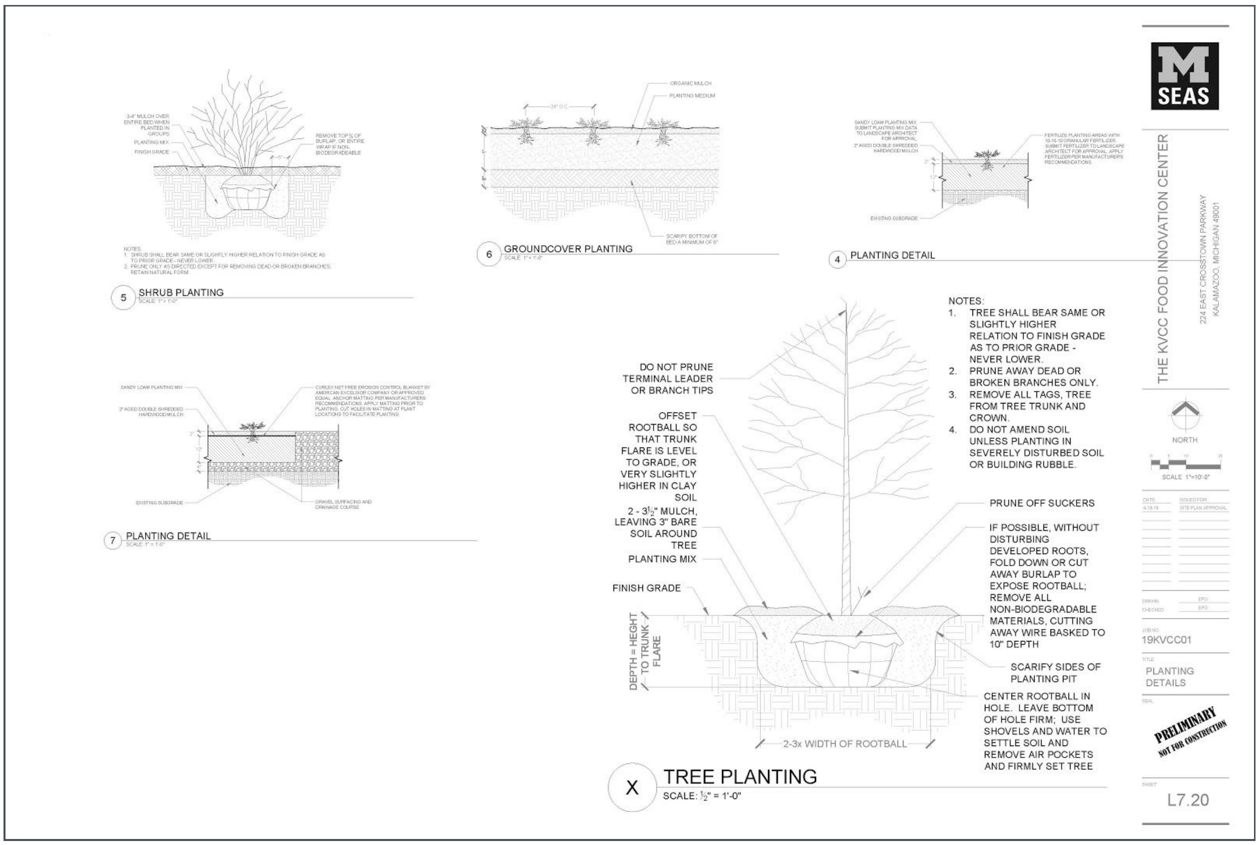


Fig. 24. Suggested timeline for project phases

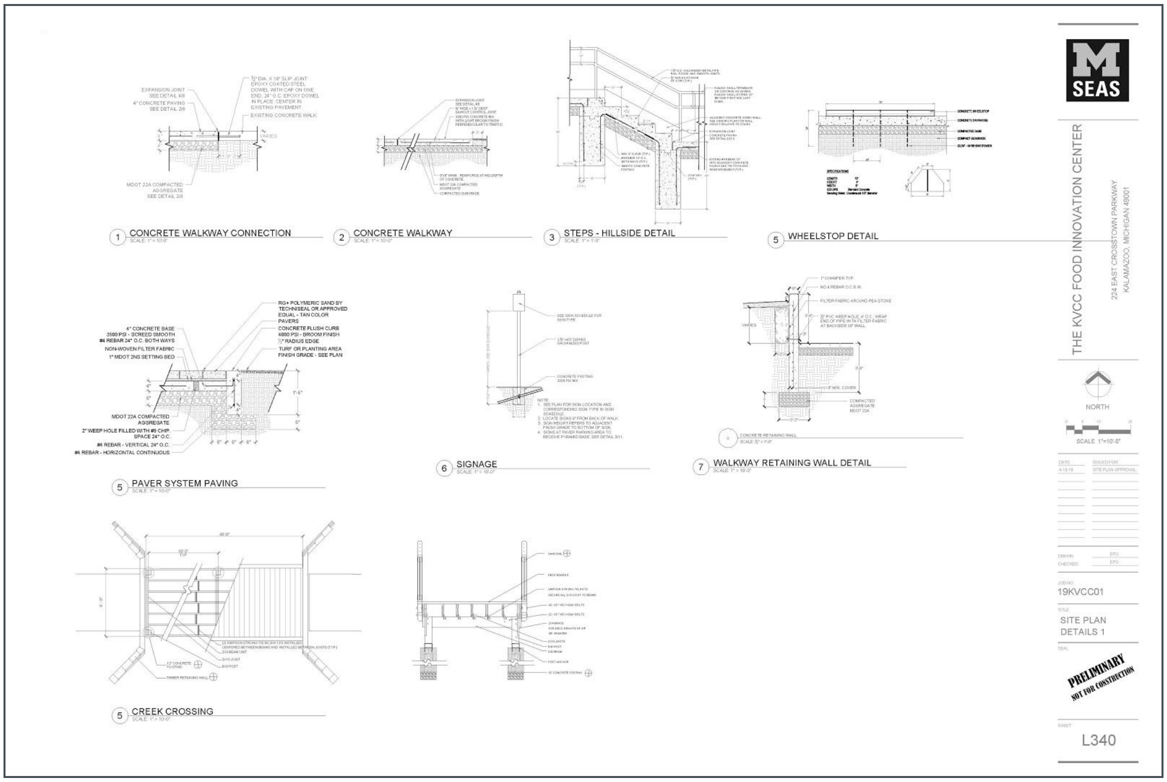
Appendices

Construction Documents and Details

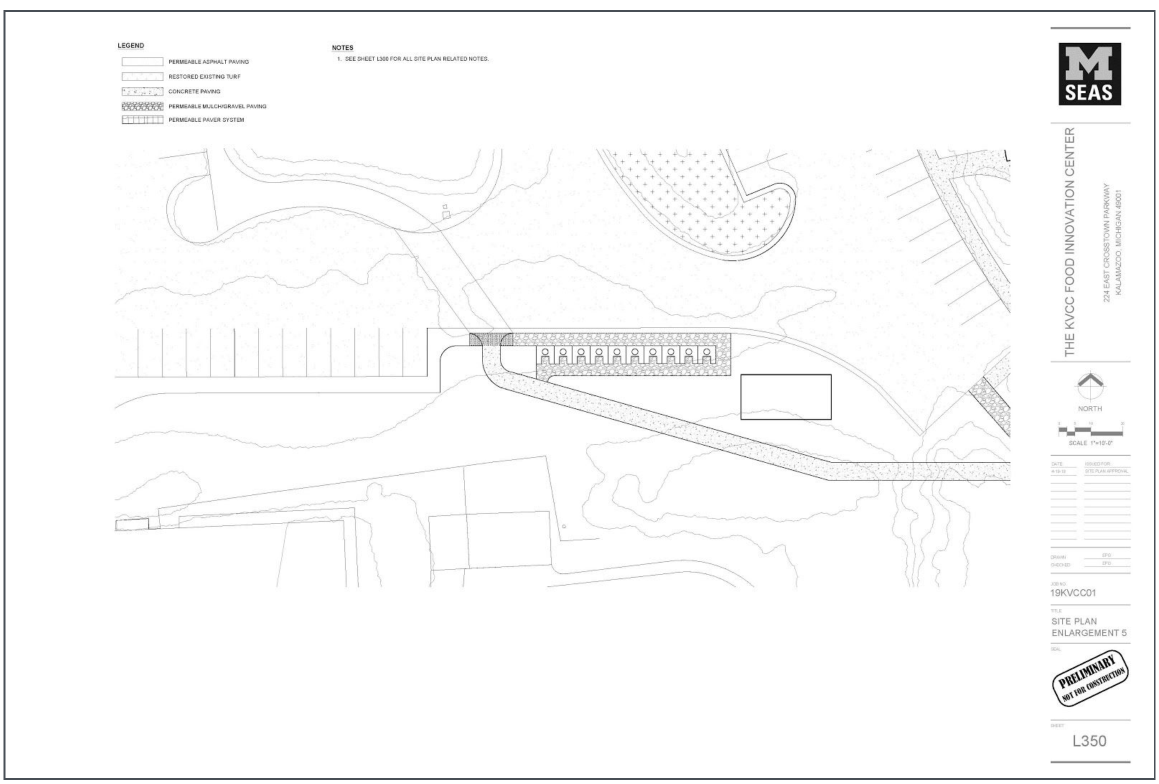
Below are selected examples of planting and construction details for delivery to the client.



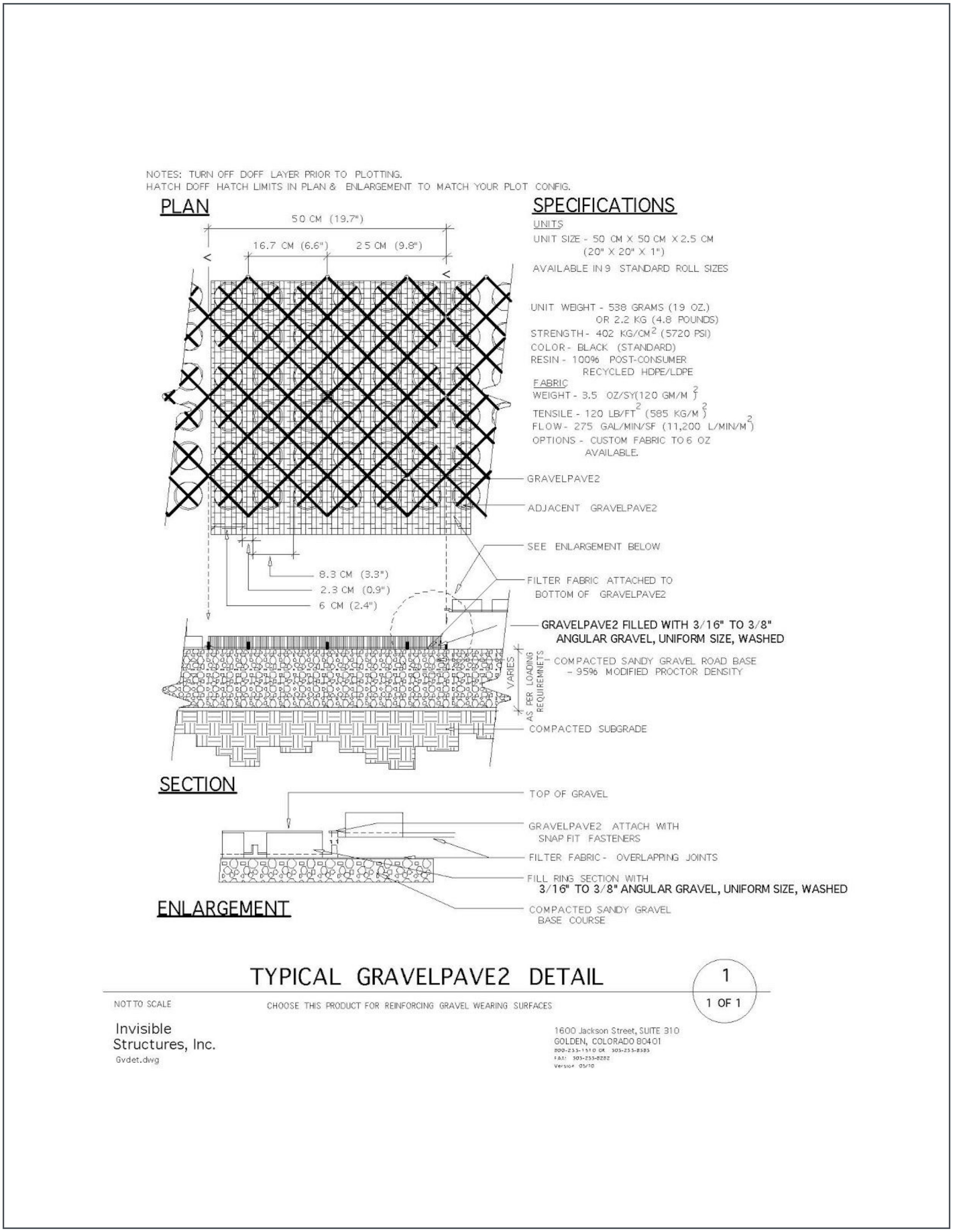
Examples of tree & shrub planting details



Examples of boardwalk, concrete, and other hardscape construction details



Keyhole garden detailed plan (not to scale)



Gravel pathway installation detail

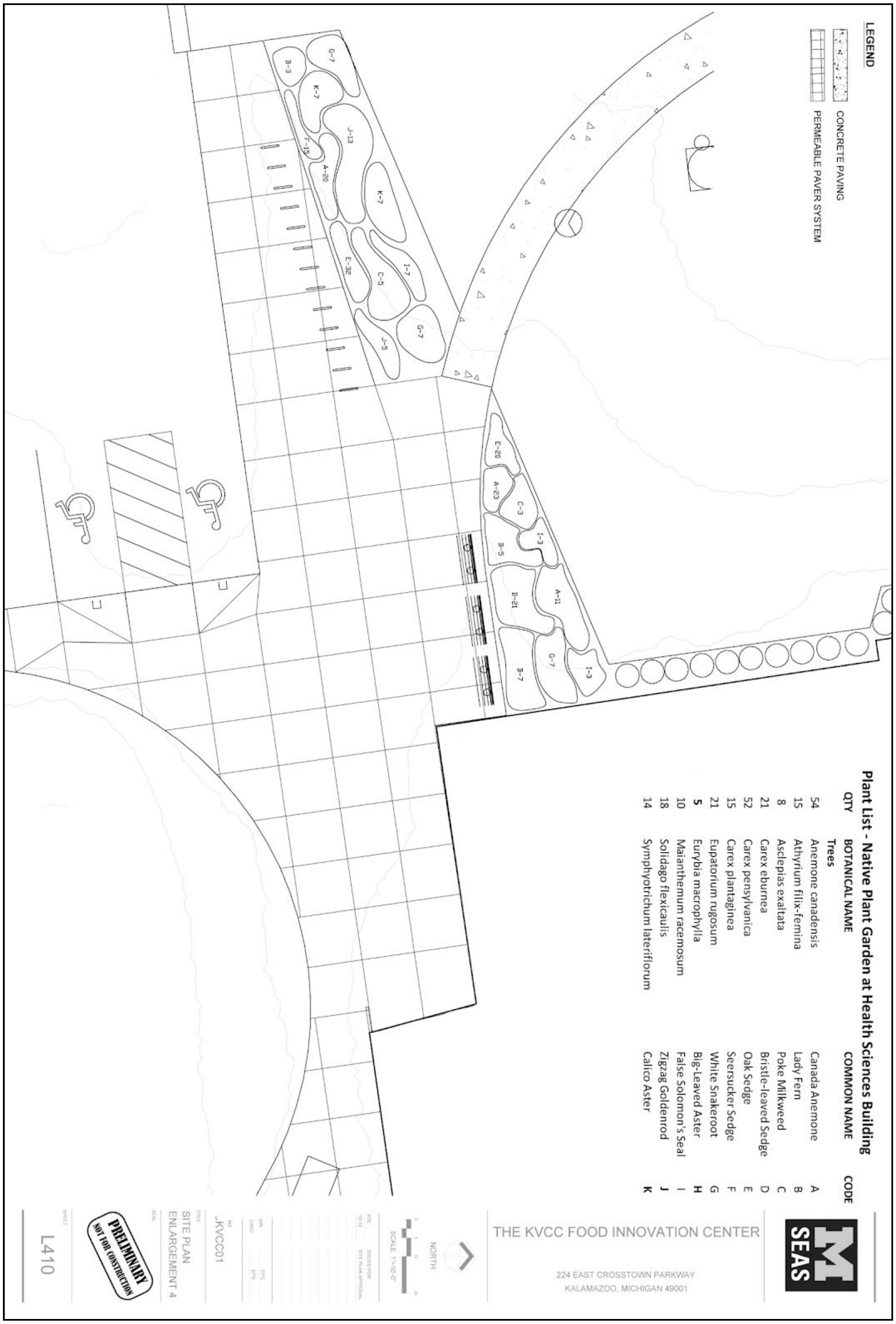
Native Plant Seed Mix Cost Assessment

1. Figures for native seed mix cost assessment.

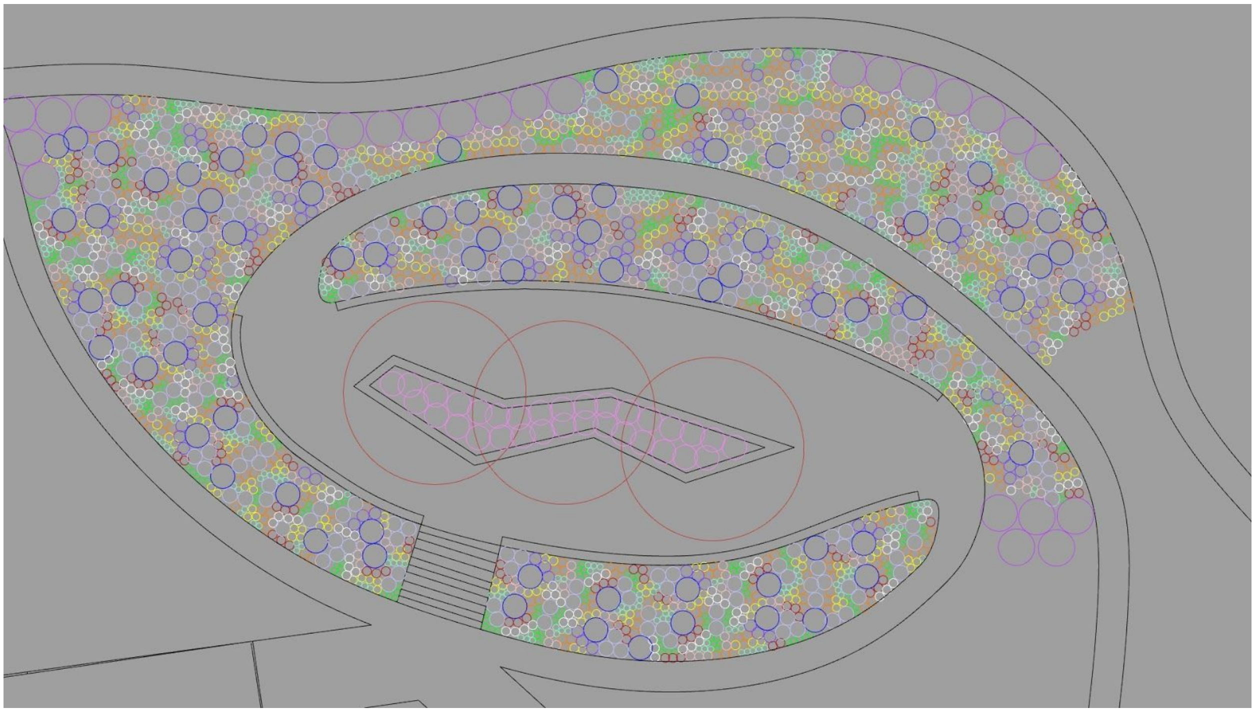
Plot Number	Plot Location	Plot Size (sf)	Seed Mix	Price Per Oz ($)	Price Per lb ($)	Price Per 1/4 Acre ($)	Quoted Installation Price
1	Southern Entrance	10,000	Michigan wildflower farm pollinator mix	16.5	264	660	
2	Parking Lot (east)	2,700	Michigan wildflower farm roadside mix	11	NA	NA	
3	Parking Lot (west)	2,100	Michigan wildflower farm roadside mix	11	NA	NA	
4	Keyhole Gardens	2,100	Michigan wildflower farm butterfly garden mix	11	NA	NA	
5	Northern Entrance	6,500	Michigan wildflower farm dryland mix	10.5	168	NA	
							Total = $3,000

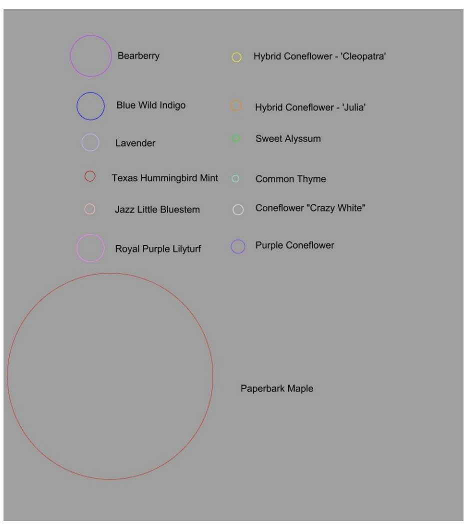
Note: Creating Sustainable Landscapes LLC, a local contractor specializing in the installation and maintenance of native plant landscapes, quoted the installation price. Installation methods include killing of existing turf grass and once annual visits to control for non-native species. However, their cost estimation methods are proprietary and cannot be shared.

Northern Entrance Native Plant Garden



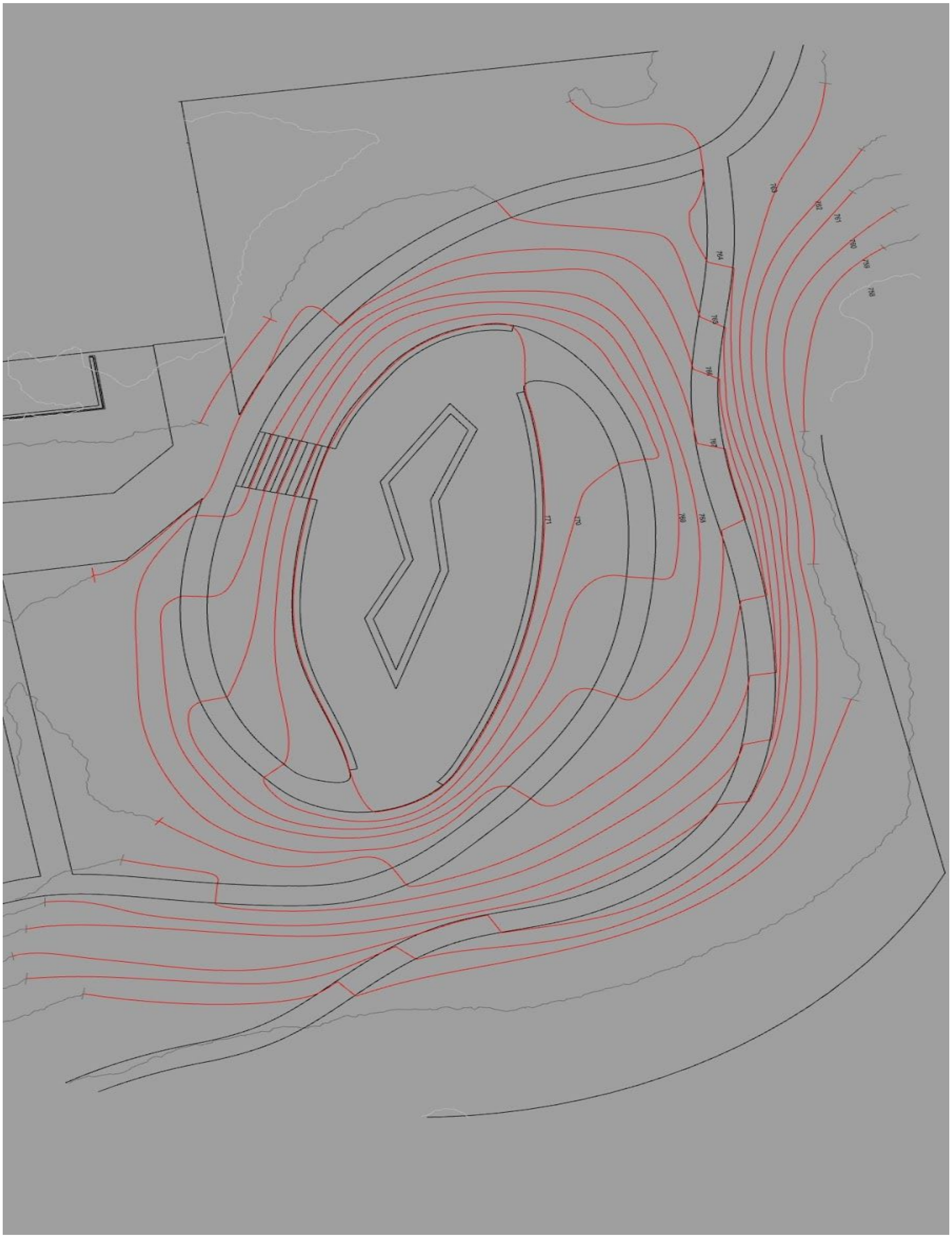
Hilltop Gathering Space Planting Design



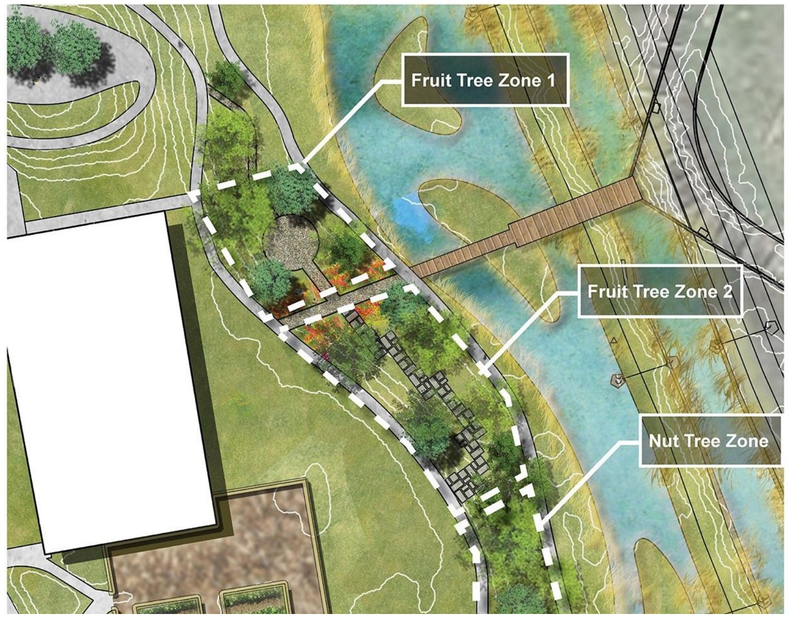


Scientific Name	Common Name	Mature Height	Mature Width	Water Use	Exposure	Plant Type	Quantity
Acer griseum	Paperbark Maple	30ft.	30ft.	Medium	Full Sun, Part Shade	Tree	3
Arctostaphylos uva-ursi	Bearberry	12 inches	6ft.	Low to Medium	Full Sun, Part Shade	Shrub	25
Agastache cana	Texas Hummingbird Mint	24 inches	18 inches	Low to Medium	Full Sun, Part Shade	Perennial	201
Baptisia australis	Blue Wild Indigo	4ft.	4ft.	Low to Medium	Full Sun, Part Shade	Perennial	80
Echinacea 'Cleopatra' (Butterfly)	Hybrid Coneflower	14 inches	16 inches	Low to Medium	Full Sun, Part Shade	Perennial	395
Echinacea 'Julia'	Hybrid Coneflower	12 inches	18 inches	Low to Medium	Full Sun, Part Shade	Perennial	414
Echinacea 'Noam Saul' CRAZY WHITE	Coneflower	18 inches	18 inches	Low to Medium	Full Sun, Part Shade	Perennial	326
Echinacea purpurea	Eastern Purple Coneflower	24 inches	24 inches	Low to Medium	Full Sun, Part Shade	Perennial	129
Lavandula augustifolia 'Niko' PHENOMENAL	Lavender	24 inches	30 inches	Low to Medium	Full Sun	Perennial	236
Liriope muscari 'EXC 051' PURPLE EXPLOSION	'Purple Explosion' Lily Turf	8 inches	4ft.	Medium	Full Sun, Part Shade	Perennial	33
Lobularia maritima	Sweet Alyssum	9 inches	12 inches	Low to Medium	Full Sun, Part Shade	Perennial	434
Thymus vulgaris	Common Thyme	12 inches	12 inches	Low to Medium	Full Sun, Part Shade	Perennial	462
Schizachyrium neomexicanum	Jazz Little Bluestem	30 inches	18 inches	Low to Medium	Full Sun	Grass, Ornamental	317

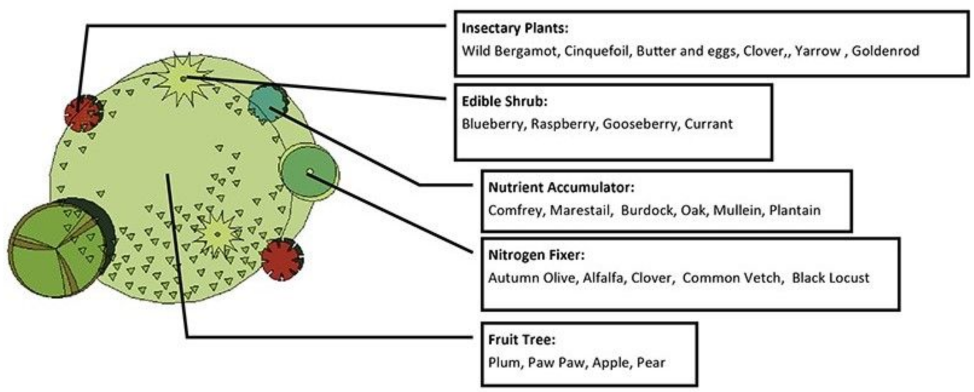
Hilltop Gathering Space Grading

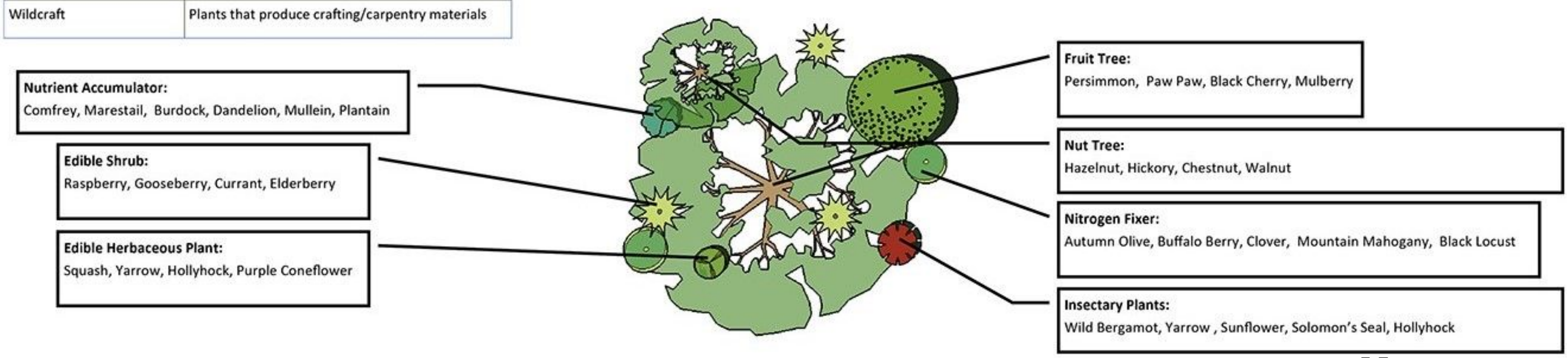


Food Forest Planting Overview



Guild Function	Definition
Animal Forage	Provides food for domestic animals.
Erosion Control	Holds soil in place, typically using a fibrous root
Barrier	Provides a barrier from unwanted plants/animals.
Insectary	Attracts pollinators and other beneficial insects.
Mulch Maker	Produces large biomass that decomposes quickly.
Nitrogen Fixer	Fixes atmospheric nitrogen into a plant-available
Nurse/Scaffold	Hardy pioneer species that protect more vulnera-
Nutrient Accumulator	Plants with deep root systems that collect many nutrients from the soil and deposit them in the topsoil through decomposition.
Pest Repellant	Repels/confuses pests
Soil Cultivator	Deep-rooted plants that break up compacted soil
Toxin Absorption	Bioremediators that leech harmful chemicals from the soil
Wildlife Food	Provide food for local wildlife
Wildlife Habitat	Provide habitat for local wildlife
Medicine	Plants with medicinal value
Wildcraft	Plants that produce crafting/carpentry materials





Permaculture Guild Guidelines

Guild Design—Seven Stories

Much like wild forest ecosystems, a Food Forest can also be divided into the vertical layers of Canopy, Midstory, Understory, Herbaceous, Groundcover, Roots and Vines. When permaculture designers plan a guild, they are looking for plants from each of these layers that perform one or more one of the functions described in table 6. Some notes on the role of these layers in a Food Forest system will help when designing the plant community moving forward.

Groundcover	Herbaceous:	Understory:	Midstory:	Canopy:
1: Groundcover plants are crucial for weed-prevention and suppression. They should be able to spread out and establish large swaths of land, outcompeting and then preventing other species from becoming established. 2: This layer is unique in it's ability to fill space in all guilds and across all zones of the Food Forest. Use groundcover plants to fill small spaces that other species can't occupy. 3: Some perennial groundcovers can be maintained as a "Living Mulch" over much of the forest floor. During the season they are planted directly into as needed, and at the end of the season they are chopped down for mulch/compost.	1: Many of the plants in this layer should produce mulch to build soil, prevent erosion, hold water in the ground, and accumulate nutrients from the deeper soil into their biomass. 2: Perennials should be prioritized, but annual plants can play an important role as well. Annuals requiring more maintenance throughout the season should be kept in Zone 1 guilds. 3: Self-seeding plants such as Asparagus and Hollyhock will return each year and occupy new areas of the forest. This will make it difficult to plan exactly what species will grow in which guilds. Signage should be able to change throughout the season to remain accurate.	1: Midstory and Canopy species such as Hazelnut and Black Locust can be maintained in this layer as saplings or smaller trees. Doing so mimics the natural generational shifts in forests, where younger trees will grow slowly in the shadier understory until larger trees fall down and clear room in the canopy. 2: The wide range of plant choices that fill this layer allow the designer to emphasize certain yields and functions of the forest above others -- plants can be selected for crafts, food, medicine, wildlife value, native plants, biodiversity, or even simple aesthetics. 3: Famed permaculturalist Martin Crawford suggests that between 20-40% of the plants in a sunny area should be nitrogen fixers, and 50-80% in shadier areas.	1: Naturally smaller fruit trees such as peaches, apricots, and plums work well in this layer. 2: Shade tolerant fruit trees are preferable, since they are better adapted to the lighting conditions created by the canopy layer. 3: This layer often functions as the canopy in smaller forest garden installations. 4: Mountain Mahogany and Siberian Pea-shrub are fast-growing nitrogen-fixers that can be pruned often to create mulch/compost for the soil. Frequent pruning also keeps these trees into an open-shape, allowing light to the lower forest layers.	1: Deciduous trees play an important role in nutrient cycling throughout the year by shedding their leaves, which provide mulch for the rest of the forest. 2: Tree roots can stretch far beyond the drip line of the tree and impact soil conditions across large portions of the forest. The presence of certain trees will also dramatically affect the fungal species composition in the soil ecosystem. 3: Dense, spreading species such as Maple and Oak are not ideal for zones 1-3, since they create dense shade over large swaths of the forest. Such trees are best removed from the site, or pruned into an open shape.

Cover Crops

The tables below, adapted from tables in "Gaia's Garden" by Toby Hemenway, may be referenced whenever the site design calls for the following cover crops:

Annual Cover Crops:

Common Name	Botanical Name	N-Fixer	Soil Preference	Height	Insectary	Comments
Black-eyed Peas	Vigna unguiculata	X	Many	3-4'	X	Chokes weeds
Buckwheat	Fagopyrum esculen-tum		Loam	1-3'	X	Chokes weeds
Cowpeas, red	Vigna sinensis	X	Loam	1-2'	X	Drought-resistant
Lablab	Lablab purpureus	X	Many	5-10'	X	Drought resistant
Pinto beans	Phaseolus vulgaris	X	Loam	2-4ft	X	Drought-resistant
Sesbania	Sesbania macrocarpa	X	Many	6-8'	X	Drought resistant
Soybeans	Glycine max	X	Many	2-4'	X	Mix w/ non-legumes
Sudan grass	Sorghum bicolor		Many	6-8'		Mix w/ non-legumes
Sunn Hemp	Crotolaria juncea	X	Loam	3-6'	X	Tolerates acid soil

Annual cover crops are planted in the spring or summer as a groundcover, and are tilled before setting seed for mulch/compost. They can also be used in crop rotation systems to restore nitrogen to land that was heavily cropped the previous year.

Perennial Cover Crops:

Common Name	Botanical Name	N-Fixer	Soil Preference	Height	Insectary	Comments
Alfalfa	Medicago sativa	X	Loam	2-3'	X	Well-limed soil
Birdsfoot trefoil	Lotus corniculatus	X	Many	3-5'	X	Droughtresistant
Chicory	Cichorium intybus		Heavy	2-3'	X	Opens heavy soil
Clover, strawberry	Trifolium fragiferum	X	Many	1'	X	Needs moisture
Clover, white dutch	Trifolium repens	X	Many	6-10'	X	Needs moisture
Fescue, creeping red	Festuca rubra		Many	2-3'		
Orchardgrass	Dactylis glomerata		Many	1-2'		
Ryegrass, perennial	Lolium perenne		Heavy	2-3'		
Timothygrass	Phleum pretense		Heaby	2-3'		Needs moisture

Perennial cover crops form the primary ground cover in much of the Food Forest. They may be mowed to generate mulch/compost, or let alone to serve as "Living Mulch". Masanobu Fukuoka, a renowned permaculture designer, would often use white Dutch Clover as a groundcover on his land. The clover can simply be opened with a spade or trowel and planted directly into. This fixes nitrogen, generates compost, holds water in the soil, prevents erosion, suppresses weeds, and attracts pollinators to the garden.

Soil Test Results

Fibertec environmental services

Analytical Laboratory Report
Laboratory Project Number: 86202
Laboratory Sample Number: 86202-001

Order: 86202
Page: 2 of 5
Date: 08/23/18

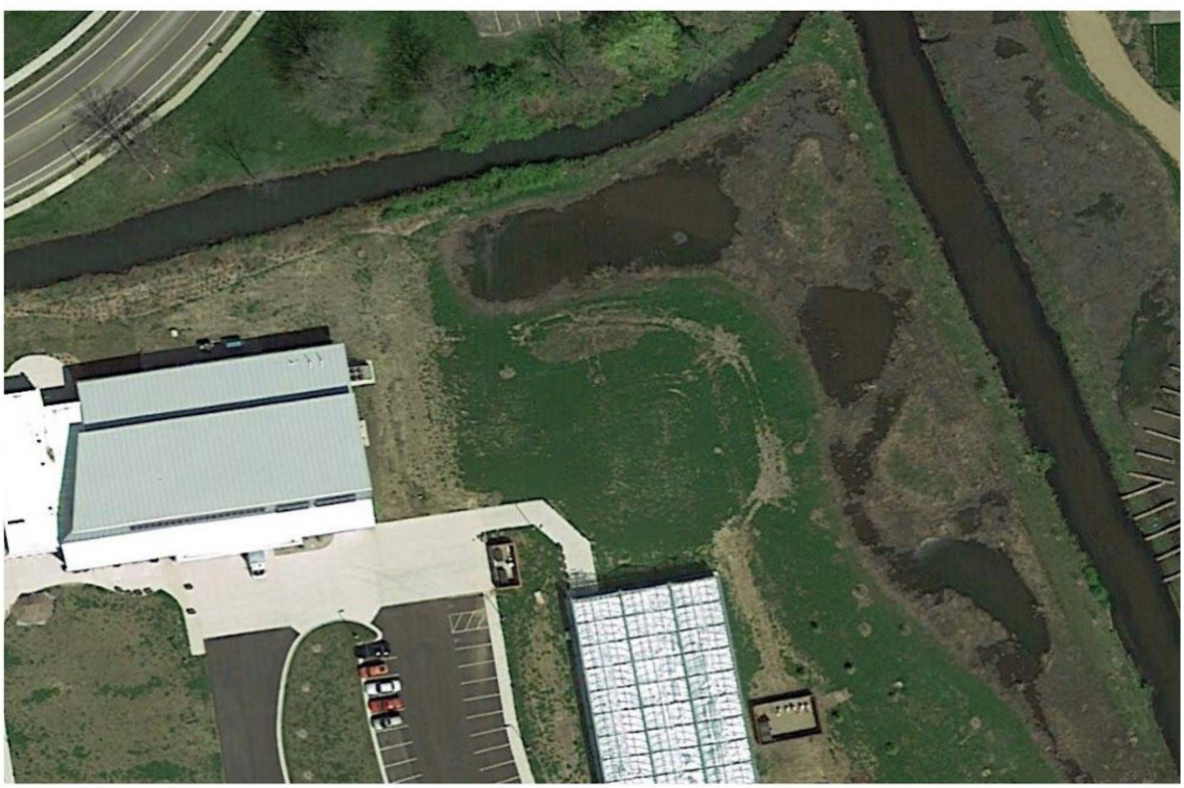
Client Identification:	**Granito, Evan**	Sample Description:	**#1**	Chain of Custody:	**167627**
Client Project Name:	**KVCC Food**	Sample No:	**#1**	Collect Date:	**08/07/18**
Client Project No:	**NA**	Sample Matrix:	**Soil/Solid**	Collect Time:	**NA**

Sample Comments: **Soil results have been calculated and reported on a dry weight basis unless otherwise noted.**

Definitions: Q: Qualifier (see definitions at end of report) NA: Not Applicable ‡: Parameter not included in NELAC Scope of Analysis.

Michigan 10 Elements by ICP/MS **Aliquot ID: 86202-001** **Matrix: Soil/Solid**
Method: EPA 0200.2/EPA 6020A **Description: #1**

						Preparation		Analysis		
Parameter(s)	Result	Q	Units	Reporting Limit	Dilution	P. Date	P. Batch	A. Date	A. Batch	Init.
1. Arsenic	**2900**		µg/kg	100	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
2. Barium	**48000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
3. Cadmium	**150**		µg/kg	50	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
4. Chromium	**6700**		µg/kg	500	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
5. Copper	**6400**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
6. Lead	**9700**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
7. Selenium	U		µg/kg	200	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
8. Silver	U		µg/kg	100	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
9. Zinc	**32000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV



Fibertec environmental services

Analytical Laboratory Report
Laboratory Project Number: 86202
Laboratory Sample Number: 86202-003

Order: 86202
Page: 4 of 5
Date: 08/23/18

Client Identification:	**Granito, Evan**	Sample Description:	**#3**	Chain of Custody:	**167627**
Client Project Name:	**KVCC Food**	Sample No:	**#3**	Collect Date:	**08/07/18**
Client Project No:	**NA**	Sample Matrix:	**Soil/Solid**	Collect Time:	**NA**

Sample Comments: **Soil results have been calculated and reported on a dry weight basis unless otherwise noted.**

Definitions: Q: Qualifier (see definitions at end of report) NA: Not Applicable ‡: Parameter not included in NELAC Scope of Analysis.

Michigan 10 Elements by ICP/MS — **Aliquot ID: 86202-003** — **Matrix: Soil/Solid**
Method: EPA 0200.2/EPA 6020A — **Description: #3**

						Preparation		Analysis		
Parameter(s)	Result	Q	Units	Reporting Limit	Dilution	P. Date	P. Batch	A. Date	A. Batch	Init.
1. Arsenic	**6200**		µg/kg	100	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
2. Barium	**48000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
3. Cadmium	**140**		µg/kg	50	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
4. Chromium	**7100**		µg/kg	500	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
5. Copper	**10000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
6. Lead	**26000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
7. Selenium	U		µg/kg	200	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
8. Silver	U		µg/kg	100	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
9. Zinc	**38000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV

Fibertec environmental services

Analytical Laboratory Report
Laboratory Project Number: 86202
Laboratory Sample Number: 86202-002

Order: 86202
Page: 3 of 5
Date: 08/23/18

Client Identification:	**Granito, Evan**	Sample Description:	**#2**	Chain of Custody:	**167627**
Client Project Name:	**KVCC Food**	Sample No:	**#2**	Collect Date:	**08/07/18**
Client Project No:	**NA**	Sample Matrix:	**Soil/Solid**	Collect Time:	**NA**

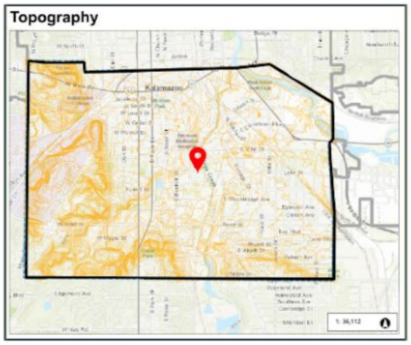
Sample Comments: **Soil results have been calculated and reported on a dry weight basis unless otherwise noted.**

Definitions: Q: Qualifier (see definitions at end of report) NA: Not Applicable ‡: Parameter not included in NELAC Scope of Analysis.

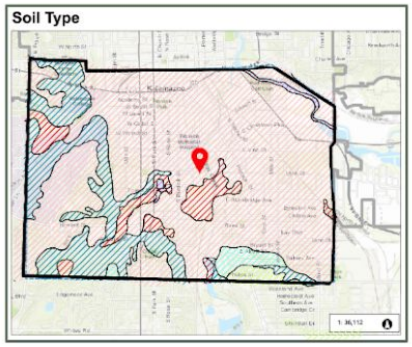
Michigan 10 Elements by ICP/MS — **Aliquot ID: 86202-002** — **Matrix: Soil/Solid**
Method: EPA 0200.2/EPA 6020A — **Description: #2**

Parameter(s)	Result	Q	Units	Reporting Limit	Dilution	Preparation P. Date	Preparation P. Batch	Analysis A. Date	Analysis A. Batch	Init.
1. Arsenic	**4400**		µg/kg	100	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
2. Barium	**46000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
3. Cadmium	**290**		µg/kg	50	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
4. Chromium	**9100**		µg/kg	500	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
5. Copper	**14000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
6. Lead	**49000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
7. Selenium	**230**		µg/kg	200	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
8. Silver	U		µg/kg	100	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV
9. Zinc	**59000**		µg/kg	1000	20	08/21/18	PT18H21B	08/21/18	T418H21A	NRV

GIS Data



5' Contours

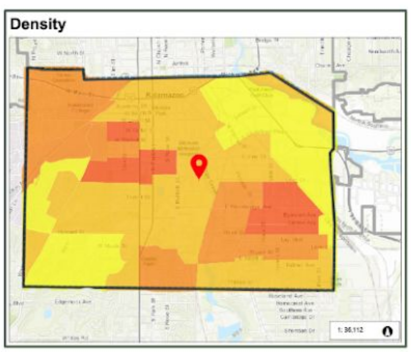


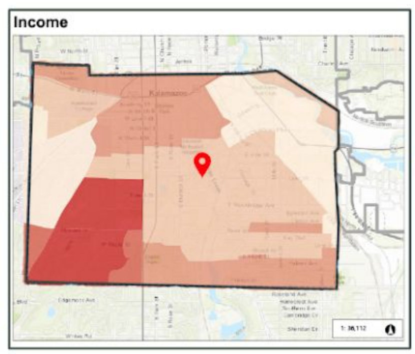
Urban Land
Urban Land Glendora
Urban Land Kalamazoo
Urban Land Oshtemo

Waterways

People/Square km2

- 14 - 660
- 661 - 1633
- 1634 - 3205
- 3206 - 5966
- 5967 - 13338





Wealth/Person (USD)

- 0 - 6116
- 6117 - 15916
- 15917 - 25594
- 25595 - 38763
- 38764 - 65191

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