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Interdisciplinary Design Studio: Programming Document Visioning for a Robotic Demonstration, Research, and Engagement Dairy

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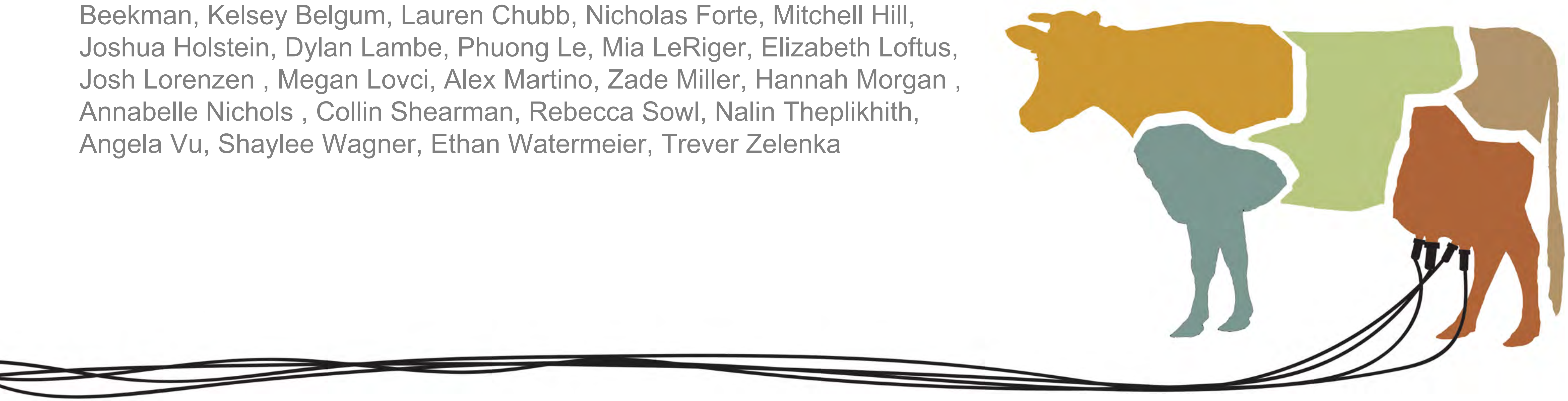
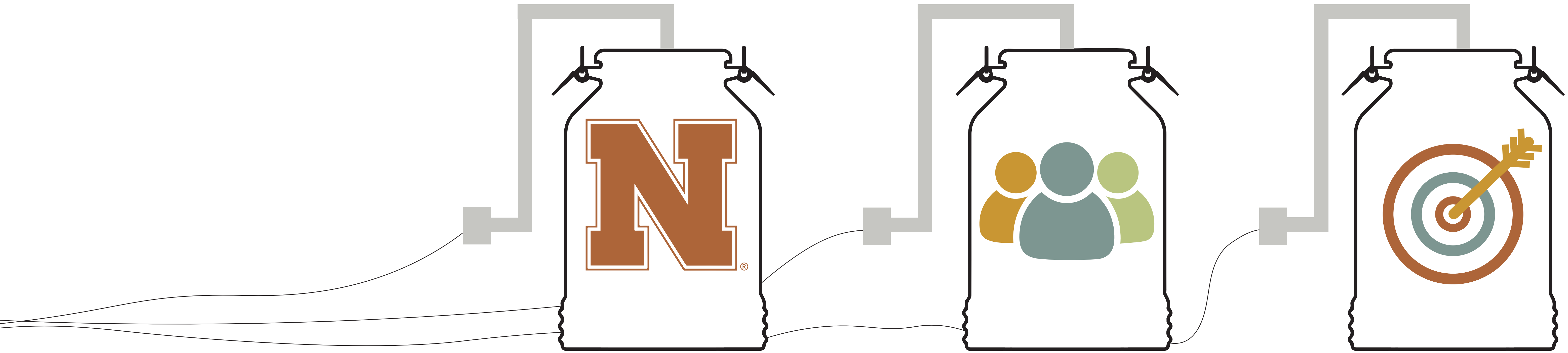
The 2022 COLLABORATE Design Studio brought together students from various disciplines to address a complex, real-world project which required collaborative input from different perspectives. The studio worked to advance the co-creation of knowledge between external stakeholders, students, and instructors. The course was co-taught by faculty from different disciplines, and areas of expertise. During the semester, Nate Bicak and Steven Hardy worked with students from Architecture and Interior Design in collaboration with students in Dr. Tami Brown-Brandl's students in Biological Systems Engineering and Animal Science to explore the values, spatial qualities, and area requirements of a Robotic Demonstration, Research, and Engagement Dairy.

Students organized a series of meetings and participatory activities to gather information from a range of project stakeholders including: Heather Akin (Agricultural Leadership, Education & Communication), Kris Bousquet (NE Dairy Association), Paul Kononoff (Animal Science), Eric Markvicka (Mechanical and Material Engineering), Julia McQuillan (Sociology), Santosh Pitla (BioSystems and Agricultural Engineering), Ling Ling Sun (NE Public Media), and Rosanna Villa Rojas (Food Science & Technology). The information gathered helped to frame the overall problem - both quantitative and qualitative - to be addressed during the design visioning stage (not included in this document).

Student contributors included: Sarah Alduaylij, Noor Al-Maamari, Devyn Beekman, Kelsey Belgum, Lauren Chubb, Nicholas Forte, Mitchell Hill, Joshua Holstein, Dylan Lambe, Phuong Le, Mia LeRiger, Elizabeth Loftus, Josh Lorenzen , Megan Lovci, Alex Martino, Zade Miller, Hannah Morgan , Annabelle Nichols , Collin Shearman, Rebecca Sowl, Nalin Theplikhith, Angela Vu, Shaylee Wagner, Ethan Watermeier, Trever Zelenka





Introduction

We are a group of fourth year students through the college of Architecture at the University of Nebraska-Lincoln. Our group is made up of Architecture and Interior Design students. We have collaborated with graduate students in Animal Science and Biological Systems Engineering, as well as faculty, researchers, and industry experts regarding their numerous expertise in dairy facility planning.

Stakeholders

This facility aims to serve the city of Lincoln, the State of Nebraska and the entire Great Plains Region. Project stakeholders include current and future dairy farmers, food scientists, animal scientists, university researchers, instructors, and students, as well as the general public. This facitly strives to be a research, education, and demonstartion hub for showcasing sustainable, robotic dairy production methods that are as appealing to the public as they are to dairy experts.

Goals

The goal is to design a prototype flagship facility which can support a distributed network of environmentally sustainable and resilient technology-based small dairy producers/processors. This facility will also increase public understanding of automated dairies of the future to safeguard continued consumption of dairy, while also demonstrate and encouraging potential STEM and agriculture-based careers.

TABLE OF CONTENTS

INFORMATION AND VALUES

SITE

BUILDING PROGRAM

AREA, DETAIL, AND EQUIPTMENT

CONSTRUCTION

INFORMATION AND VALUES

Values

Primary Core Values

"A collaboration between the University of Nebraska-Lincoln (UNL), Michigan State University (MSU), Nebraska Public Media (NPM), and Seoul National University (SNU), the Small Technology-based Animal-focused Green center for Engagement (STAGE) initiative aims to create a distributed network of environmentally sustainable and resilient technology-based small dairy producers/processors. To ensure sustainability, this project will increase public understanding of automated dairies of the future to safeguard continued consumption of dairy and demonstrate potential STEM and agriculture-based careers."

Public Understanding

Definition
A social context emphasis on agriculture and livestock education.

Project Goal
Give the public a better understanding of robotic dairy practices, as well as dairy cow natural instincts.

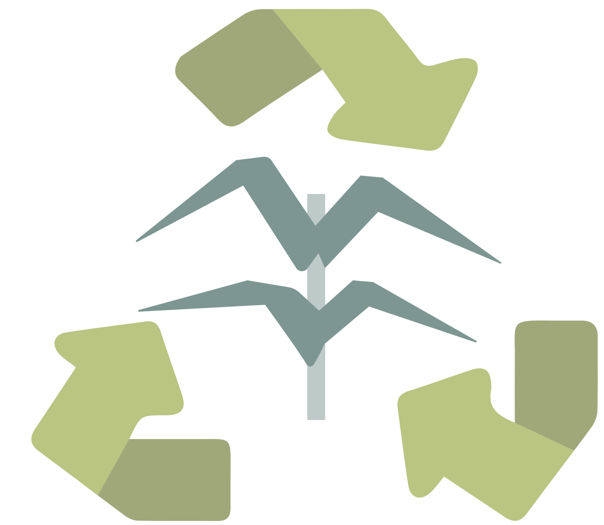
Implementation Strategy
Incorporate an exhibition area, as well as livestock observation windows or screens, where the public can witness first-hand how dairy is produced and processed, for the benefit of both humans and cows.

Animal Welfare

Definition
An animal's quality of life.

Project Goal
Exercise quality assurance practices in the lives and routines of the livestock. Create an environment where each cow's mental, physical, and emotional state are of the utmost importance, and are recorded regularly.

Implementation Strategy
Utilizing technology to help dairy farmers track and record each cow's vitals and movement. As data is collected for each individual cow, the environment can change accordingly to increase comfortability.



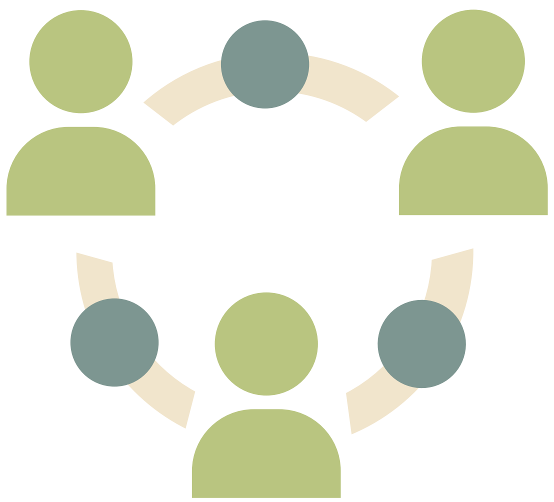
Sustainability

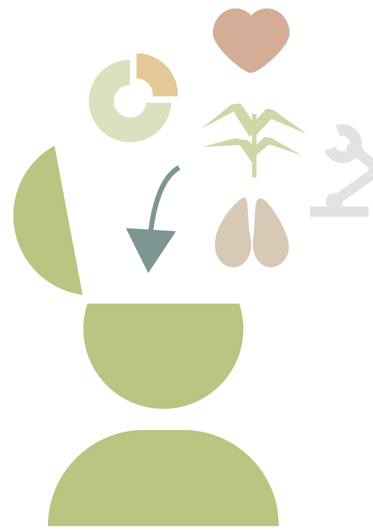
Definition
The practice of meeting self needs without compromising the ability of future generations to meet their needs.

Project Goal
Utilize this facility as a model of exceptional sustainable practices.

Implementation Strategy
Establish environmentally friendly and self-preserving standards by decreasing the amount of waste and carbon emission. As well as encourage recycling of single use materials, and repurpose the cow manure as crop fertilizer.

Secondary Core Values





Collaboration

Definition
The process of learning from and working with others.

Project Goal
Recognize and utilize the variety of strengths displayed and expressed each stockholder and through every spatial program.

Implementation Strategy
Combine knowledge, teaching, and experience of each spatial program to well round the facitily. Utilize the variety of different practices including agriculture, technology, food production, engineering, design, and construction.

Education

Definition
An enlightening experience in which knowledge is gained.

Project Goal
Utilizing the space to create an environment of enlightenment, engagement, and learning.

Implementation Strategy
Prioritize the concept of openly and enthusiastically sharing and trading knowledge with not only students and children in classroom spaces, but also with any and all visitors interested.

Research

Definition
A systematic investigation conducted to answer an unknown question.

Project Goal
Reaching outside of the box to question the indefinite or uncertain and strive to continually know more.

Implentation Strategy
Place emphasis on acquiring the proper equipment and technology to conduct study on dairy cows or the dairy process, as well as design the proper space to support this research.

Value Assesment

Overall values considered and reviewed by stockholders.

Collaboration	★★★★★★
Effective	½
Workforce Impact	★½
Research	★★★★½
Innovative	★
Animal Welfare	★★★★★★★★★★
Sustainable	★★★★★★★★★
Precision	½
Experiencial	★★
Hands - On	★½
Carbon Footprint	★
Resilient	½
Production	★★
Education	★★★★★½
Mentoring	★
Interactive	★½
Technology	★★
Diversity	★★
Consumer	½
Transdisciplinary	★
Public Understanding	★★★★★★★★★★½
Transparency	★
Cow Comfort	★
Extension	½

★ = stockholder rankings

1. Source 1
2. Source 2 . . . etc.

Robotic milking, otherwise known as AMS (Automated Milking Systems) or RMS (Robotic Milking Systems) is a voluntary milking system that allows cows to set their own milking schedule.

Info on milk quantity and quality and cow health is collected and ensures a quicker and cleaner process for collecting the milk for human consumption

RMS provides labor savings, flexibility to schedules, precise and accurate data collection, & better herd management

Wi-Fi connects Robotic Milking Systems to Microbiologists, other dairy farmers, production plant specialists, robotic technology specialists, mechanical engineers, and veterinarians

Top AMS is the GEA R9500– all milking necesseties in a single attachment

Lely Astronaut A5 delivers usability, longevity, and reliability creating a healthy and stress-free milking experience

3,000-plus robotic milking systems in the U.S.
30,000-plus robotic milking systems worldwide

$150,000 - $200,000 per robot
50-70 cows each

About a 5-10x production increase than parlor system milking

Agritourism provides statistically significant and positive effects on farm profitability, mental health and education

RMS supports local job creation, farmers, and builds communities

AMS offers Fresher foods, preservation of open space, lighter carbon footprints

AMS is future focused, it empowers consumers, and boosts local economy

What is Robotic Milking?

Robotic milking, otherwise known as AMS (Automated Milking Systems) or RMS (Robotic Milking Systems) is a voluntary milking system that allows cows to set their own milking schedule. Because the robot milks the cow, farmers have more flexibility in how they use their time, and more time can be devoted to farm management or other activities. Automatic milking systems collect information on milk quantity and quality and cow health, which helps farmers better manage their herd. Not only does robotic milking collect data for better herd management, but robotic milking also ensures a quicker and cleaner process for collecting the milk for human consumption. This leads to labor savings, flexibility to schedules, more precise and accurate data collection on each individual cow, better herd management. AMS create an environment that can be continuously improved through updated technology integrations. This technology allows the cows to be comfortable, and better attended to individually which allows better performance during lactation as opposed to traditional milking systems. Wearable sensors including neck monitoring collars “learn” about each individual cow’s behavior. Wi-Fi connects these automated milking systems to a diverse range of professionals including microbiologists, other dairy farmers, production plant specialists, robotic technology specialists, mechanical engineers, and veterinarians. Due to its global connection and practice, questions regarding these automated milking systems can be posed at any time of the day and receive a prompt response from the other side of the globe! Thanks to RMS, health issues in cows can be treated early, and GPS tracking of cows to make sure all cows are accounted for. These cows can “milk themselves” which reduces overall stress in the cow, and the future of Robotic Milking Systems works towards also converting manure into energy which promotes renewable energy sources as well as saving money on electricity.

The best Robotic Milking Systems include the GEA DairyRobot which is engineered with an open, cow-friendly, and adjustable design suited for different cow sizes and breeds. The GEA R9500 is perhaps the only robot that performs everything from – stimulation, teat preparation, forest ripping, milk harvest, and post-dipping – in a single attachment. The second best milking system is the Lely Astronaut A5, designed to deliver top-level usability, longevity, and reliability, creates a healthy and stress-free milking experience for both the farmer and their cows. Each robot costs anywhere from $150,000 - $200,000, and can milk between 50-70 cows each. The production of milk is increased 5-10x when milked twice a day from these robots when compared to traditional parlor-sytle milking. To achieve maximum benefit of the robots, it is preferred to put them into a new, higher technology, low labor requirement facility.

As of 2018, the Netherlands is the world’s largest milk supplier, both in robotic milking statistics and parlor milking statistics. For the United States, the top performing robotic dairy producers were ranked as number 1-Reidstra Dairy Ltd., Mendon, Michigan, number 2-Bouma Farms, Lynden, Washington, number 3-Feltz Family Farms, Stevens Point, Wisconsin, number 4-Great Brook Farm, Carlisle, Massachusetts, and number 5-Malvern Hills, Glasgow, Kentucky.

1. Source 1
2. Source 2 . . . etc.

58,000 Dairy cow

Dairy milk is naturally nutrient rich. Vitamin D, Vitamin A and potassium are also prevalent. (due to pasteurization, Vitamin D & A are reduced, so fortification in those vitamins is required)

Dairy cows spend the majority of their life in a dairy

Regular milk has no added sugars unlike most milk alternatives

3 dairy processing plants in Nebraska

Dairy Milk Price- about 25 cents per glass. Alternative Milk Price- about 70 cents per glass

Non-dairy milk can lead to gaps in calcium and other key nutrients like high quality protein, phosphorus and Vitamin B12

1,832,000 Beef Cow

Calves born on a calf ranch spend the majority of their lives on grass before being sent to a feedlot for finishing

Beef- 3rd highest agricultural export

Nebraska Rank #2 for human to cow ratio-3.29

6 meat processing plants in Nebraska

Nebraska's the top beef export ranking to it being the home of some of the nation's largest packing plants

Nebraska-"The Beef State"

Dairy in "The Beef State"?

Beef vs Dairy in NE

There are approximately 58,000 Dairy cows and 1,832,000 Beef Cows in Nebraska. Nebraska ranks #2 for human to cow ratio-3.29 cows per 1 individual. Beef- 3rd highest agricultural export, while Dairy products do not rank among the top 10 agricultural exports. Beef production is the largest sector of agriculture Nebraska's the top beef export ranking to it being the home of some of the nation's largest packing plants. There are a total of 6 meat processing plants and 3 dairy processing plants within the state.

Calves born on a cow/calf ranch typically spend the majority of their lives on grass before being sent to a feedlot for finishing, whereas dairy cows spend the majority of their life in a dairy.

Dairy vs Alternative Dairy

Though widely compared against one another, there are benefits to consuming dairy products over alternative dairy sources. Non-dairy milk can lead to gaps in calcium and other key nutrients like high quality protein, phosphorus and Vitamin B12. Naturally nutrient rich dairy milk also has Vitamin D, Vitamin A and potassium. Due to pasteurization, Vitamin D and Vitamin A are reduced, so fortification in those vitamins is required before shipping. Regular milk has no added sugars unlike most alternative milk choices, which can have anywhere from 15-30 grams excess sugar. As for pricing, the priceof dairy milk is around 25 cents per glass, and 70 cents per glass for alternative dairy sources, respectively.

The Importance

What's so important about implementing more dairy within a beef state? One of the key factors for progressive agricultural, and educational growth is agritourism. In one study, visitors to dairy and agritourist sites perceived considerable improvement in their immediate mood compared to a control group who stayed home. Research indicates a significant interaction between self-reported wellbeing and agritourism activities and a combined effect on improved mood.Agritourism is a resource for positive mood and improved mental health

Not only does agritourism promote positive mood and mental health, statistically significant and positive effects on farm profitability are also reported. Profit impacts reported from agritourism are noted to be highest among small farms operated by individuals primarily engaged in farming. Overall, agritourism mostly serves to capture new farm customers, while also educating the public about agriculture

Enhances the quality of life for the farm family

Agritourist experience consists of five dimensions: uniqueness, learning, staff, escape, and peace-of-mind.

Tourist experience, perceived value, satisfaction, and motivation are significant determinants of agritourist loyalty toward the attraction.

Tourist experience dimensions, learning and uniqueness have the biggest impact on tourist satisfaction, motivation, and loyalty

1. Source 1
2. Source 2 . . . etc.

North America reduced emissions intensity by 2.2% per year, even as milk production increased 2.1%. In addition, total emissions decreased by 5% over the entire time period

U.S. dairy accounts for just 2% of total U.S. greenhouse gas (GHG) emissions, 5.1% of U.S. water use and 3.7% of U.S. farmland

LTU anticipates this project will produce 100 billion British thermal units of renewable natural gas annually, the equivalent of about 875,000 gallons of gasoline

Manure from a dairy milking 200 cows can produce as much nitrogen as is in the sewage from a community of 5,000-10,000 people

Soil ecosystems are amongst the most diverse on earth, hosting c.25% of all of the species on the planet

Lincoln's Methane Digesters are actively creating vehicle fuel that is currently being sold on the national market.

Cows produce manure, which when mixed with remnants of local crops, can become a seemingly endless supply of filtering material, fertilizer and energy

Our own species derives 95% of our food from the soil, whether directly or indirectly

"Cradle-to-Cradle" cycles suggest that every product and all packaging should have a complete closed-loop cycle mapped out for each component

Manure from a dairy milking 200 cows can produce as much nitrogen as is in the sewage from a community of 5,000-10,000 people

Closed Loop Sustainability in a Dairy Barn?

Due to the increasing urgency of things like climate change, sustainability in farming has been highlighted as an important issue. Sustainability usually gets boiled down to a few concepts. Recycling is a topic that often gets brought up. As well as carbon footprint and especially now, microplastics and pollution. These issues are important to consider in the agricultural aspects of the building as well as in the construction and in the public component of this project.

In general recycling, open and closed loop systems are ways of explaining a material's life cycle. Open loop systems are most common. In an open loop system material is manufactured, used, then reused or recycled. This recycling process creates an inferior product and eventually the product reaches the end of its life cycle and gets sent to a landfill. In a closed loop system a product is manufactured once and infinitely recyclable. The material doesn't degrade or accumulate toxins in a closed loop system and if a product goes to a landfill it is biodegradable. For example aluminum is nearly infinitely recyclable and most of the aluminum used in making soda cans can be recycled into new soda cans. Closed loop recycling takes "cradle to cradle" considerations of products by thinking from the start about the beginning and end state of products. The eventual goal of closed loop recycling is a zero waste system.

This closed loop thinking can also be applied to dairy production. Dairy production produces waste most notably through cow manure and other animal waste. Cow manure is a fantastic fertilizer to help infuse the soil with valuable nutrients that get stripped through the growing process. Manure creates logistical problems for farmers as well though as it is difficult to move, treat, and distribute large amounts of manure especially as size and production ramp up. Closed loop systems have been implemented on dairy farms previously, such as Three Mile Canyon Farm in Oregon. They use dairy byproducts and Biochar from manure to generate fertilizer and energy for their farm and in turn the farm provides food for the cows.

Lincoln already uses human waste to create energy from methane with their methane digesters. The Lincoln Transportation and Utilities Department (LTU) takes Lincoln's wastewater and turns it into natural gas fuel. This fuel is then used locally or sold back to the national market to fund further expansions to energy infrastructure.

1. Source 1
2. Source 2 . . . etc.

Using robots on farms worldwide has led to improvements in labor efficiency, animal wellbeing and changes in the quality of life for farm owners and employees.

From 1992 to 2018, over 94,000 family dairies closed their doors at the rate of 10 dairy farms per day. Just in the last year, 2,731 dairy farms went out of business.

Robotic milking has improved the quality of life of dairy cows by 50%, and improved cow's welfare by 76.9%.

Robotic dairy focuses on cow safety and and cow health along with milk production.

Milk consumption has dropped by 40 percent since 1975, a trend that is accelerating as more people embrace oat and almond milk.

The rotalacter machine not only reitrives milk from the cows udders, but it washes them and drys them to ensure cow comfort.

Over the past decade, 20,000 dairy farms have gone out of business, representing a 30 percent decline, according to the Department of Agriculture.

Robotic dairy allows cows to have freedom in deciding when they eat, drink, sleep, and get milked

Dairy contributes significantly to the American economy. Reports show that the dairy industry accounts for 1 percent of the U.S. Gross Domestic Product (GDP), generating an economic impact of $628 billion.

The industry also creates nearly 3 million U.S. jobs that generate around $159 billion in wages.

Public Perception and Understanding

Public Impact On Dairy Production

Research shows that public perception of robotic dairy farming plays a large role in the success of dairy farming businesses as dairy farms become more dependent on robotic technologies. Many of the hesitations people have towards dairy farming revolve around the safety and health of the cow. The animal's quality of life is a heavy concern. Studies show that many people believe the robots will put the cow in danger—that they could pinch or hurt the cow. There are fears that the machines could malfunction and cause serious damage. Animal rights activists have a markedly different take on farms like Mr. Chittenden's that satiate the nation's appetite for milk, cheese and yogurt. To them, dairy farmers are cogs in an inhumane industrial food production system that consigns these docile ruminants to a lifetime of misery. After years of successful campaigns that marshaled public opinion against other long-accepted farming practices, they have been taking sharp aim at the nation's $620 billion dairy industry. The effort to turn Americans against dairy is gaining traction at a time when many of the nation's farms are struggling to turn a profit. Milk consumption has dropped by 40 percent since 1975, a trend that is accelerating as more people embrace oat and almond milk. Over the past decade, 20,000 dairy farms have gone out of business, representing a 30 percent decline. And the coronavirus pandemic has forced some producers to dump unsold milk down the drain as demand from school lunch programs and restaurants dried up.

What You Need To Know

Based on the previous information, it is important to educate the public on the safety features that robotic dairy provides for the animals. For example, Modern robotic milking facilities, when properly configured, offer some unique advantages for not only the producer but for the dairy cow itself. Most robotic systems collect over 100 different points of information on each animal every time it enters the milking station. Managers can use this information to monitor the daily status of each animal.

Among other things, data from IBAMS shows an increase in longevity resulting from fewer foot and leg problems, better herd and udder health, increased breeding efficiency, less herdmate social pressure and improved milk quality under comparable management expertise.

Recognizing what leads to these advantages requires an understanding of robotic systems and how those systems operate. Robotic milking systems offer better udder health through consistent unvaried milking procedures. Easily retrieved cow status and health reports provided by the robotic system help improve milk quality, breeding efficiency and earlier recognition of health problems including mastitis.

Social stress is greatly reduced and fewer foot and leg problems are caused by not ushering cows to be milked or subjecting them to long times in holding areas. Robotic milking systems offer an advantageous cow time budget, which includes all those things the cow does in any 24-hour period, such as eating, drinking, resting, ruminating, walking and being milked.

Foot and leg injuries are a fact of life in dairy farming. Moving cows, especially in groups, can increase the chances of an injury. Allowing the cow to move freely through her total milking, feeding and resting environment can help reduce the chance of injury. Elimination of the holding area reduces physical stress on the feet and legs of the cow from standing time and jostling for position in the holding area. In this system, Hoof health is improved and preventative hoof health care time and expense are notably reduced when compared with all other systems.

A generally consistent factor of all RMSs is the per quarter attachment and detachment of teat cups, this can be considered a far more natural milking experience for cows as it more closely resembles natural suckling from calves and reduces risks associated with over milking. Essentially an RMS offers more freedom and choice to cattle and has been demonstrated, largely, to maintain their diurnal natural behavior with most milking occurring between 7 am and 10 pm. Furthermore, 80% of these producers also noted it was easier to specifically detect illness using RMSs (via the integrated health monitoring software) than in traditional milking, with reductions in clinical mastitis cases being observed. Whilst software and automation with RMSs offer the potential to detect illness with minimal labor input it is important to note that farmer observation and expertise are still essential.

Through the use of AMS, dairy milk consumers can be confident that animal welfare is a top priority when it comes to milk production.

1. Source 1
2. Source 2 . . . etc.

Robotic vs Traditional Milking Which is Better?

According to an article written and published by Catherinne Cunnane, an author, editor, sixth-generation drystock and pedigree with farm animals, and general manager at "That's Farming", 1/3 of a dairy farmer's total workload is the milking process. Milking robots reduce the milking process on average to 40 mins per day from 3 hours when compared to conventional milk collecting techniques. Large amounts of information on a cow is recorded, analyzed and compared to previous data from that same cow. Standard parlor systems have data collection typically only once a day, and the information gathered is not as specified and quantitative as seen with robotic milking systems.

Robotic milking systems reduce the time associated with milking processes. Grazing management time is increased, while standard dairy jobs remain the same on-farm. These robotic milking systems are developed for indoor systems primarily.

A few disadvantages of robots are that they are more capital intensive in an expanding farm scenario. Higher service costs and ESB (Enterprise Service Bus) costs are higher compared to a parlor system milking. The main challenge farmers face when changing to a robotic system is managing new grazing systems and movement of the cows.It is critical to maximize the use of grazed grass and reduce other feed costs when comparing robotic milking systems to conventional milking systems. Farmers who struggle with grazing management tend to feed more concentrates through the robot and increase their cost of production. Return on investments can be seen as a function of profit divided by total investment. Achieving good milk output from a grass-based system increases profits and delivers higher return investment. Robotic systems that provide the cows with pre-measured food are dispersed hourly, whereas parlor systems refresh food three to four times a day. Typically, a robotic milking unit will have a lower return on investment per cow than a mid-spec parlor, as the investment cost per cow tend to be higher in a robotic system. Some different financial options a farmer can choose from vary. Farmers can apply for leasing arrangements as they would with other farm machinery, however, they cannot use a leasing or HP option if availing of a TAMS grant. Farmers can also apply for a normal term loan from their bank, normally on a 10-15-year term.

1. Source 1
2. Source 2 . . . etc.

Sources

1) Rezaei, Mehdi, Doohwan Kim, Ahad Alizadeh, and Ladan Rokni. 2021. “Evaluating the Mental-Health Positive Impacts of Agritourism; a Case Study from South Korea.” Sustainability 13 (16): 8712. https://doi.org/10.3390/su13168712z

2) Schilling, Brian J., Witsanu Attavanich, and Yanhong Jin. 2014. “Does Agritourism Enhance Farm Profitability?” Journal of Agricultural and Resource Economics 39 (1): 69–87. https://www.jstor.org/stable/44131315#metadata_info_tab_contents.

3) Tew, Christine, and Carla Barbieri. 2012. “The Perceived Benefits of Agritourism: The Provider’s Perspective.” Tourism Management 33 (1): 215–24. https://doi.org/10.1016/j.tourman.2011.02.005.

4) Dwi Suhartanto, David Dean, Brendan T. Chen & Lusianus Kusdibyo (2020) Tourist experience with agritourism attractions: what leads to loyalty?, Tourism Recreation Research, 45:3, 364-375, DOI: 10.1080/02508281.2020.1736251 Full article: Tourist experience with agritourism attractions: what leads to loyalty? (tandfonline.com)

5) “Choose Your Robotic Milking System Wisely.” 2020. Farm Progress. June 3, 2020. https://www.farmprogress.com/dairy/choose-your-robotic-milking-system-wisely.

6) NT, Baiju. 2021. “Top 9 Best Robotic Milking Machines to Consider in 2022 [Updated].” RoboticsBiz. January 2, 2021. https://roboticsbiz.com/top-9-best-robotic-milking-machines/.

7) “Milk vs Non-Dairy Milks | GonnaNeedMilk.” n.d. Milk: Fueling Athletes for Centuries | GonnaNeedMilk. https://gonnaneedmilk.com/articles/milk-vs-non-dairy-milks/.

8) admin. 2015. “8 Reasons to Join the Local Food Movement.” Drink Milk in Glass Bottles. July 9, 2015. http://www.drinkmilkinglassbottles.com/join-the-local-food-movement/.

9) “Biggest Advantages to Buying Local Dairy | Dairy Services.” n.d. Www.modernmilkman.com. Accessed September 21, 2022. https://www.modernmilkman.com/modern-milkman-blog/biggest-advantages-to-buying-local-dairy/.

10) “The Power of Technology on Today’s Dairy Farms.” n.d. Www.fb.org. https://www.fb.org/viewpoints/the-power-of-technology-on-todays-dairy-farms.

11) Levi. 2021. “How Technology Is Changing Dairy Farming.” SUSMILK. November 4, 2021. https://www.susmilk.com/technology/how-technology-is-changing-dairy-farming/.

12) Review of Dairy Growth and Development Study. 2014. Legislative Bill 941, November, 2–80. https://nda.nebraska.gov/promotion/dairysurvey.pdf.

13) Cook, Rob. 2019. “Cattle Inventory vs Human Population by State.” Beef2live.com. 2019. https://beef2live.com/story-cattle-inventory-vs-human-population-state-0-114255.

14) "USDA/NASS 2020 State Agriculture Overview for Nebraska." n.d. Www.nass.usda.gov. https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=NEBRASKA.

15) "Dairy Robotic Milking Systems – What Are the Economics? – DAIReXNET." 2019. Extension.org. August 16, 2019. https://dairy-cattle.extension.org/dairy-robotic-milking-systems-what-are-the-economics/.

16) "Do Milking Robots Pay?" n.d. Extension.umn.edu. https://extension.umn.edu/precision-dairy/do-milking-robots-pay.

17) Editorial. n.d. "Six Key Benefits of Automatic Milking Systems (AMS)." https://roboticsbiz.com/six-key-benefits-of-automatic-milking-systems-ams/.

18) Heba Soffar. 2019. "Automatic Milking or Robotic Milking Advantages and Disadvantages | Science Online." Science Online. July 11, 2019. https://www.online-sciences.com/robotics/automatic-milking-or-robotic-milking-advantages-and-disadvantages/.

19) Welfare Advantages Differ among Robotic Milking Environments - Progressive Dairy | Ag Proud." n.d. Www.agproud.com. Accessed September 21, 2022. https://www.agproud.com/articles/21512-welfare-advantages-differ-among-robotic-milking-environments.

20) Rodenburg, Jack. 2017. "Robotic Milking: Technology, Farm Design, and Effects on Work Flow." Journal of Dairy Science 100 (9): 7729–38. https://doi.org/10.3168/jds.2016-11715.

21) "Dairy Robotic Milking Systems – What Are the Economics? – DAIReXNET." 2019. Extension.org. August 16, 2019. https://dairy-cattle.extension.org/dairy-robotic-milking-systems-what-are-the-economics/.

22) "Milking Machine Market: The Netherlands Is the World's Largest Supplier." 2018. Bizvibe Blog.
March 12, 2018. https://blog.bizvibe.com/blog/agriculture/milking-machine-market-netherlands-largest-supplier.

23) Cunnane, Catherina. 2021. "Robotic Milking Systems: A Guide for Farmers before Investing -." Thatsfarming.com. June 28, 2021. https://thatsfarming.com/dairy/robotic-milking-systems/#:~:text=PD%3A%201%2F3%20of%20a%20dairy%20farmer%E2%80%99s%20total%20workload

24) Bechtel, Wyatt. 2017. Review of Top North American Robotic Dairy Farms Recognized by DeLaval. Daily Herd Management. June 27, 2017. https://www.dairyherd.com/news/top-north-american-robotic-dairy-farms-recognized-delaval.

25) Jacobs, Andrew. 2020. "Is Dairy Farming Cruel To Cows?" New York Times Publishing. Dec 29th, 2020. https://www.nytimes.com/2020/12/29/science/dairy-farming-cows-milk.html

26) Dr Cutress, David. 2020. "Robotic Milking and Cattle Welfare" Farming Connect. August 5th, 2020. https://businesswales.gov.wales/farmingconnect/news-and-events/technical-articles/robotic-milking-and-cattle-welfare

SITE

East Campus

East campus is known for housing the agricultural academic buildings for the University of Nebraska-Lincoln alongside Law and Dentistry colleges, the Barkley Memorial Center for Hearing and Speech Disorders, the Division of Continuing Studies and the Nebraska Educational Television Network.

Context

Buildings that were analyzed for architectural and material context were the Animal Science Building, East Union, Dinsdale Family Learning Commons, and Agriculture Hall. The Animal Science, East Union, and Agriculture Hall all share brick for their building material with the difference being their color. The learning commons, being the most recent build compared to the other three buildings, went with a different material choice of aggregate stone for their columns.

Wind and Sun

The Wind Diagram shows the average wind speeds from January to December. The prevailing winds are in the North and South direction which impacts the tunnel vent barn style. The average wind speeds are holding steady around 10 mph and the max being over 40 mph and the lows at 0 mph.

The Sun Diagram shows the average range of sun throughout the day. The sun rises in the East and sets in the West with the majority of the sun being during the solar noon. In Lincoln, based on the summer and winter solstices, the longest days are around June 21st and the shortest days around December 21st. The average sun hours are highest in June and July with over 300 sunhours a month and the lowest in December and February with around 150 sunhours. This impacts the cows circadian rhythm which impacts milk production.

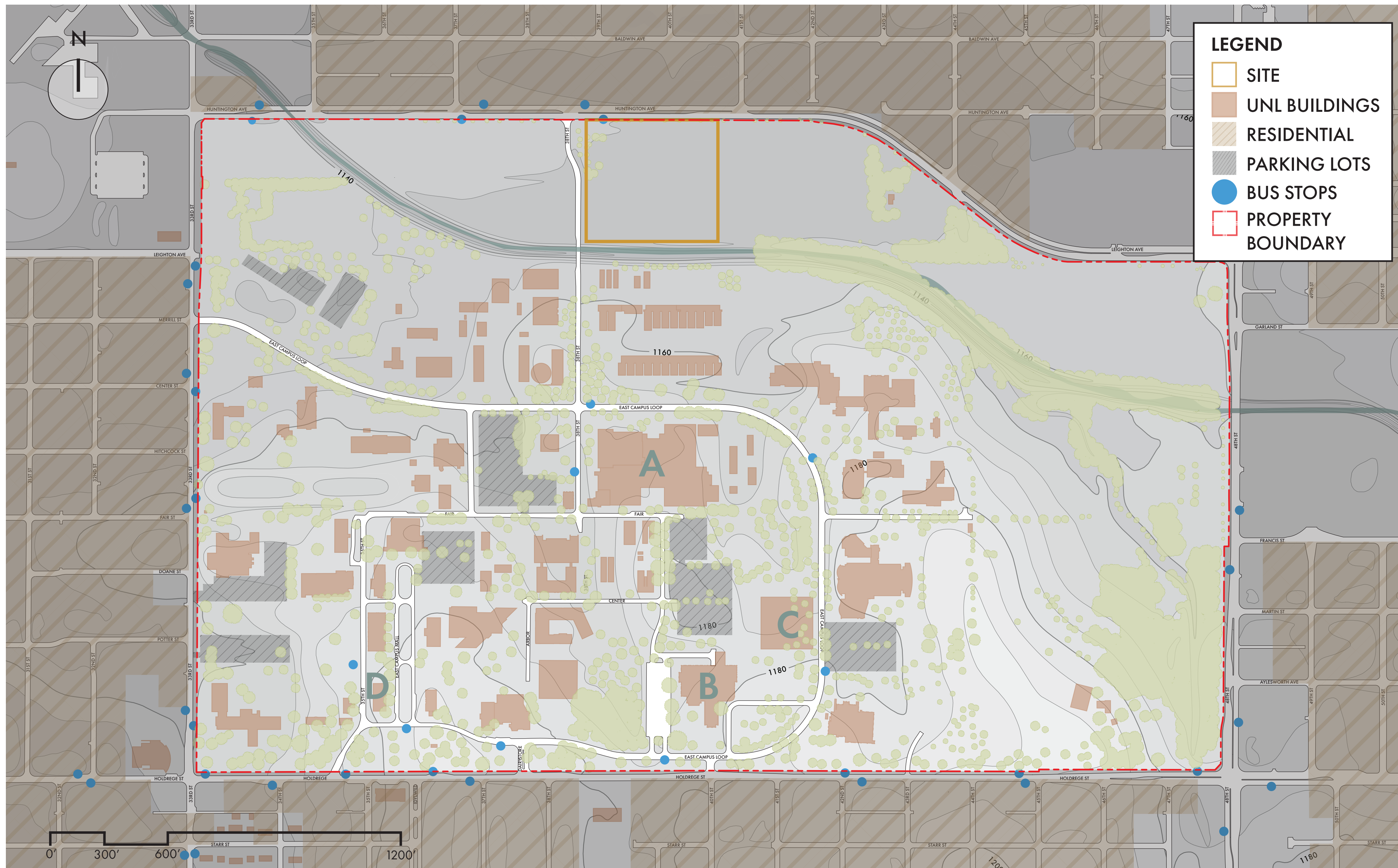
The two campuses are located in the same city, therefore have the same wind and sun data. The diagrams can be seen on the next page.

Animal Science Building

East Union

Dinsdale Family Learning Commons

Agriculture Hall



Food Innovatin Center

Bob Devaney Sports Center

Scarlet Hotel

The Mill

Innovation Campus

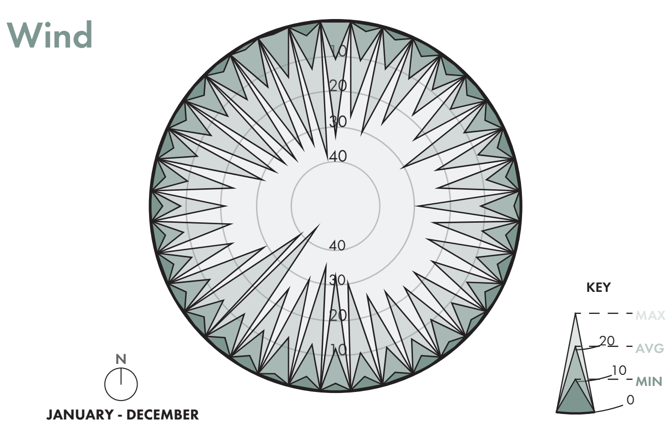
Innovation Campus is known to have in-depth partnerships with private sector businesses associated with the University of Nebraska-Lincoln. On campus, there are new and exciting buildings including the Scarlet Hotel and Innovation Center and will continue to see growth as the university expands its sports complex.

Context

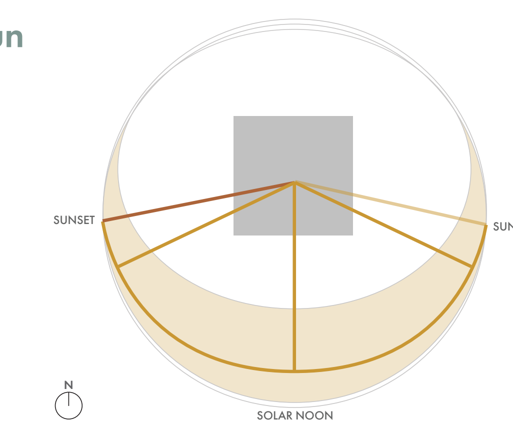
Buildings that were analyzed for architectural and material context were the Food Innovation Center, Bob Devaney Sports Center, Scarlet Hotel, and The Mill. The Food Innovation Center and Scarlet Hotel share the brick for the exterior material with different shades, and the Bob Devaney Sports Center and The Mill both have exterior tile for theirs. Buildings on Innovation Campus have a more modern architectural style due to being much younger than East Campus.

Wind and Sun Diagrams

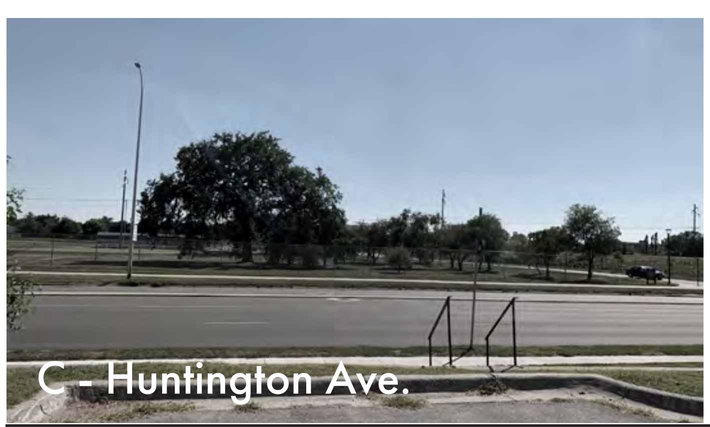
Wind

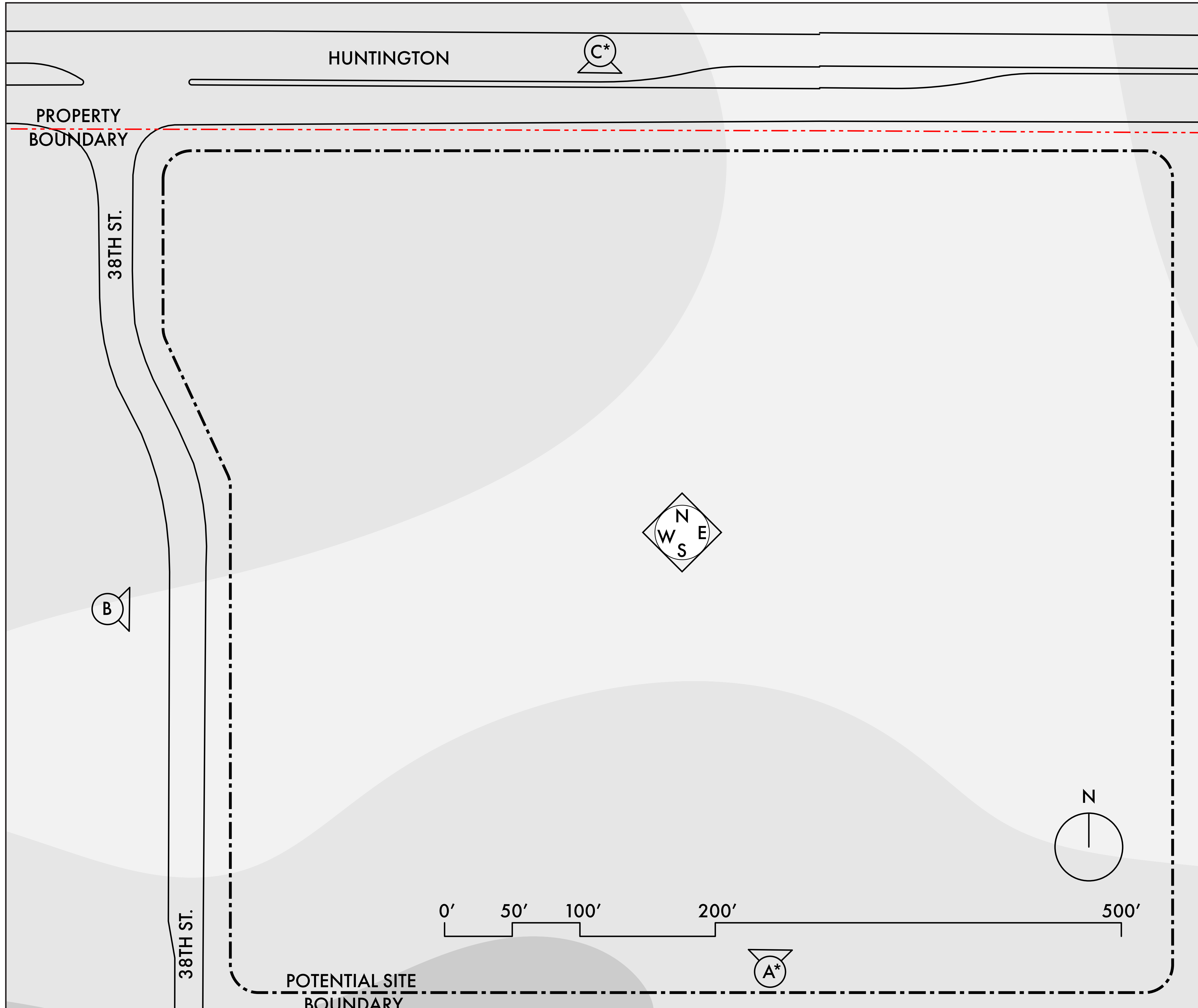


Sun



East Campus
Site 1 - Views





East Campus

Site 1 - Visibility

Reasoning

This site is a prime spot to bring identity to the North end of East Campus. This site would give public interest and attract more people to the campus. Putting the Barn close to people would promote research to the effects of livestock farming in populated areas. Huntington Avenue holds the existing infrastructure to support semi-truck traffic and visitor traffic to the dairy barn. Additionally, this site has room for expansion in the future if it is necessary.

Description

East Campus Site 1 is located on the Northern border of Campus with connections to 38th Street and Huntington Avenue. The current site is 6.37 acres and holds turf management fields and maintenance sheds. A gravel service road splits the site in half and connects to fields bordering the site to the east. Bordering the North end of the site, Residential Apartment buildings are located behind Huntington Avenue. To the South, the center of East Campus is behind the Greenhouses.

East Campus

Site 1 - Study 1

Overview

This building orientation is situated for visibility. The buildings near the road make it better for visibility and accessibility to the public, but also creates a stronger relationship between the apartment complex across the street. The site is laid out with parking and public engagement coming first off the street for easy access. The operational aspects of the site and private elements are set out of the reach of the public. The truck route is in a loop to provide easy mobility and is separate from the public to improve safety.

Opportunities

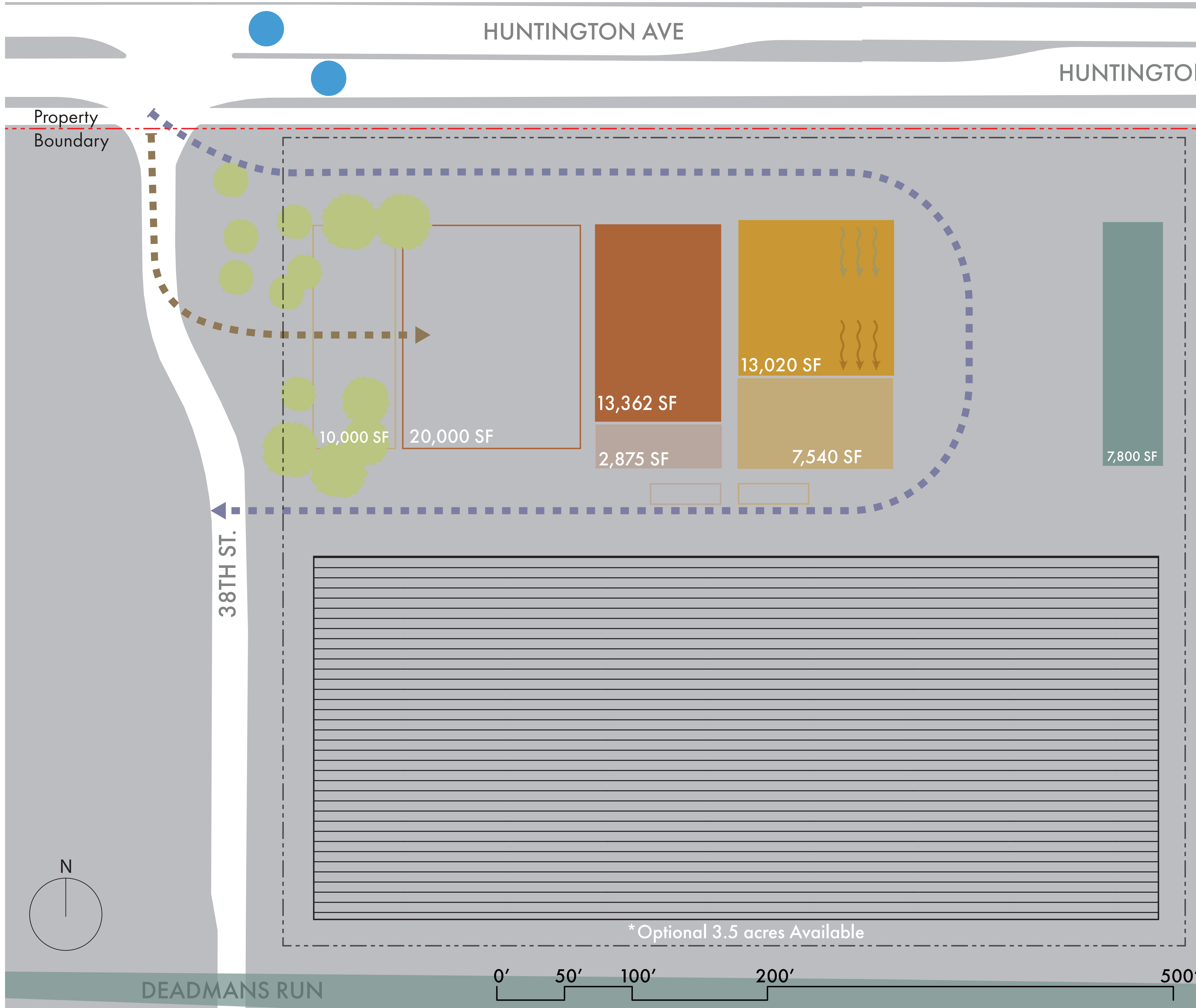
This building orientation has opportunities for easy visibility by situating the buildings near Huntington Ave. It is also easily accessible for this reason. There is plenty of room to the south and east for expansion. There is also a natural line created of where the public is and isn't allowed.

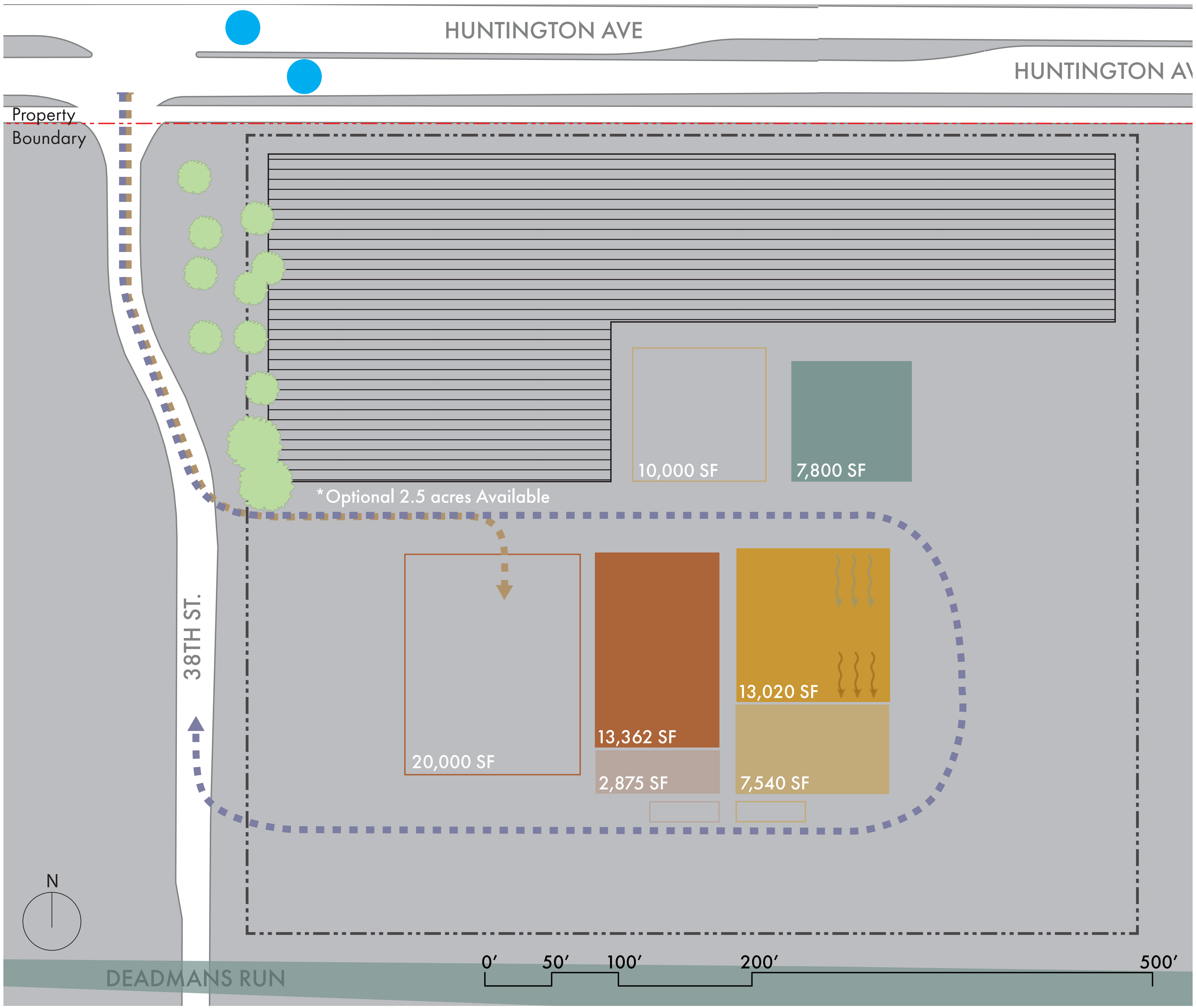
Constraints

This building orientation has constraints with its positioning near the main road that can cause excess noise. Situating the acres on the south side puts a buffer in between the site's buildings and campus which could cause a disconnect between the two.

Legend

Site	Public Route
External	Truck Route
Barn Operations	Bus Stop
General Operations	Barn
Public Engagement	





East Campus

Site 1 - Study 1

Overview

This building orientation is situated for the reduction of smell. Although the wind is blowing north to south carrying the smells created by the facilities away from the neighborhood, there is a possibility that the public would have a negative reaction. With this being said, the acres are placed north on the site and the buildings are placed on the south.

Opportunities

This building orientation has opportunities for reduced smell being placed on the south side of the site. It also has easy access for trucking with a truck loop which keeps large vehicles from having to turn around. There is also a lot of space on the edges of the site for growth and/or landscaping.

Constraints

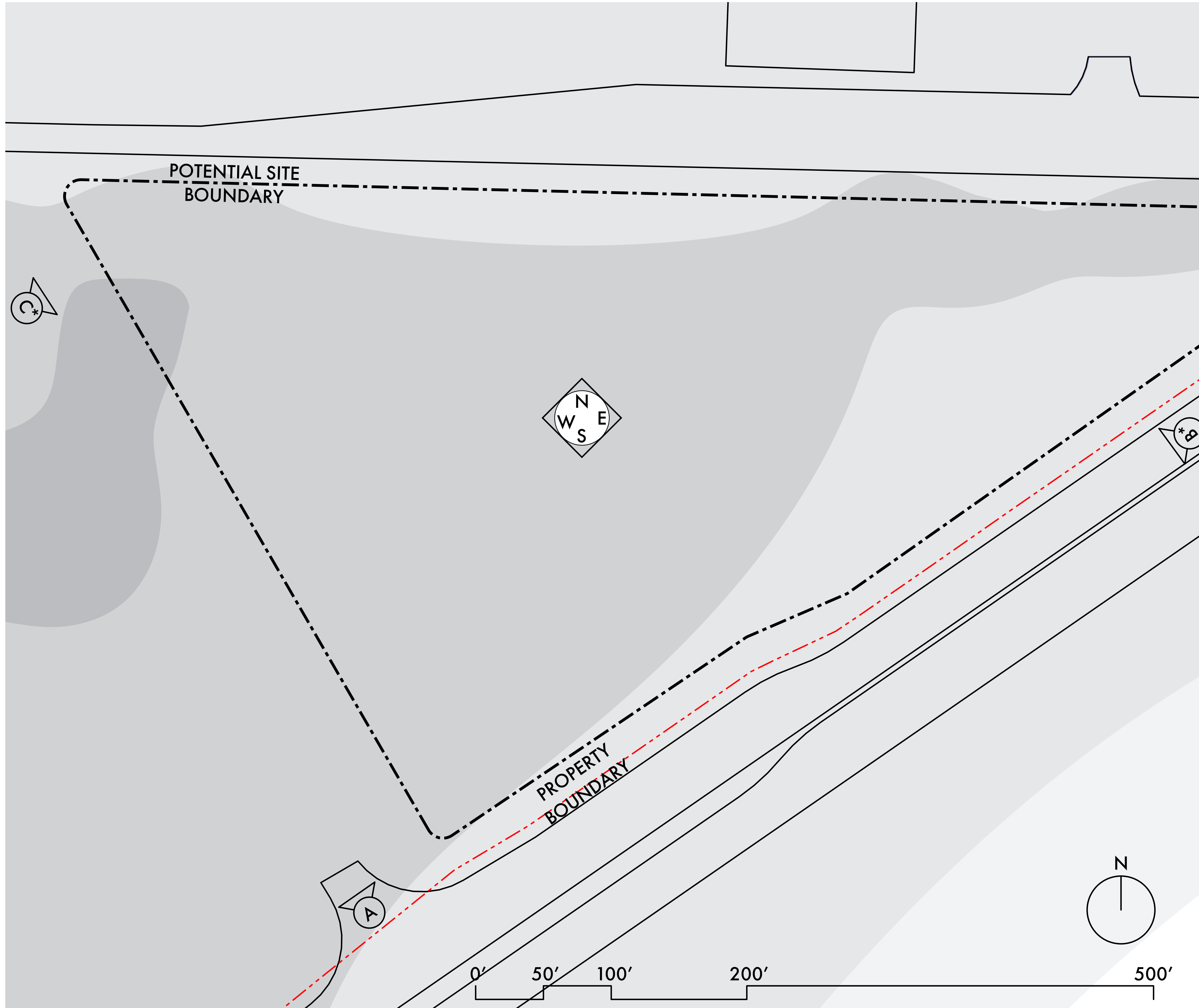
This building orientation has constraints with its positioning on the southern half of the site. This makes visibility an issue as it is farther from the main road. Having the public and trucking share the same entrance road could potentially cause issues and be more of a safety concern. The non-public facilities are easily accessible to the public which is not ideal.

Legend

Site	Public Route
External	Truck Route
Barn Operations	Bus Stop
General Operations	Barn
Public Engagement	

Innovation Campus

Site 1 - Views



Innovation Campus

Site 1 - Visibility

Reasoning

Site 1 is the ideal spot for visibility on Innovation Campus. Salt Creek Roadway and the Antelope Valley Parkway intersections are one of the busiest intersections in Lincoln. The road infrastructure is already in place to accommodate semi-truck traffic and is set up for future road expansions. Emissions concerns would not be relevant to residents or businesses in the area. Additionally, the master plan already designates the site to focus on agricultural development.

Description

Innovation Campus Site 1 has 8.37 acres and is the most visible site on East Campus. The topography is currently flat with a tree-filled ditch that separates the site from Transformation drive North. The Lincoln Digester plant is also located in the distance to the North. To the South, the site constantly hears traffic from Salt Creek Roadway and the Train yard at the ADM Grain Elevator. Designing this site would have to take into consideration the effects of noise from these two factors. To the West is the Scarlet Hotel, Rise Building, and Food Processing Center. These buildings would not be affected by the emission factors caused by the Dairy Barn.

Innovation Campus

Site 1 - Study 1

Overview

The primary organizational principle of this layout was to create the best access to the barn and related activities for trucks. This was achieved by encircling the barn and related activities with an access loop that is separated from the public engagement access.

Opportunities

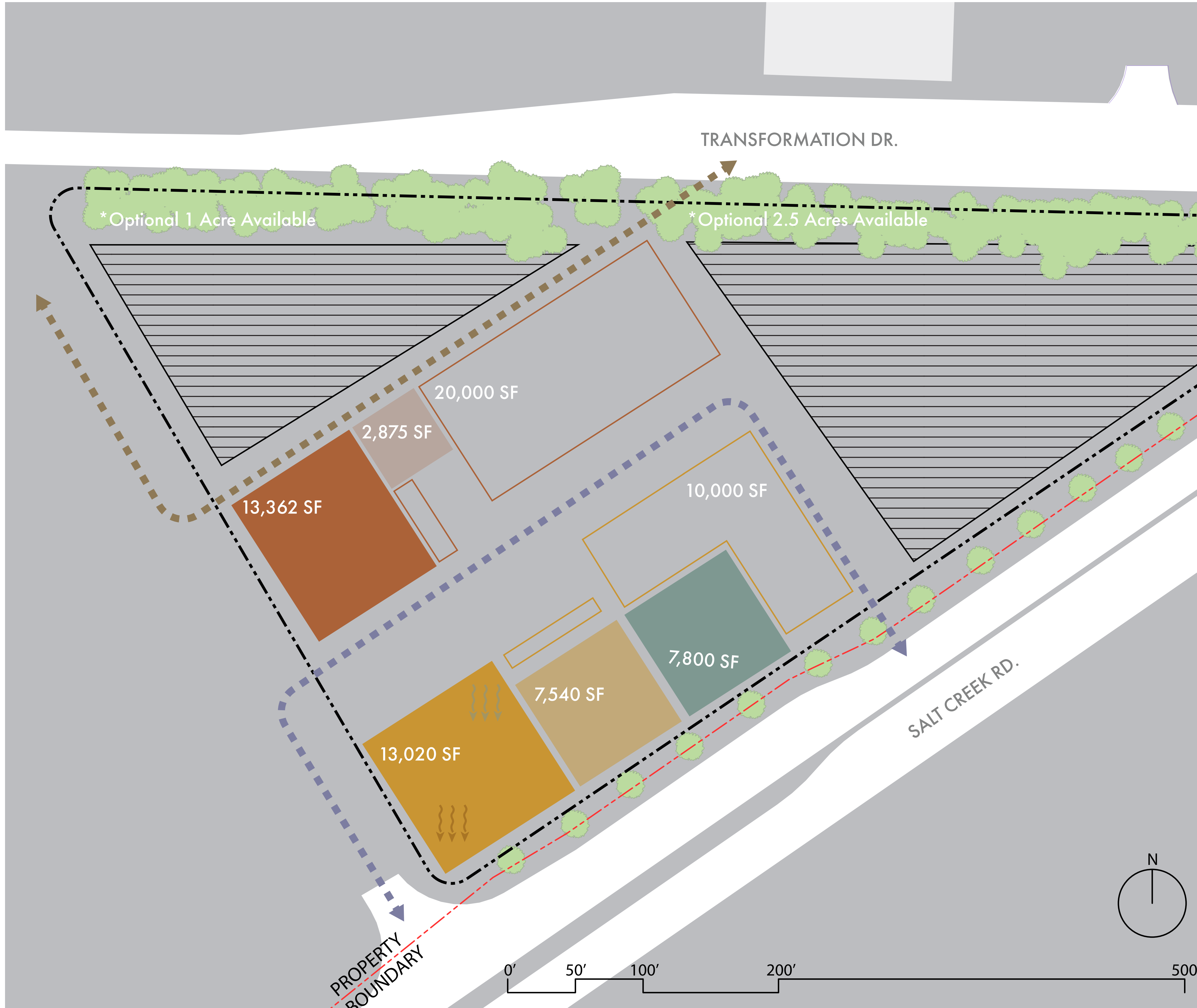
The barn is primarily located off of Salt Creek Roadway in this study. Salt Creek Road sees a lot of traffic during husker football, and volleyball games. This traffic is different from the traffic typically seen on campus because Husker sporting events attract more than just students and staff. By engaging with this traffic on Salt Creek Roadway one may be able to attract a broader range of people.

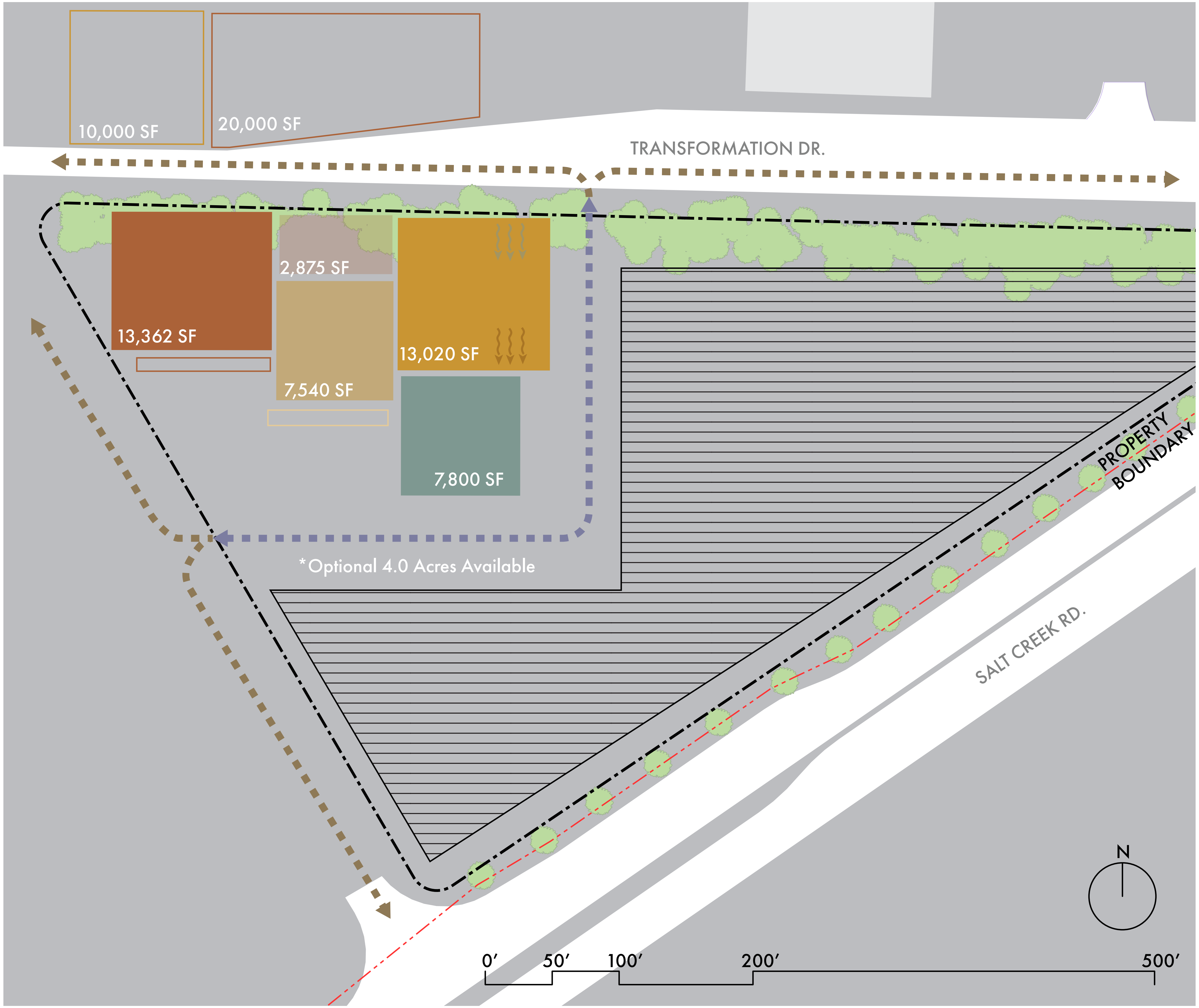
Constraints

The trucking corridor separates the public engagement from the barn. This separation may disengage the people from the cows because of the physical barrier between the spaces. The barn is primarily oriented to Salt Creek Roadway. This disengages the building from Innovation Campus. Because the busy street is relatively high speed, this may be too far from the heart of campus to attract people who are walking through campus.

Legend

Site	Public Route
External	Truck Route
Barn Operations	Bus Stop
General Operations	Barn
Public Engagement	





Innovation Campus

Site 1 - Study 2

Overview

The primary organizational principle of this layout is to engage with innovation campus through Transformation Dr. Transformation Dr. is the main street of innovation campus and as the campus is built out it will have a diverse range of activities and modes of transportation, all with the focus of innovation.

Opportunities

The buildings are oriented to face Transformation Drive. This study has the most area open for an optional grazing pasture or robotics demonstration field. With the inclusion of a demonstration field the researchers can demonstrate robotics innovation in harvesting feed for the cows. Or with a grazing pasture the dairy cows would have the ability to be out in the open which is not common in commercial dairy practices.

Constraints

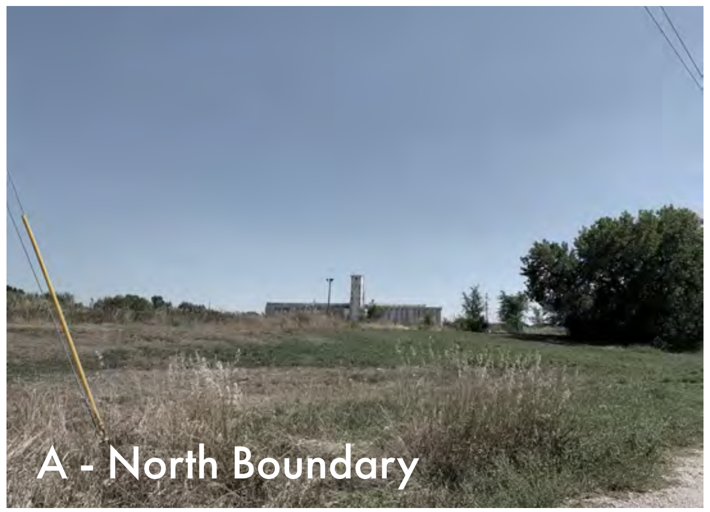
One of the biggest constraints of this location is that it is on the end of Transformation Drive. While Innovation Campus is a great place to put a building that is pushing the boundaries of technology, the campus has not been fully built out. If this building is built before the rest of the campus you risk the first few years of low engagement.

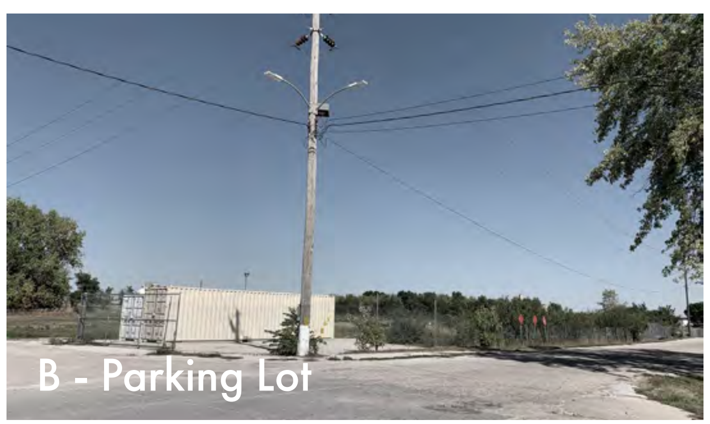
Legend

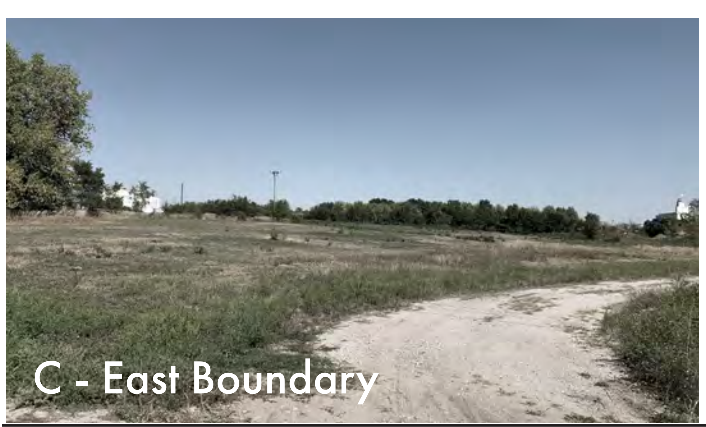
Site	Public Route
External	Truck Route
Barn Operations	Bus Stop
General Operations	Barn
Public Engagement	

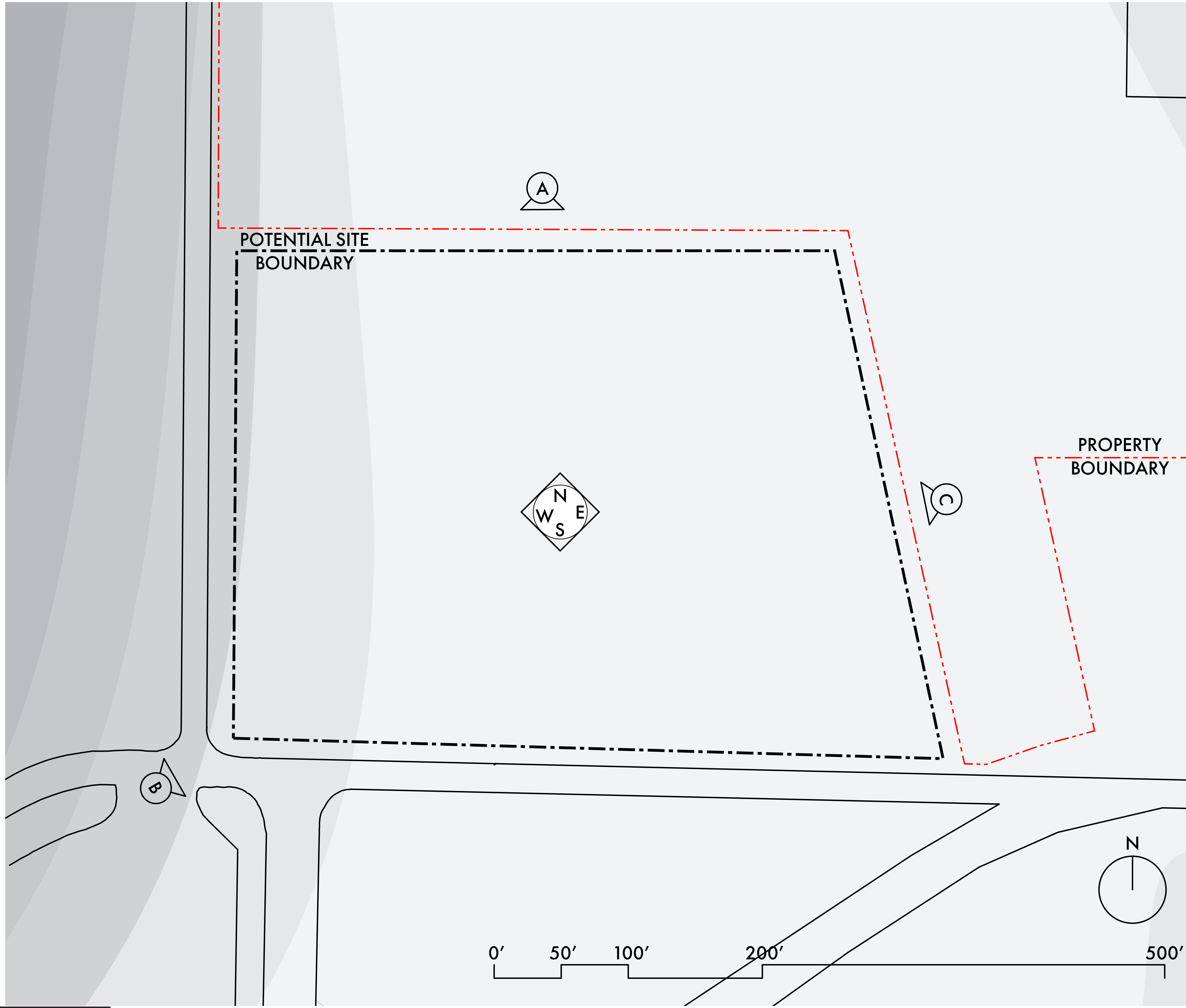
Innovation Campus

Site 2 - Views


A - North Boundary


B - Parking Lot


C - East Boundary



Innovation Campus

Site 2 - Visibility

Reasoning

Site 2 is tucked away in the quieter Northeastern corner of Innovation Campus. This site is notable for its adjacency to the Lincoln Digester plant and would cause minimal interference to the existing buildings in the area. Additionally, the road infrastructure exists to support semi trucks getting to the site. Parking for this site already exists across the street and would not require much additional parking in the site itself.

Description

Innovation Campus Site 2 has 6.39 acres and borders the Lincoln Wastewater facilities. The current topography slopes up to the North and could offer a more challenging terrain to design for. The land on Innovation Campus is in a flood plain and would need to be built up to accommodate those challenges. To the South, the site is distant from the train yard, Scarlet Hotel, and the Rise Building. A light maintenance road exists running the length of the site. Innovation Campus is easily visible to a heavy traffic intersection on Antelope Valley Parkway and Salt Creek Roadway. Given the constricting boundaries to the site, it would not offer much additional land for growth.

Innovation Campus

Site 2 - Study 1

Overview

This orientation study is emphasizing the value of visibility by having the main public and barn programs closest to the road. This allows easy access to the public through an existing parking lot on Innovation Campus. The operational aspects of this site are placed linearly next to the public program and are visible from the main access street. The truck routes are in multiple loops making it easy to get to the separate loading docks for the specific trucks while also keeping this separate from the public parking.

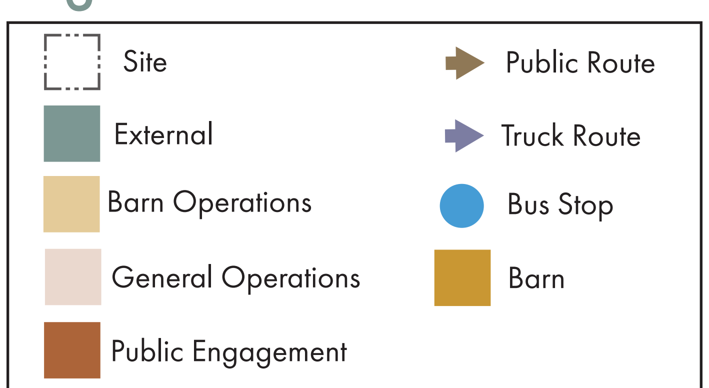
Opportunities

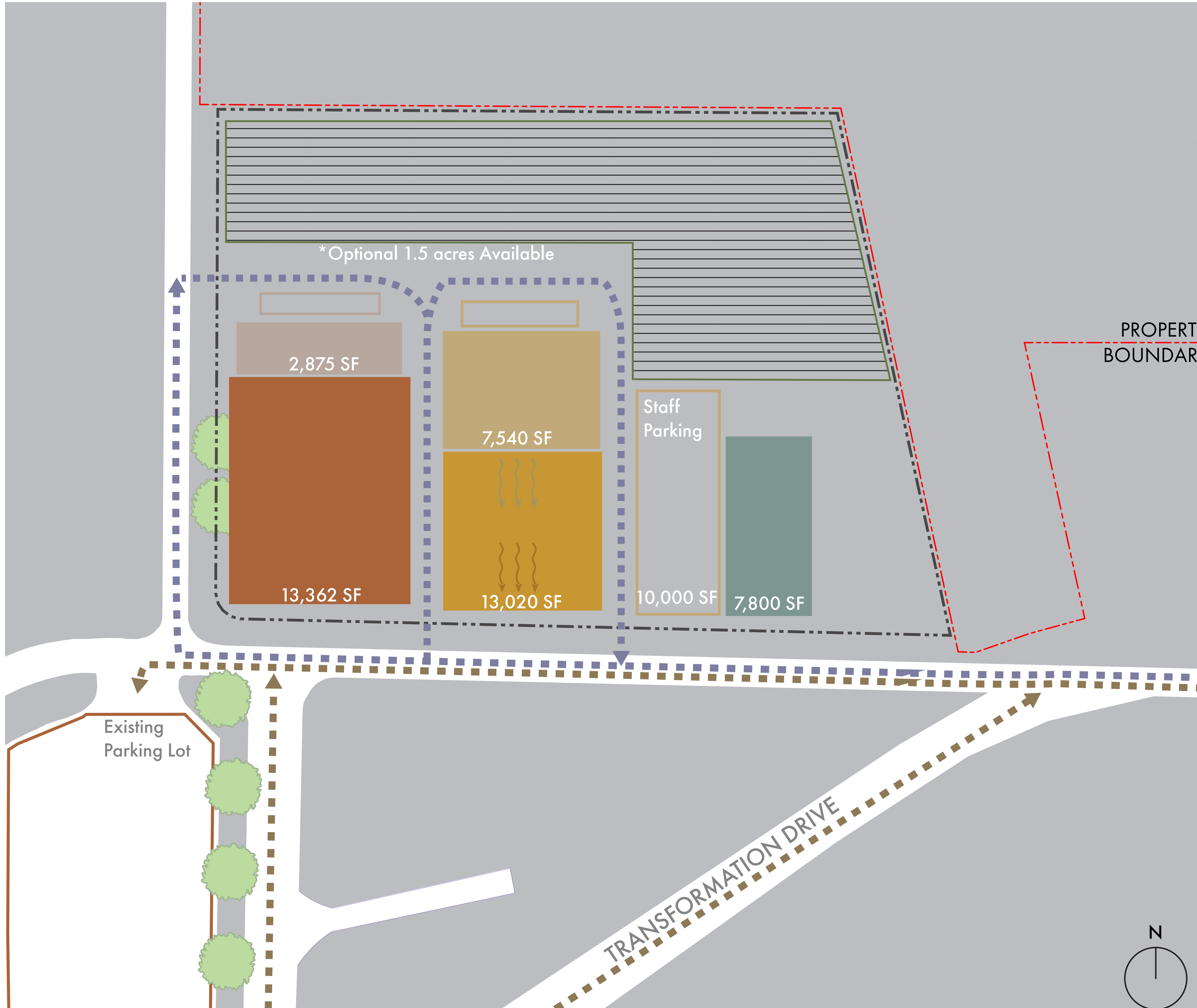
This specific building orientation allows for maximum visibility by having all programs as far South as possible, while also increasing accessibility. The City of Lincoln's Methane Digesters are North of the site, making it the closest site that can remove waste quickly. There is an additional 1.5 acres available for any additional programs the design teams would like to incorporate.

Constraints

This is the smallest site and proves some limitations on how the programs can be placed within the site boundaries, with only a few options being viable. The site is set off from the main road making it less obvious of a site and one the user would have to find through signs, and less direct routes for semi truck drivers.

Legend





Innovation Campus

Site 2 - Study 2

Overview

This orientation allows for more breathing room between buildings and allows the ventilation from the barn to bypass the public spaces. The public space will be the first sight the user will notice approaching from the parking lot. The demonstration field or potential grazing area is off to the north and east of the programs and allows for the most space allocated to these programs that this site can have.

Opportunities

This potential site is near the methane digesters and has existing parking lots for the public. Since the location is further back on Innovation Campus, it allows buffer room from the general traffic and train tracks to help keep the cows in a content state. Although it is not placed near busy roads, it is still visible on a major street, Salt Creek Roadway and the 27th Street overpass.

Constraints

Due to being the smallest of the three sites, there are limitations on building orientation while still wanting to include a demonstration field or grazing areas. Since it is not a main road, it would force the public to find their way into the site through signage. Another factor is that there would be less direct routes for semi truck drivers.

Legend

Site	Public Route
External	Truck Route
Barn Operations	Bus Stop
General Operations	Barn
Public Engagement	

BUILDING PROGRAM

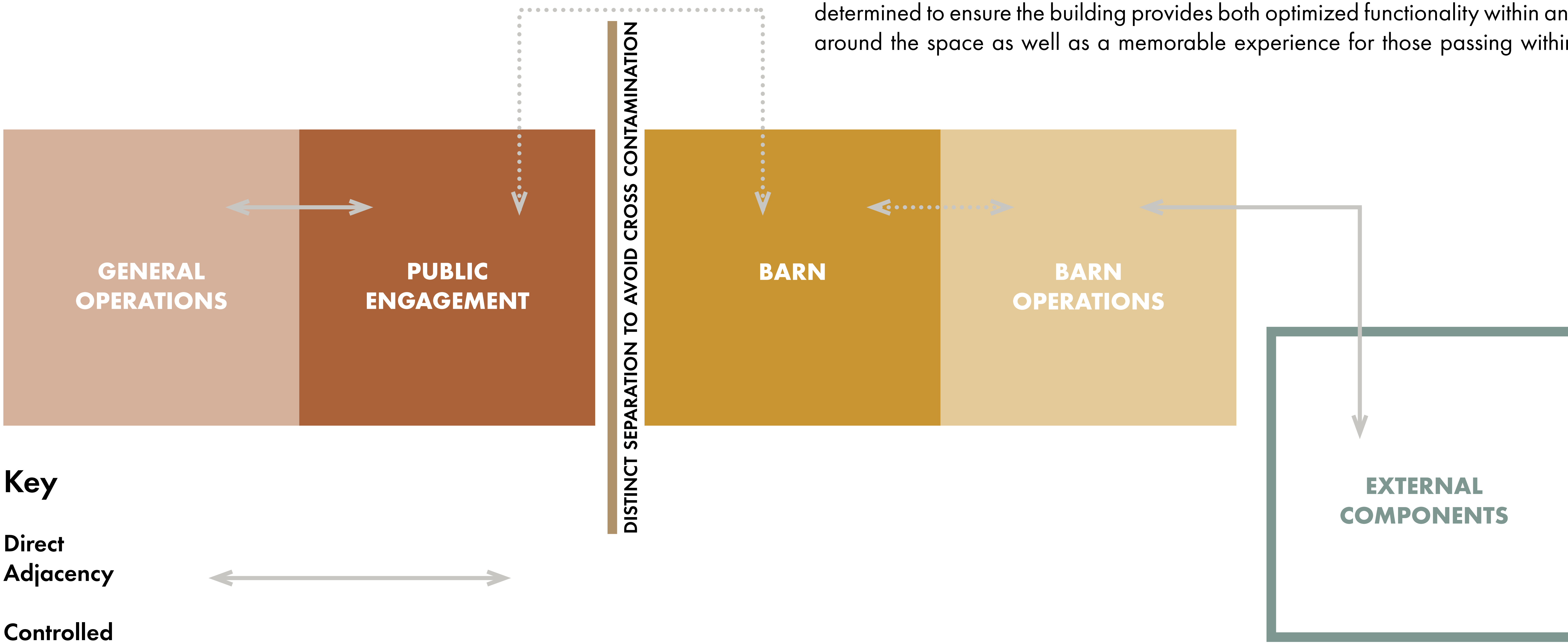
Building Program Micropaper

Lely Farm of the Future

With the average age of farmers steadily increasing along with the high purchase price of starting a dairy farm, Lely has introduced the Farm of the Future. Their vision is to fully automate the entire dairy process, so that the farmer can focus on what matters to them, which could be their family, or wanting to spend less time working and more time focusing on their personal life. Whatever the case may be, and due to the demand for dairy products increasing, this is a necessary step to keep production up. This is a farm centered around the cow, automating repetitive tasks, keeping the cows content and comfortable, all while limiting waste, reducing emissions, and creating a local farm-to-table dairy product. Automation is the answer to labor shortages and menial tasks. The Farm of the Future has milking robots, feeding robots, feed mixing robots, and manure cleaning robots. The robots are fully electric and work 24/7 to aid the cows without any need for human intervention. This process, paired with an on-site dairy processor, can bring a local element to the sustainability-conscious consumer. In addition to this, a processor can instantly separate and process fresh milk right from the cow. This keeps the dairy production on site, rather than having to ship it to an off-site location. With Lely technology, milk can be traced back to the cow who produced it, and consumers will be able to see where their milk comes from, bringing the farmer, consumer, and cow closer to each other. With Lely, we have the ability to turn The Beef State into The Dairy State!

Main Program Adjacencies

Through the utilization of various research methods, including area take-offs, spatial blocking, and extensive conversations with professionals and stakeholders, information was gathered to assist in preliminary programmatic analysis at various scales. Configurations, primary adjacencies, and optimized viewpoints were determined to ensure the building provides both optimized functionality within and around the space as well as a memorable experience for those passing within.



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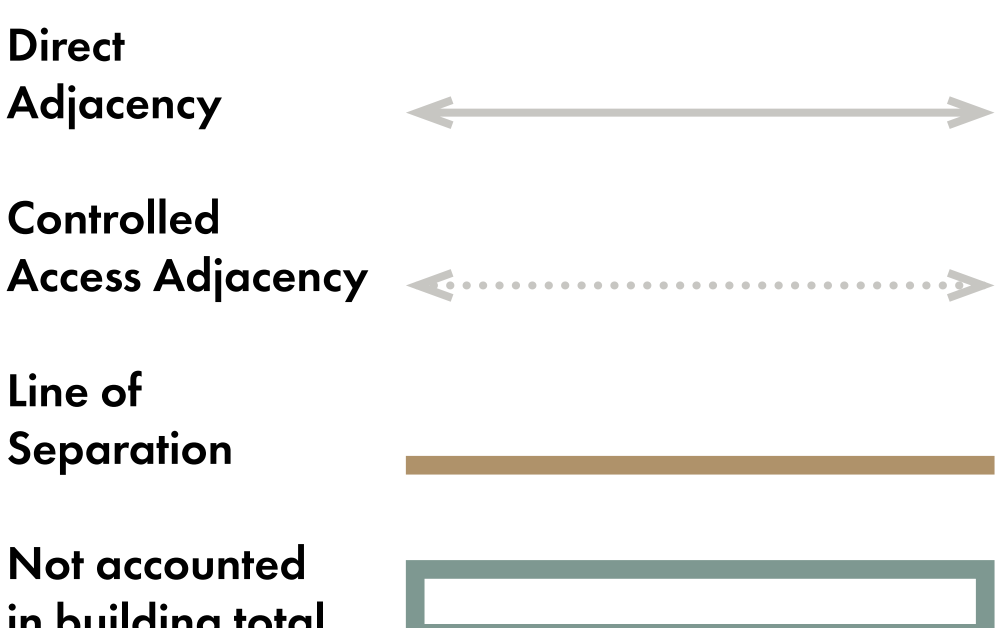


Specified Program Elements

GENERAL OPERATIONS

- OFFICES
- MEETING ROOMS
- I.T.
- FOOD PROCESS-ING
- LOADING DOCK

25% CIRCULATION

2,875 TOTAL SQ FT GENERAL OPERATIONS

PUBLIC ENGAGEMENT

- DIGITAL EXHIBITION
- PHYSICAL/ INTERACTIVE EXHIBTION
- RESTROOM
- OPEN LEARNING/ SEMINAR
- MAIN ENTRANCE
- CAFE
- CLASSROOM
- KITCHEN CLASSROOM

25% CIRCULATION

13.362 TOTAL SQ FT PUBLIC ENGAGEMENT

DISTINCT SEPARATION TO AVOID CROSS CONTAMINATION

BARN

- 2 MILKING ROBOT ROOMS
- 70 COW STALLS
- 8 SICK PENS
- 5 CALF HOLDING PENS
- 2 MATERITY PENS
- 15 DRY COW STALLS
- VECTOR KITCHEN

6,400 SQ FT OF FREE STALL AREA

13,020 TOTAL SQ FT BARN

BARN OPERATIONS

- RESTROOM
- CHANGE ROOM
- MILK PROCESSING
- FEED STORAGE
- LOADING DOCK

30% CIRCULATION

7,540 TOTAL SQ FT BARN OPERATIONS

EXTERNAL COMPONENTS

- HAY STORAGE
- ASPHALT PAD
- MACHINE SHOP & STORAGE
- GREEN-HOUSE
- GRAZING AREA

30% EQUIPMENT CIRCULATION

83,260 TOTAL OUTSIDE SQ FT

36,797 TOTAL BUILDING SQ FT

Specified Program List

GENERAL OPERATIONS

Equipment to transform on-site milk into products for consumers	**1,000 sq ft**	**Food Processing**
(2 small meeting rooms) Communal spaces for small gatherings and meetings	**500 sq ft**	**Meeting Rooms**
(5 small offices) Rooms with work areas necessary for business operations	**500 sq ft**	**Offices**
Room housing wifi routers, servers, and necessary electrical equipment	**300 sq ft**	**I.T.**
Path of travel within private spaces	**575 sq ft**	**25% Circulation**
	2,875 Total sq ft	
	950 Outside sq ft	**Loading Dock**

PUBLIC ENGAGEMENT

(Occupancy 50 people) Interim space connecting exhibit thresholds including reception and lockers	**500 sq ft**	**Main Entrance**
(Occupancy 142 people) Space showcasing models and displays through innovative technology	**1,000 sq ft**	**Digital Exhibition**
(Occupancy 285 people) Exhibition that displays physical models and static presentations	**2,000 sq ft**	**Physical/Interactive Exhibition**
(Occupancy 40 people) Flexible learning space when learning outcomes are devised	**2,500 sq ft**	**Open Learning/Seminar**
(Occupancy 43 people) Cafe and commercial kitchen utilizing on-site dairy	**1,700 sq ft**	**Dairy Bar**
(Occupancy 15 people) Open learning space emphasizing dairy and culinary education	**1,890 sq ft**	**Kitchen Classroom**
(Occupancy 18 people) Traditional small setting learning environment	**600 sq ft**	**Classroom**
Restrooms for use by the general public	**500 sq ft**	**Restroom**
Path of travel connecting all public spaces	**2,672 sq ft**	**25% Circulation**
	13,362 Total sq ft	
145 public parking stalls, bus stop, ADA accessible stalls	**20,000 sq ft**	**Public Parking**

BARN

Lactating Cows - 80 Cow Stalls	2,560 sq ft	(8'x4' stalls = 32 sq ft ea) Place of rest for cows when not eating/milking
Non-Lactating Cows -		
15 Dry Stalls	480 sq ft	(8'x4' stalls = 32 sq ea) Home for pregnant cows the last 60-90 days before giving birth
6 Sick Pens	300 sq ft	(50 sq ft pens) Sick cows rejected from milking are sorted into these pens
5 Calf Pens + 1 Communal Pen	580 sq ft	(36 sq ft calf pens + 400 sq ft communal pen) Place to separate and hold newly born calves
2 Maternity Pens	1,400 sq ft	(700 sq ft ea) Place for cows to give birth in
2 Milking Robot Rooms	300 sq ft	Rooms that house the Lely Astronaut milking robots
Vector Kitchen	1,000 sq ft	Feed is stored, selected, picked up, and loaded into the Lely Vector robot
Free Stall Area Around All Elements	6,400 sq ft	Space for cows to walk through stalls and around the barn
	13,020 Total sq ft	

BARN OPERATIONS

Feed Storage	3,200 sq ft	Storage area housing future supply of feed ingredients
Milk Processing	2,000 sq ft	Processing equipment needed to process/sterilize milk from the robots
Change Area	100 sq ft	Threshold for staff to change into PPE when entering or leaving the barn
Restroom	500 sq ft	Private restroom for staff working in the barn
30% Circulation	1,740 sq ft	Path of travel for staff in and around the barn
	7,540 Total sq ft	

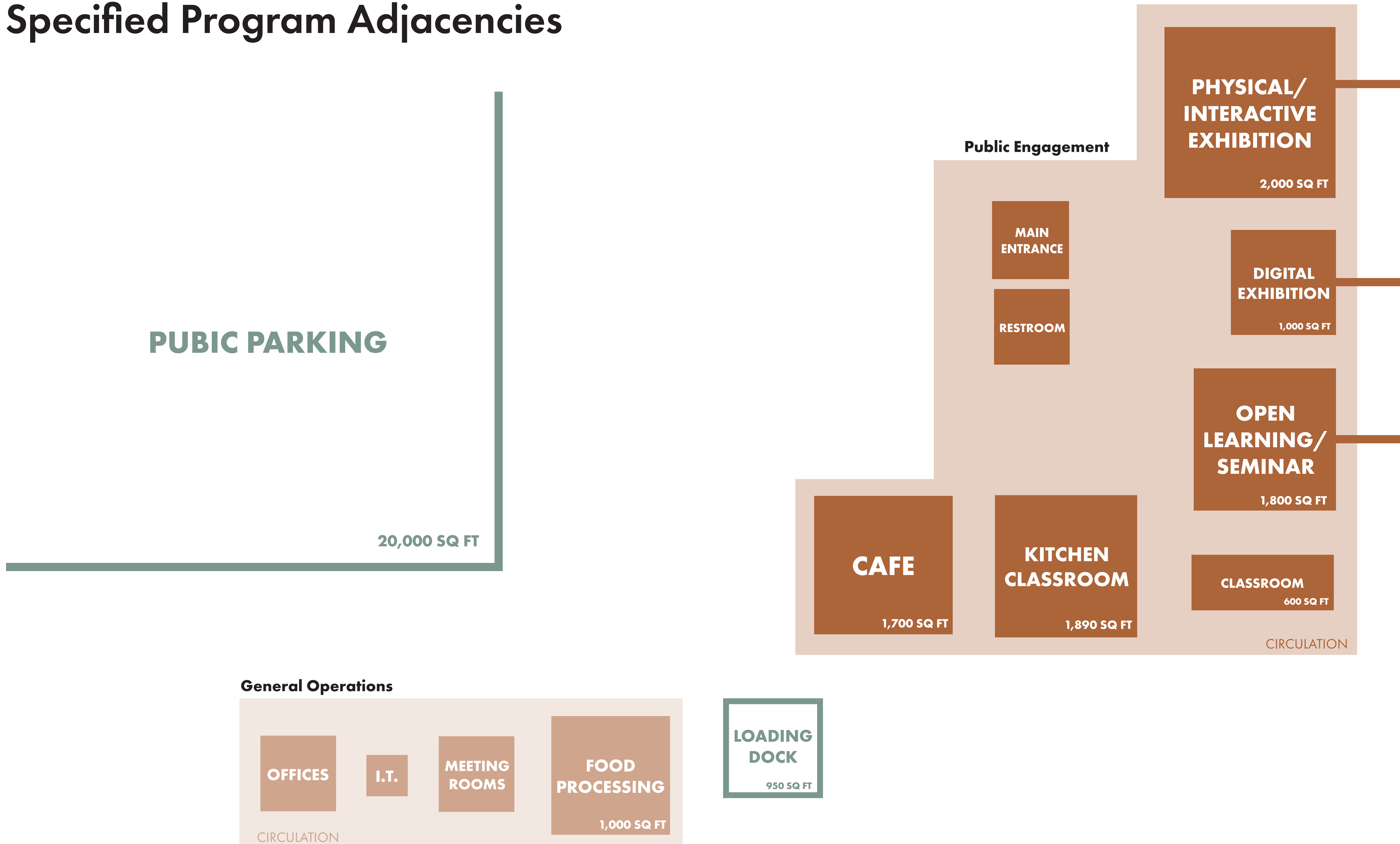
Loading Dock	950 Outside sq ft
Staff Parking	10,000 Outside sq ft

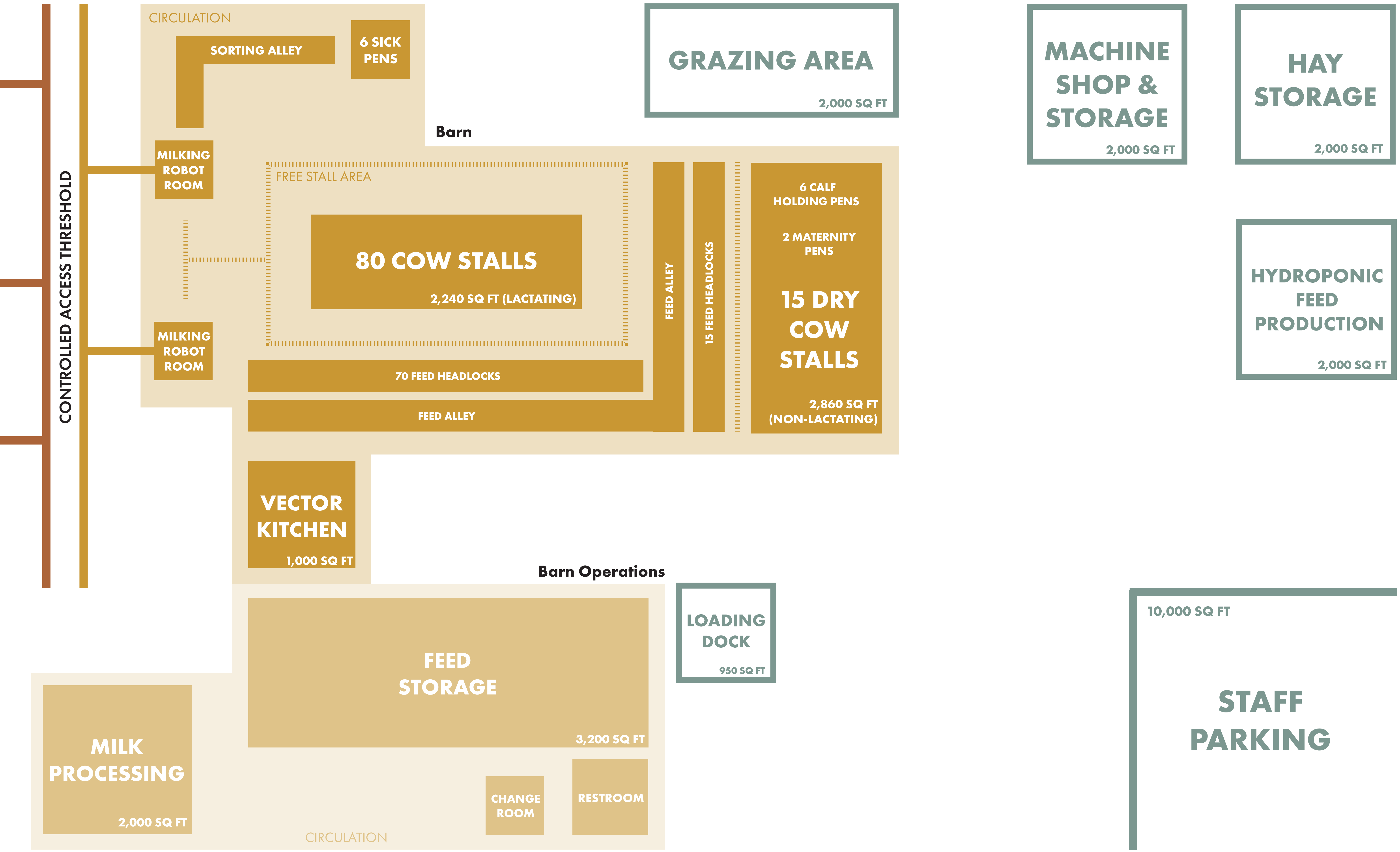
EXTERNAL COMPONENTS

Grazing	43,560 Outside sq ft	Open field necessary for external cow movement
Hydroponic Feed Production	2,000 Outside sq ft	Hydroponic indoor garden utilized for growing feed ingredients
Machine Storage/Shop	2,000 Outside sq ft	Storage for equipment and tools needed for daily operations
Hay Storage	2,000 Outside sq ft	Open-air storage with a roof to store future hay supply
30 % Equipment Circulation	1,800 Outside sq ft	Path of travel necessary for equipment movement

36,797 Total Building sq ft	**83,260 Total Outside sq ft**

Specified Program Adjacencies

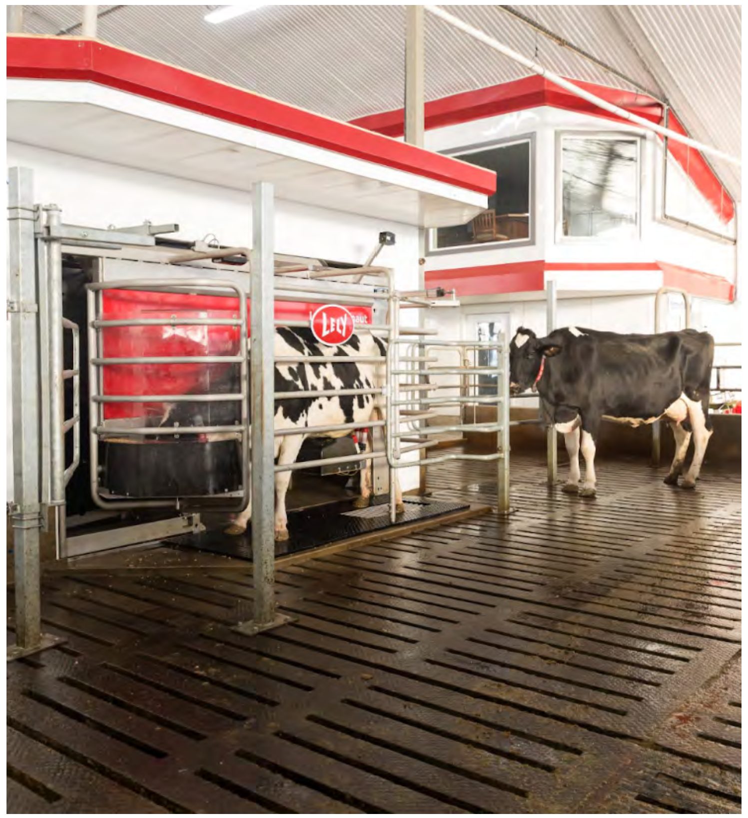




CONTROLLED ACCESS THRESHOLD
CIRCULATION
SORTING ALLEY
6 SICK PENS
Barn
MILKING ROBOT ROOM
FREE STALL AREA
80 COW STALLS
2,240 SQ FT (LACTATING)
MILKING ROBOT ROOM
70 FEED HEADLOCKS
FEED ALLEY
FEED ALLEY
15 FEED HEADLOCKS
6 CALF HOLDING PENS
2 MATERNITY PENS
15 DRY COW STALLS
2,860 SQ FT (NON-LACTATING)
GRAZING AREA
2,000 SQ FT
MACHINE SHOP & STORAGE
2,000 SQ FT
HAY STORAGE
2,000 SQ FT
HYDROPONIC FEED PRODUCTION
2,000 SQ FT
VECTOR KITCHEN
1,000 SQ FT
Barn Operations
LOADING DOCK
950 SQ FT
FEED STORAGE
3,200 SQ FT
MILK PROCESSING
2,000 SQ FT
CHANGE ROOM
RESTROOM
CIRCULATION
10,000 SQ FT
STAFF PARKING

AREA DETAILS
EQUIPMENT & QUALITIES

PUBLIC UNDERSTANDING



COLLABORATION

When it comes to the subject of dairy farming in the United States, one prominent issue that currently faces the industry is public understanding. During a time of great advancement in autonomous systems and robotics, the very way that a dairy farm operates is rapidly changing, and with it the perception that the public holds. For example, many people believe that it is unnecessary to remove a calf from its mother shortly after birth. In reality, due to certain advancements, calf mortality is much higher once removed from the mother; this removal eliminates any possible issues that the calf could suffer such as infection, physical injury or a weakened immune system due to nutrient deficiencies.

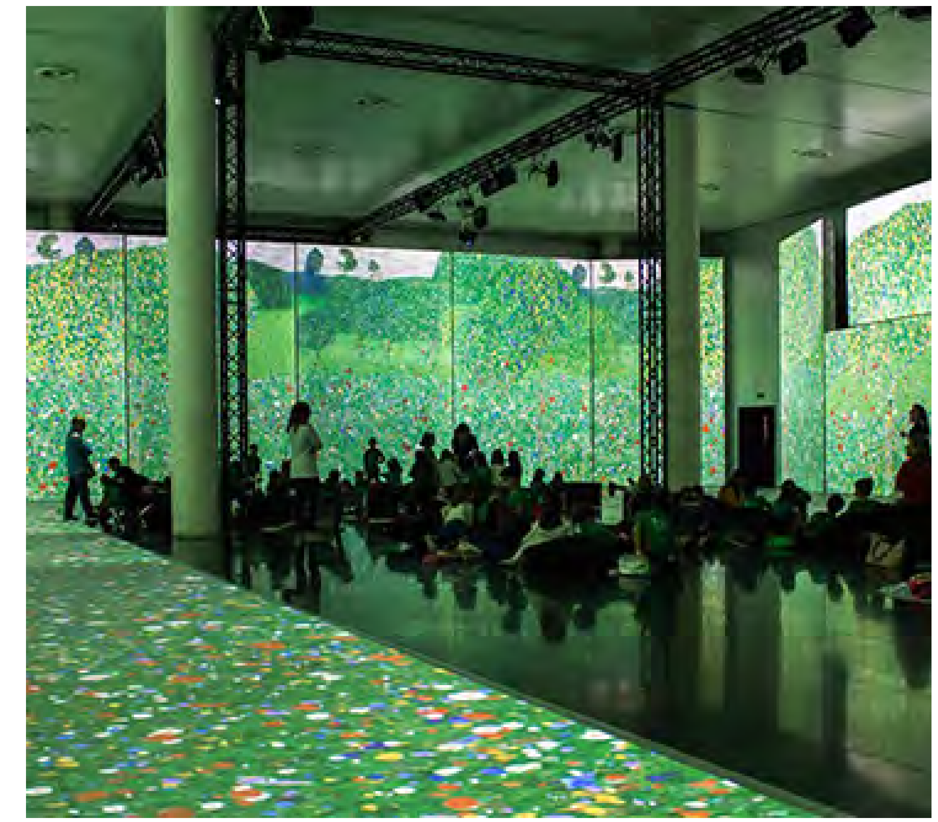
EDUCATION

Another belief is that the milking process is not mutually beneficial for the cows. As a cow produces milk throughout the day, if left unmilked the overabundance of milk produced can become uncomfortable or even painful for the cow. The milking process then alleviates this pressure and buildup producing a happier and healthier state of wellbeing for the cow. Since the implementation of robotic milkers, the process has become even more beneficial. In addition to the cow choosing when to be milked by the machine, the base design of the automatic milker is meant to function similarly to that of a farmer milking by hand, but with the added benefit of a softer material used for suction and extraction.

RESEARCH

One final aspect that is essential for public understanding in this project lies in the actual housing of the cows and whether they prefer the internal barns or external pastures. If provided access to a pasture, cows show reduced lameness despite the layout of the barn. With open access to a pasture as well as a freestall layout, cows have a low yield for developing lameness, potentially at the cost of overall milk production, with more activity leading to a less energy dependent diet and therefore less milk produced. One potential workaround is having temporary pasture access, which can allow for lame cows to recover without sacrificing overall milk yield. Cows also prefer to remain indoors on warmer days (+68ºF), and their preference between pasture and barn depends on time of day and current climate. By giving the cows partial access to this pasture, their quality of life increases drastically. Modern technology has also allowed a more constant and accurate cooling of the interior barn, creating a climate and living condition that is more suitable for the cow.

EXHIBITION DESIRED QUALITIES



CONNECTION

VISUAL INTEREST

ATMOSPHERE

In a learning exhibit, utilizing diverse and explorative means of technology can inhibit a positive environment for knowledge and growth. Digital and physical technologies come together as one to create two distinct spaces with different outcomes. A digital exhibit showcases the culmination of dairy related imagery and processes in the form of projections and digital displays. The physical exhibit offers an interactive and hands on approach to miscellaneous farm activities as well as insight on relevant dairy processes.

- Static, Physical, and Digital Displays
- Neutral and inviting color palette
- Pleasant atmosphere and positive ambience
- Open plan with various types of seating

1. https://www.cmdesign.com.au/2020/10/06/exhibition-floor-plan-design/
2. https://www.dimensions.com/collection/benches

LOBBY / RECEPTION
PROPOSED AREA

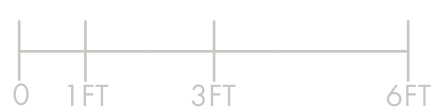
OCCUPANCY: 50
SF PER PERSON: 10 SF
OVERALL SF: 500 SQFT

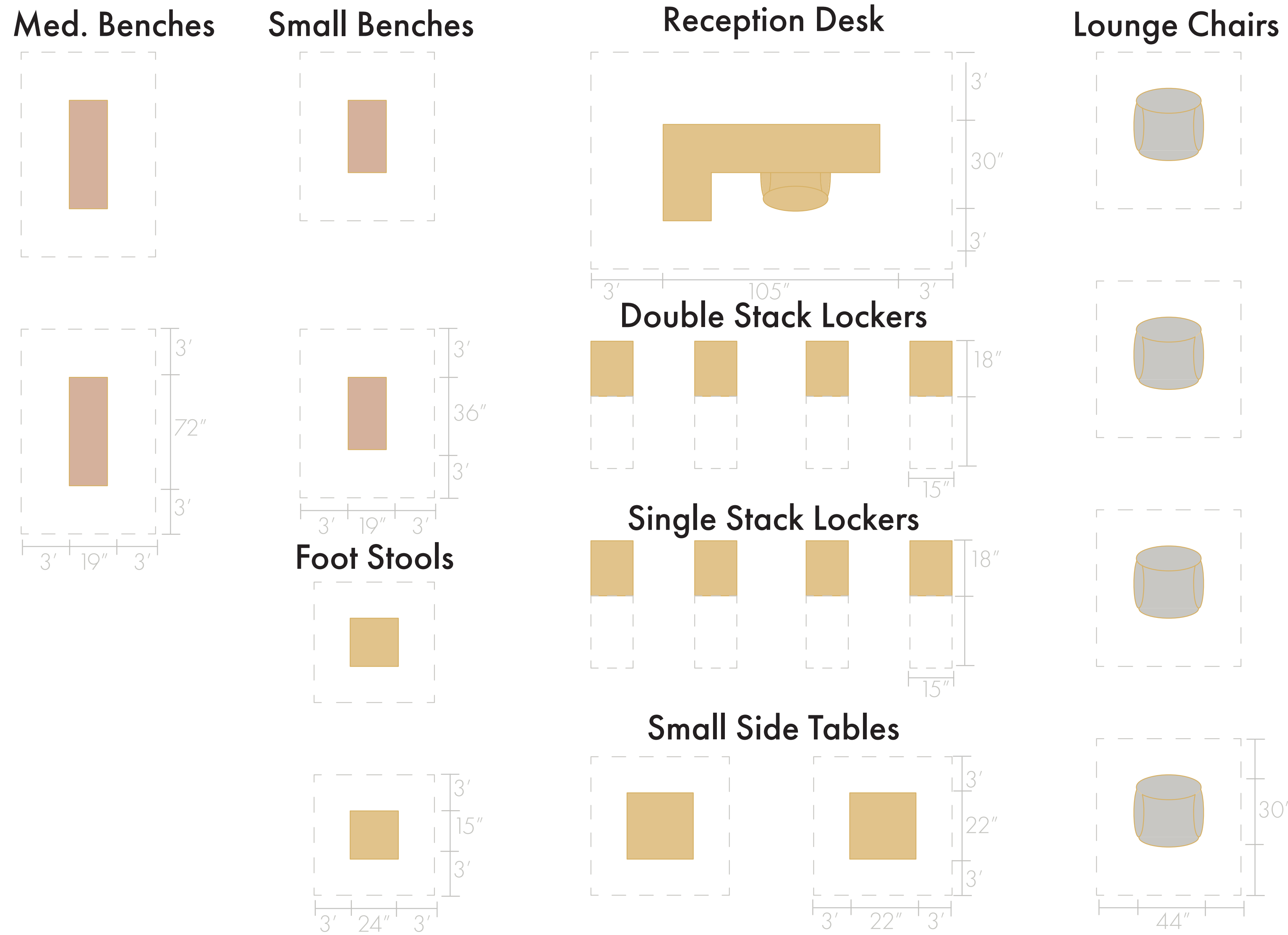
RECEPTION DESK (1): 22 SF
+ CHAIR (1)

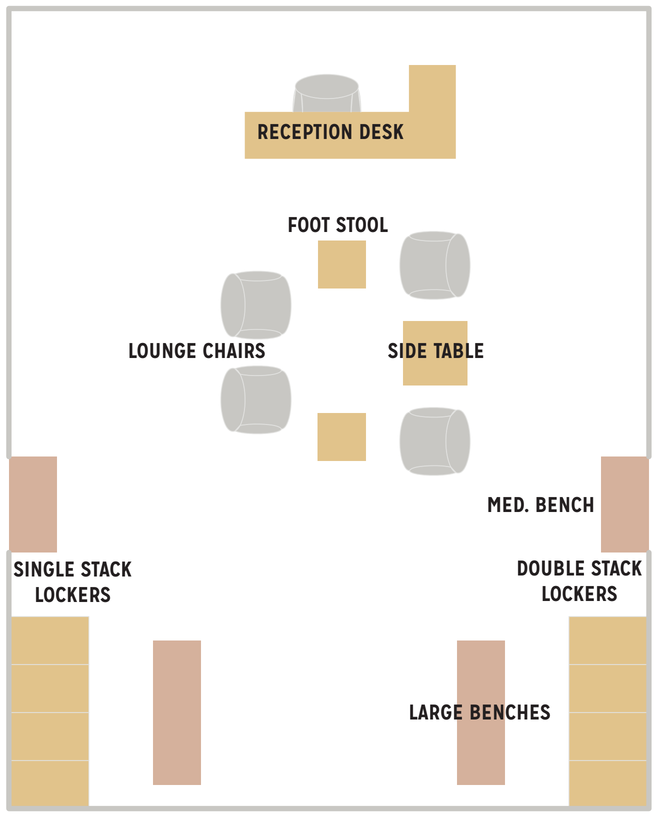
BENCHES (4): 27 SF
+ MEDIUM BENCH (2)
+ SMALL BENCH (2)

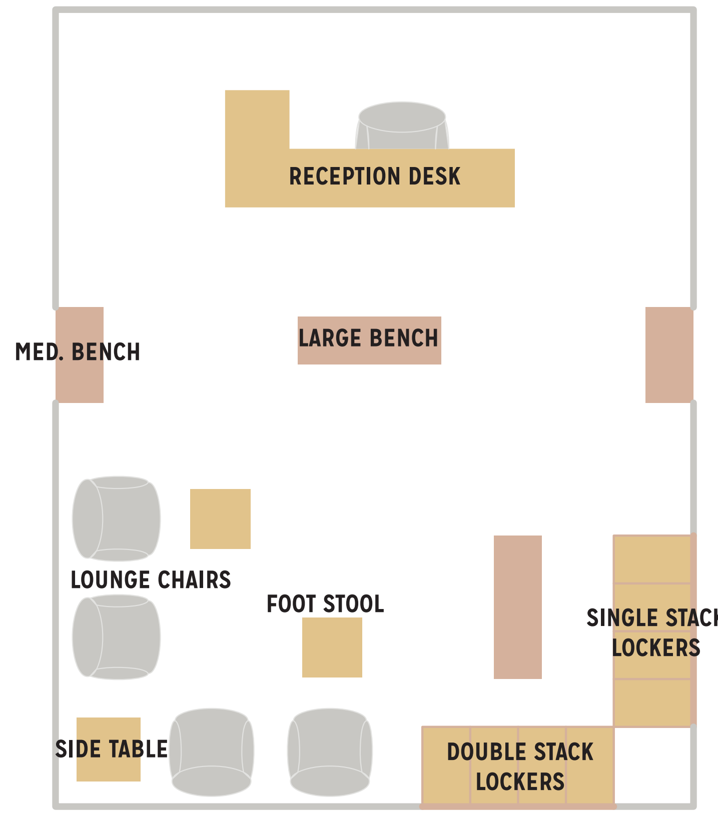
LOUNGE FURNITURE (4): 32 SF
LOUNGE CHAIRS (4)
FOOT STOOL (2)
SMALL SIDE TABLE (1)

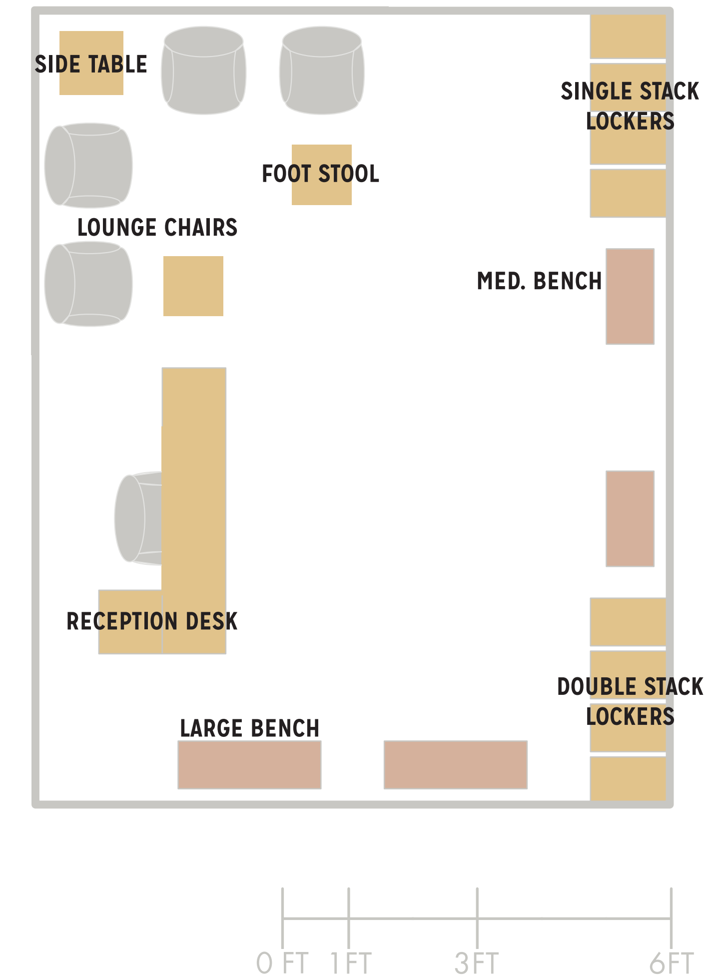
LOCKERS (8): 32 SF
+DOUBLE STACK (4)
+SINGLE STACK (4)











CENTRAL LOUNGE

- 500 sf
- Central lounge space
- Lockers flank both walls
- Ample space for incoming visitors
- Focus on reception desk upon entrance

OFFSET LOUNGE

- 500 sf
- Entrance along side
- Separation between reception and visitors
- Lockers located in cluster allowing for overflow
- More private lounge space
- More spaced out benches

NORTH LOUNGE

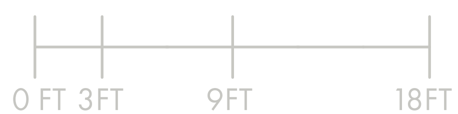
- 500 sf
- Entrance flanked by benches and lockers
- Lounge located in line with reception desk
- Ample seating along walls
- Spacious central space for incoming visitors
- Lockers spaced out to allow better access

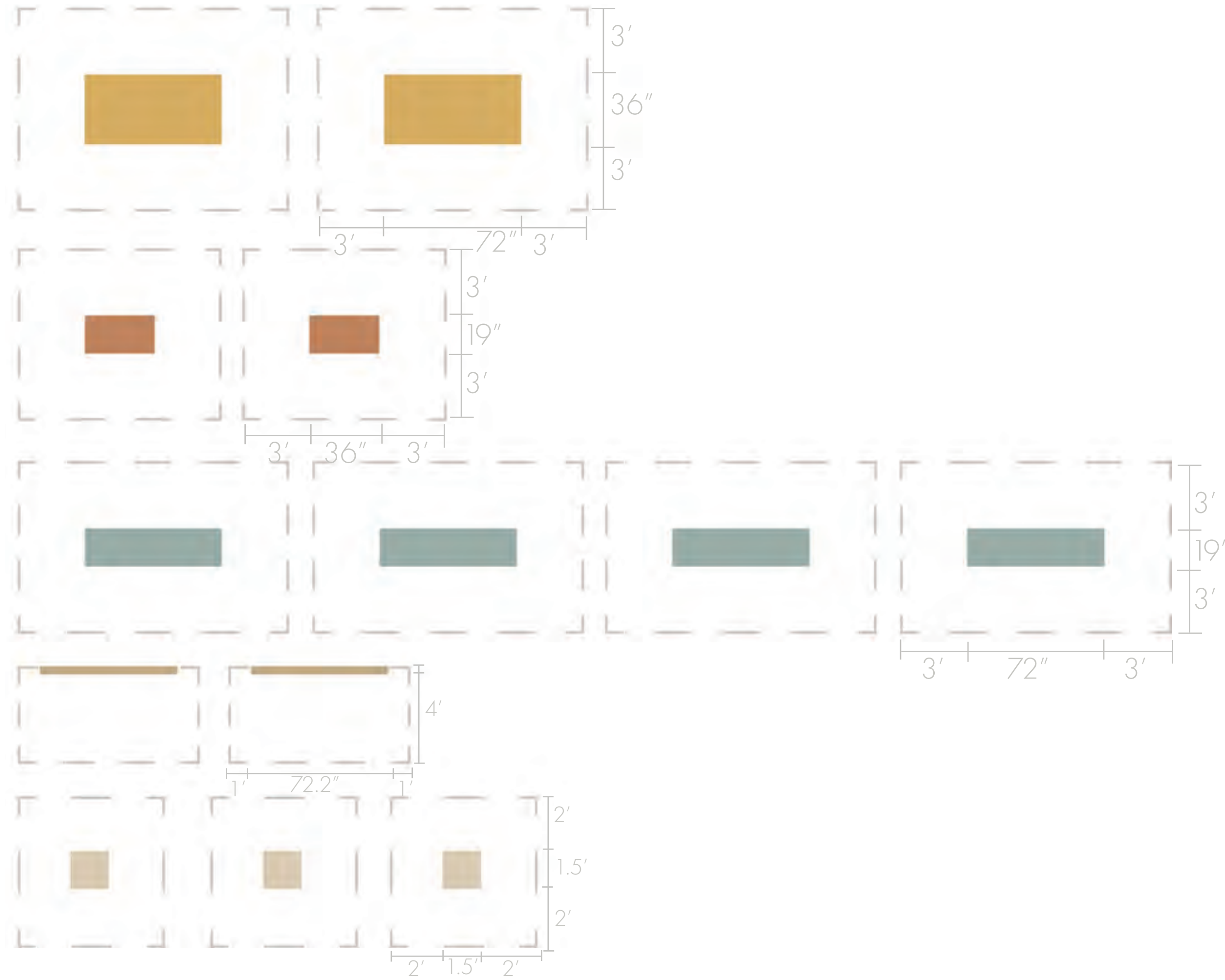
1. https://www.cmdesign.com.au/2020/10/06/exhibition-floor-plan-design/
2. https://www.dimensions.com/collection/benches

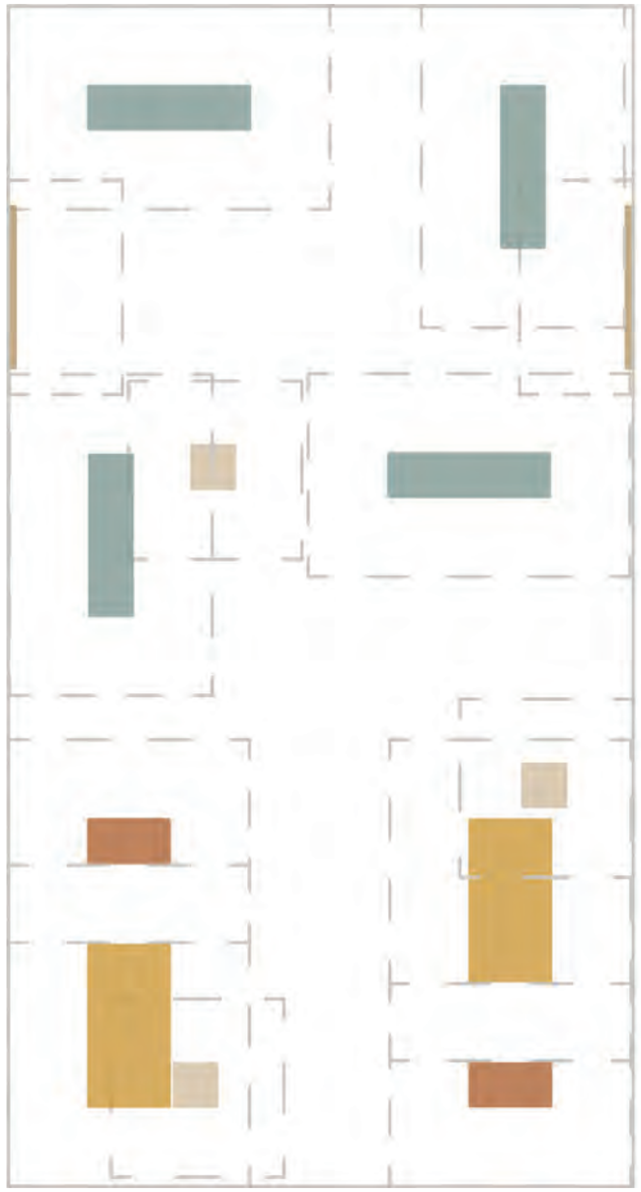
DIGITAL EXHIBITION
PROPOSED AREA

OCCUPANCY: 142
SF PER PERSON: 7 SF
OVERALL SF: 1000 SQFT

4-6 PERSON BENCH: 18 SF
1-2 PERSON BENCH: 4.75 SF
2-3 PERSON BENCH: 9.6 SF
TV'S: 3 SF
PROJECTOR: 2.25 SF

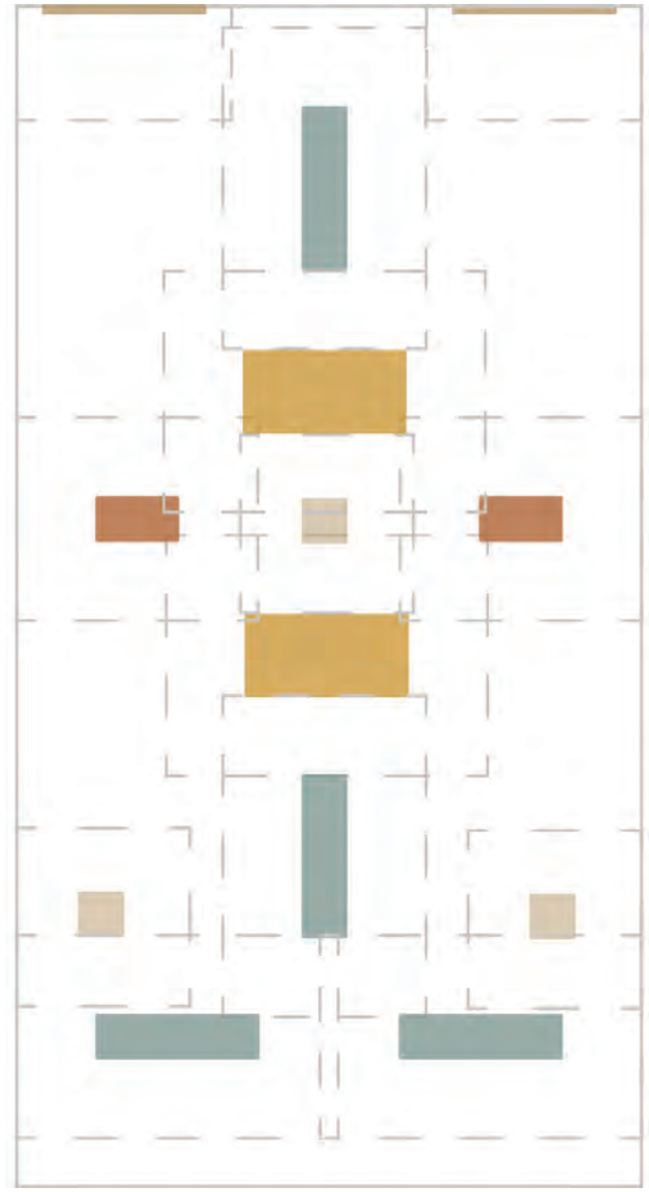






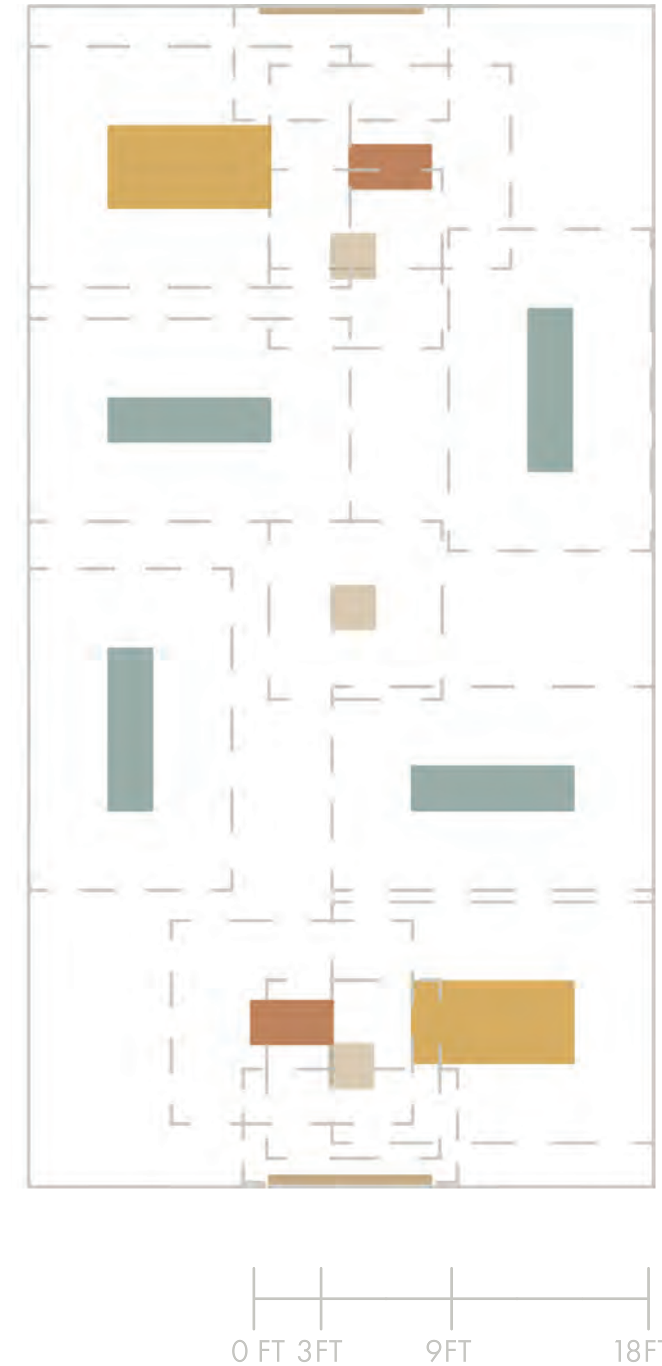
OPPOSITE DISPLAY

- 2 to 3 person benches in centralized location
- 4 to 6 person benches and 1 to 2 person benches in opposing locations
- TV's opposite one another
- Projectors in lower half of space



SYMMETRICAL DISPLAY

- Symmetrical approach
- TV's facing back wall upon entrance
- Projectors in tri-quad formation



CENTRAL DISPLAY

- Spiral formation of 2 to 3 person benches
- 4 to 6 and 1 to 2 person benches on outer perimeter
- TV's opposite one another
- Projectors splitting room into thirds

1. https://www.cmdesign.com.au/2020/10/06/exhibition-floor-plan-design/
2. https://www.dimensions.com/collection/benches

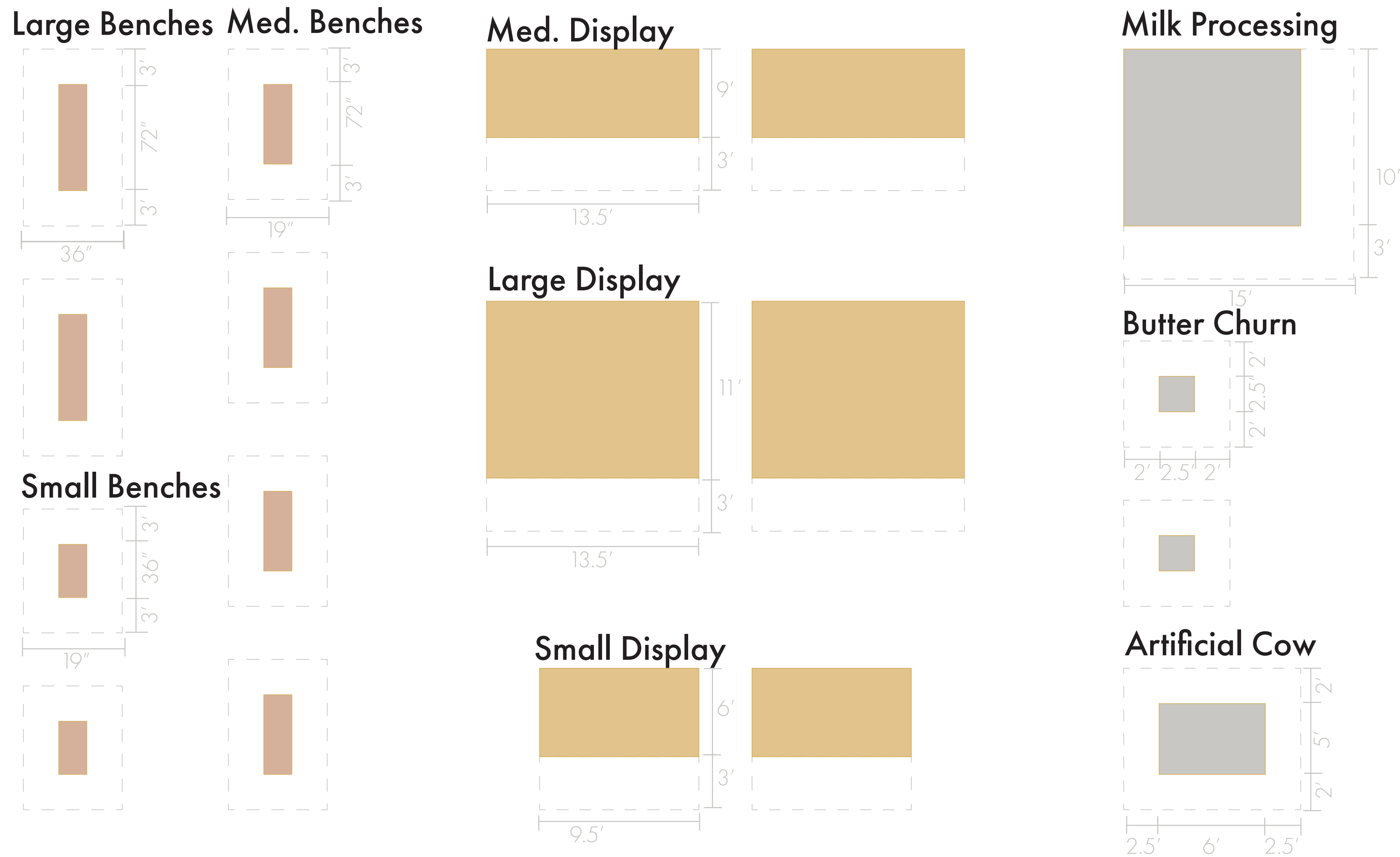
PHYSICAL EXHIBITION
PROPOSED AREA

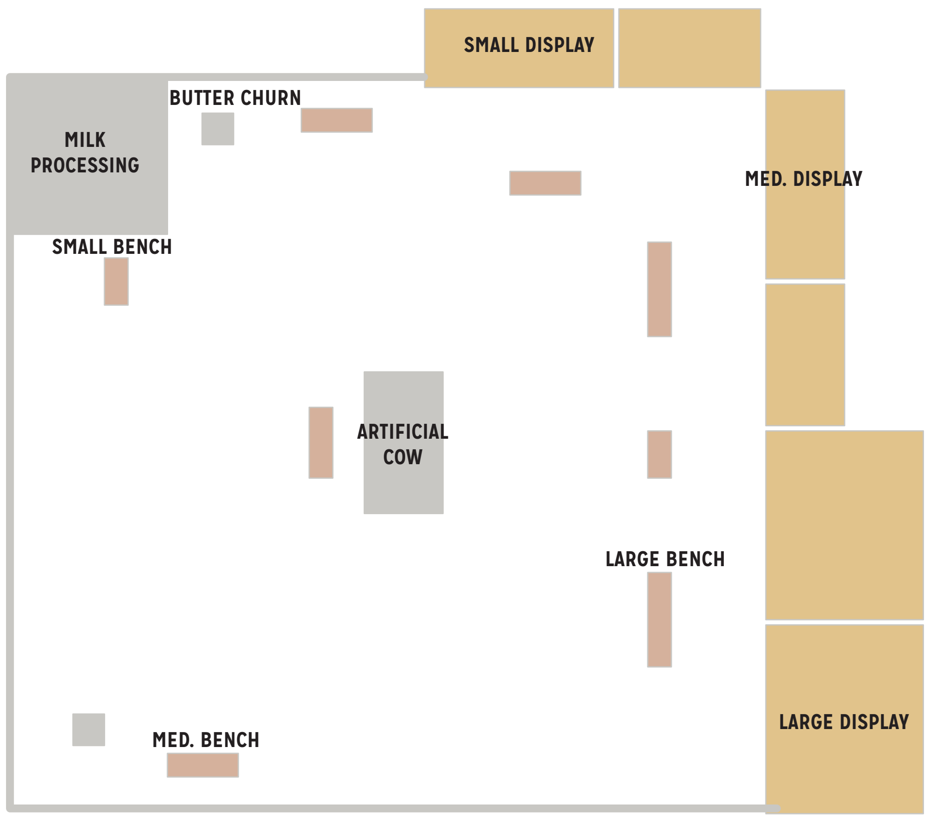
OCCUPANCY: 285
SF PER PERSON: 7 SF
OVERALL SF: 2000 SF

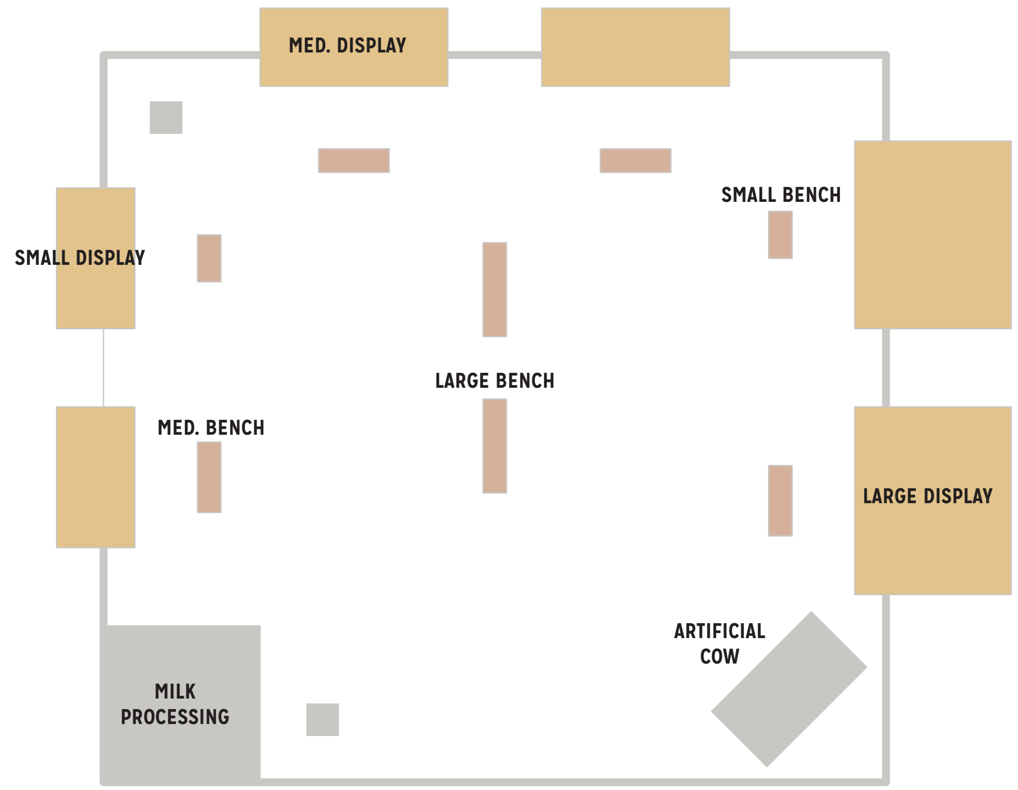
PAST TECH SHOWCASE (6): 450 SF
+SMALL DISPLAY (2)
+MEDIUM DISPLAY (2)
+LARGE DISPLAY (2)

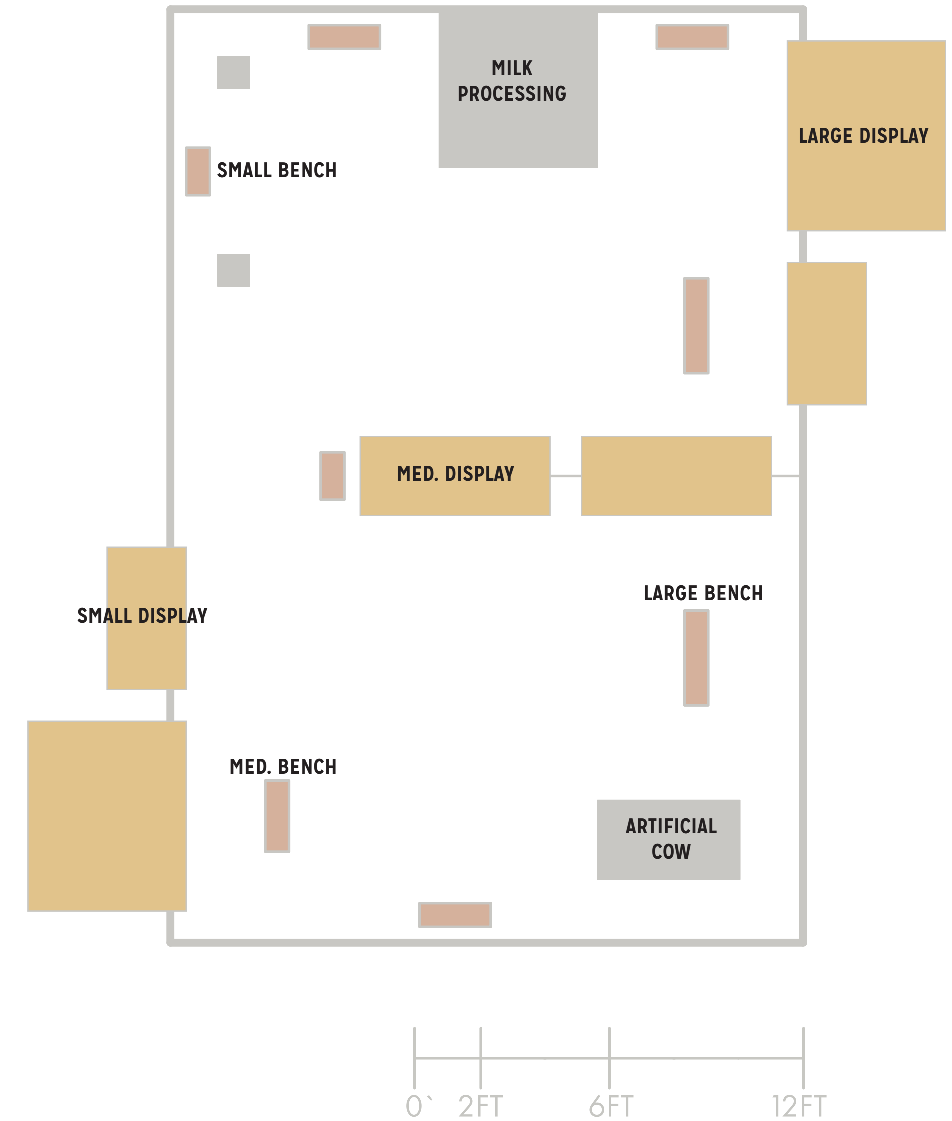
INTERACTIVE PROCESSES (4): 300 SF
+ MILK PROCESSING (1)
+ BUTTER CHURN (2)
+ ARTIFICIAL COW MILKING (1)
+ MOVEMENT SPACE

BENCHES (8): 81 SF
+ LARGE BENCH (2)
+ MEDIUM BENCH (4)
+ SMALL BENCH (2)









LINEAR DISPLAY

- 2,100 sf
- Displays organized in linear fashion
- Central focus on artificial cow
- Seating located by milk processing
- Allows for circular flow

SPACED DISPLAY

- 2,000 sf
- Displays separated to reduce congestion
- Interactive activities located along entrance wall
- Benches located in circular cluster for larger groups

SEGMENTED DISPLAY

- 2,300 sf
- Displays separated into two clusters
- Middle dividing wall creates more private experience
- Complex circulation promotes longer visits
- Allows occupants to explore at own pace

1. https://www.cmdesign.com.au/2020/10/06/exhibition-floor-plan-design/
2. https://www.dimensions.com/collection/benches

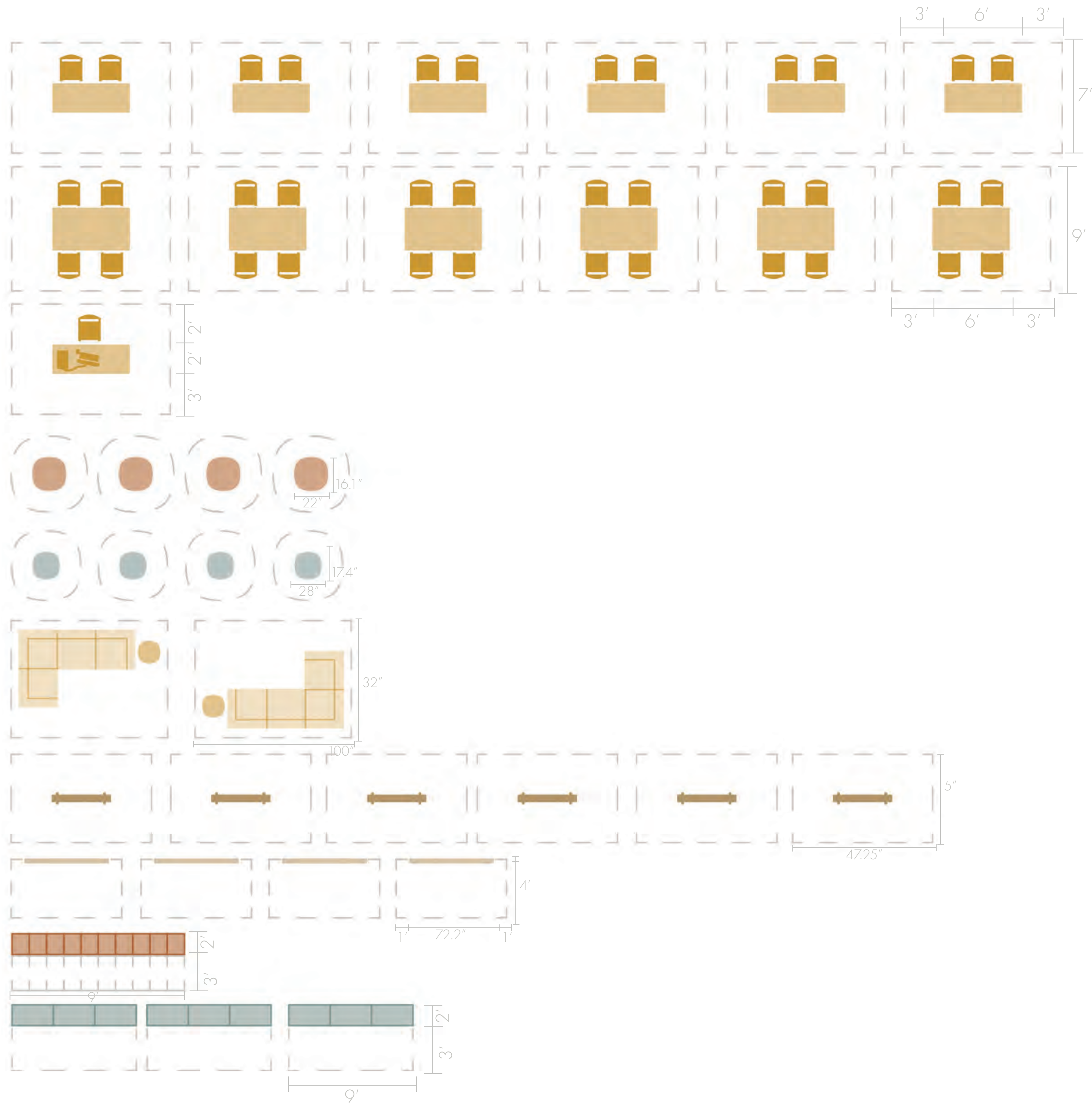
SEMINAR/ADJUSTABLE CLASSROOM

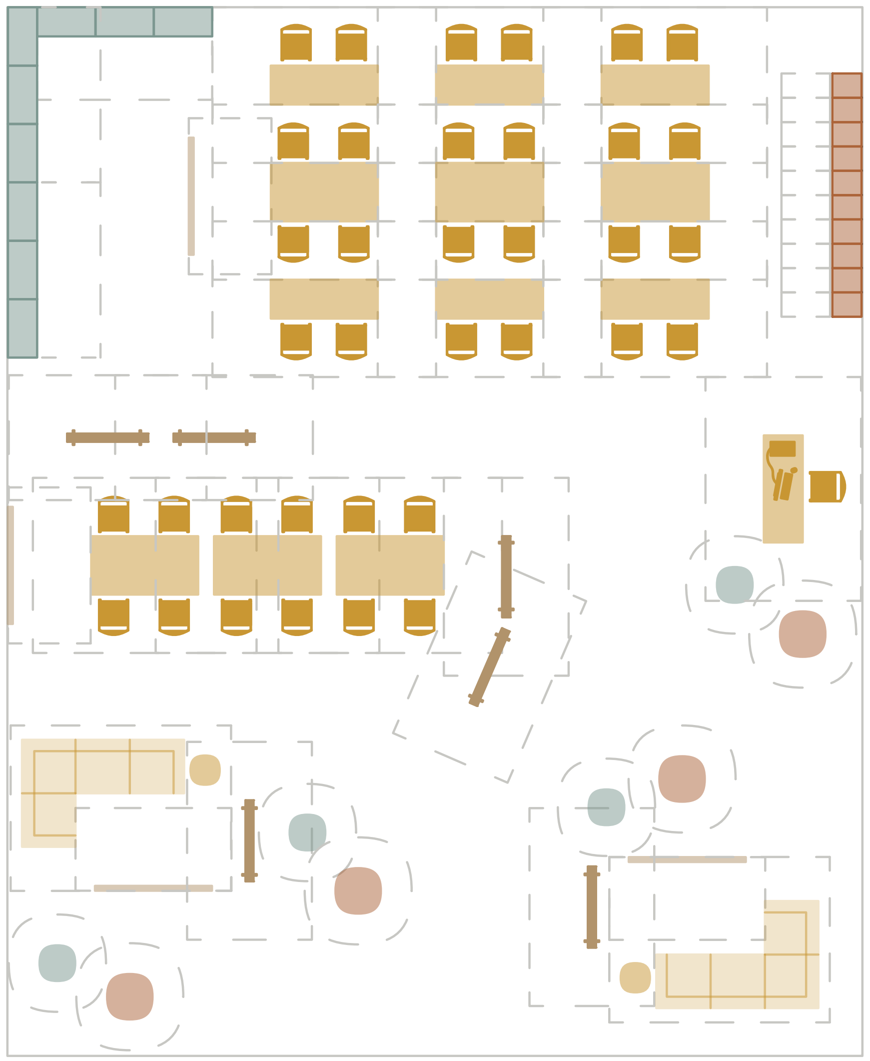
PROPOSED AREA

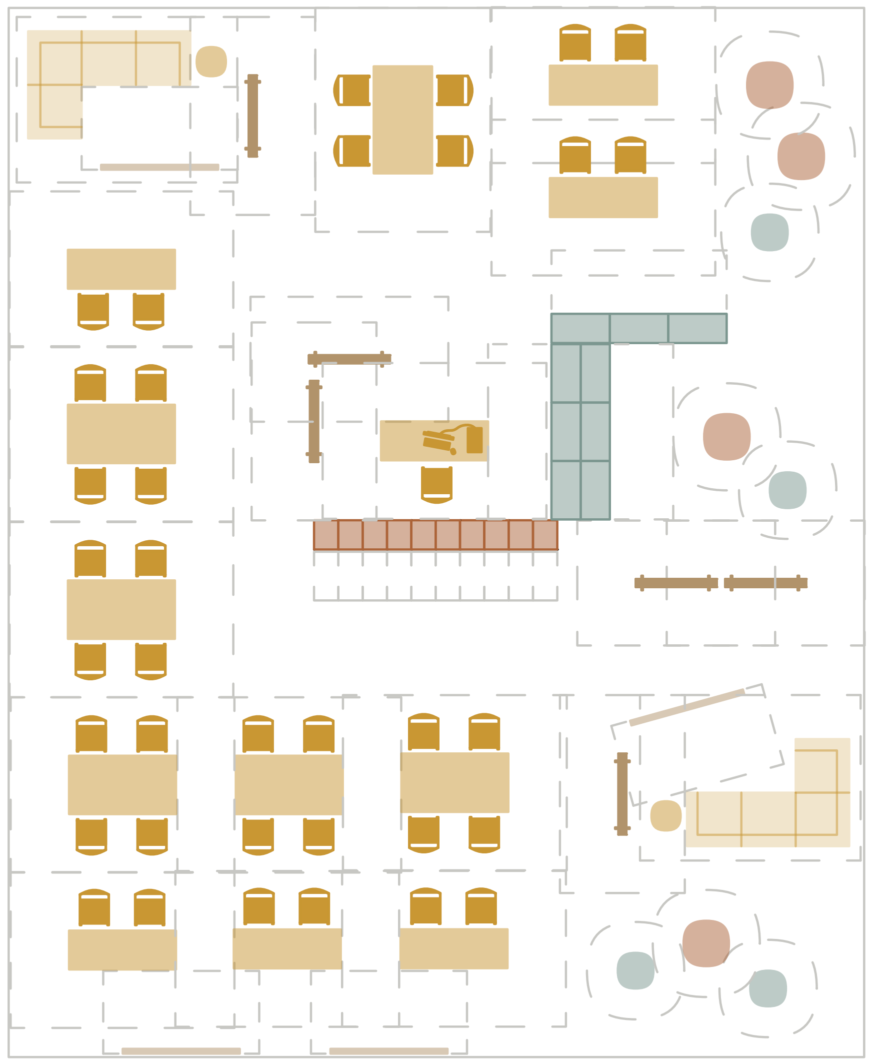
OCCUPANCY: 40
SF PER PERSON: APPROX. 28SF
OVERALL SF: 2,500 SQFT

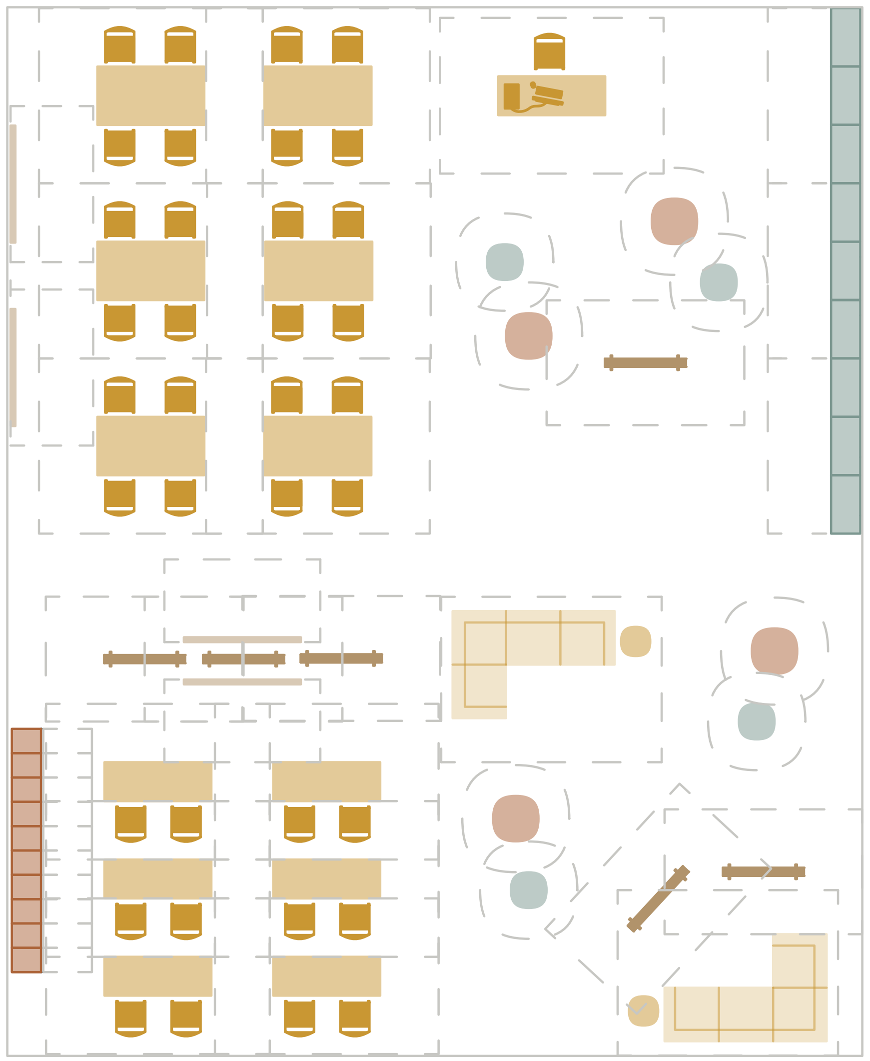
- TWO PERSON DESK (6): 9.4 SF
- FOUR PERSON DESK (6): 14.1 SF
- PC TABLE (1): 11SF
- CHAIR (36): 2.1SF
- SMALL POUFS (4): 2.3 SF
- LARGE POUFS (4): 3.2 SF
- SECTIONAL SOFAS (2): 22 SF
- ACOUSTICAL PANELS (6): 2.5 SF
- TV'S (4): 3 SF
- LOCKERS (10): 18.75 SF
- CABINET/COUNTER SPACE (3): 13.5 SF

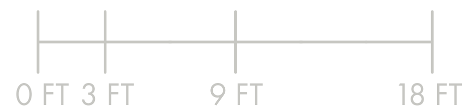
0 FT 3 FT 9 FT 18 FT











OPEN/FLEX

-Scattered approach to adjustable seating
-Combination of 2 and 4 person desks
-Fluid use of acoustical panels
-Open and flexible floor plan

WRAP AROUND

-Linearly alternating 2 and 4 person desk
-Corners allow for adjustable seating and breakaway zones
-Private use of acoustical panels
-Middle function for storage, lockers, and PC desk

GROUPED/SECTIONS

-Symmetrical approach dividing 2 and 4 person desks and break-away zones
-Centralized location for Breakaway zones
-Space dividing use of acoustical panels
-Storage and Lockers opposite

1. https://www.sitonit.net
2. https://www.sitonit.net/designplan/education.html

DAIRY BAR DESIRED QUALITIES

CONNECTION

The primary purpose of this program is to educate people about where the food we eat comes from. Having the view from the dairy bar to the cow barn through glass windows will allow public to connect with the dairy production while enjoying the dairy products

- Floor-to-ceiling glass windows
- Windows to cow shed
- Transparency

ATMOSPHERE

The desired qualities of this space is that it should reflect the program's concept and purpose by adding natural elements and farmhouse components to create a warm and inviting space that make the public feel at home in a dairy such as this while also providing learning opportunities to people who visiit the space. Considering as a gathering space, there are various seating types provided to be able to accommodate customers on a daily basis as well as hold large groups such as elementary field trips.

- Sustainable material (reclaimed wood)
- Neutral color palette (tan, cream, brown)
- Warm feeling
- Natural light (if possible)
- Minimal furniture that embraces simplicity in form
- Various seating types

COMBINATION

This program is a combination between a dairy store and coffee shop that is considered as a gathering space where customers are welcomed to stay. can dine in, enjoy the dairy products from the barn, such as sandwiches and pastries made using cow's milk or having a cup of hot chocolate, milkshakes or coffee while getting views to cows.

- Diverse food and drinks made using cow's milk
- Grab-and-go
- Dine in

DAIRY BAR
PROPOSED AREA

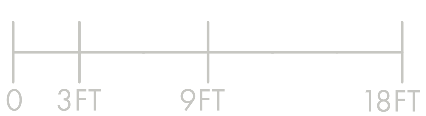
OCCUPANCY: 40
SF PER PERSON: 25-27 SF
OVERALL SF: 1000 -1100 SQFT

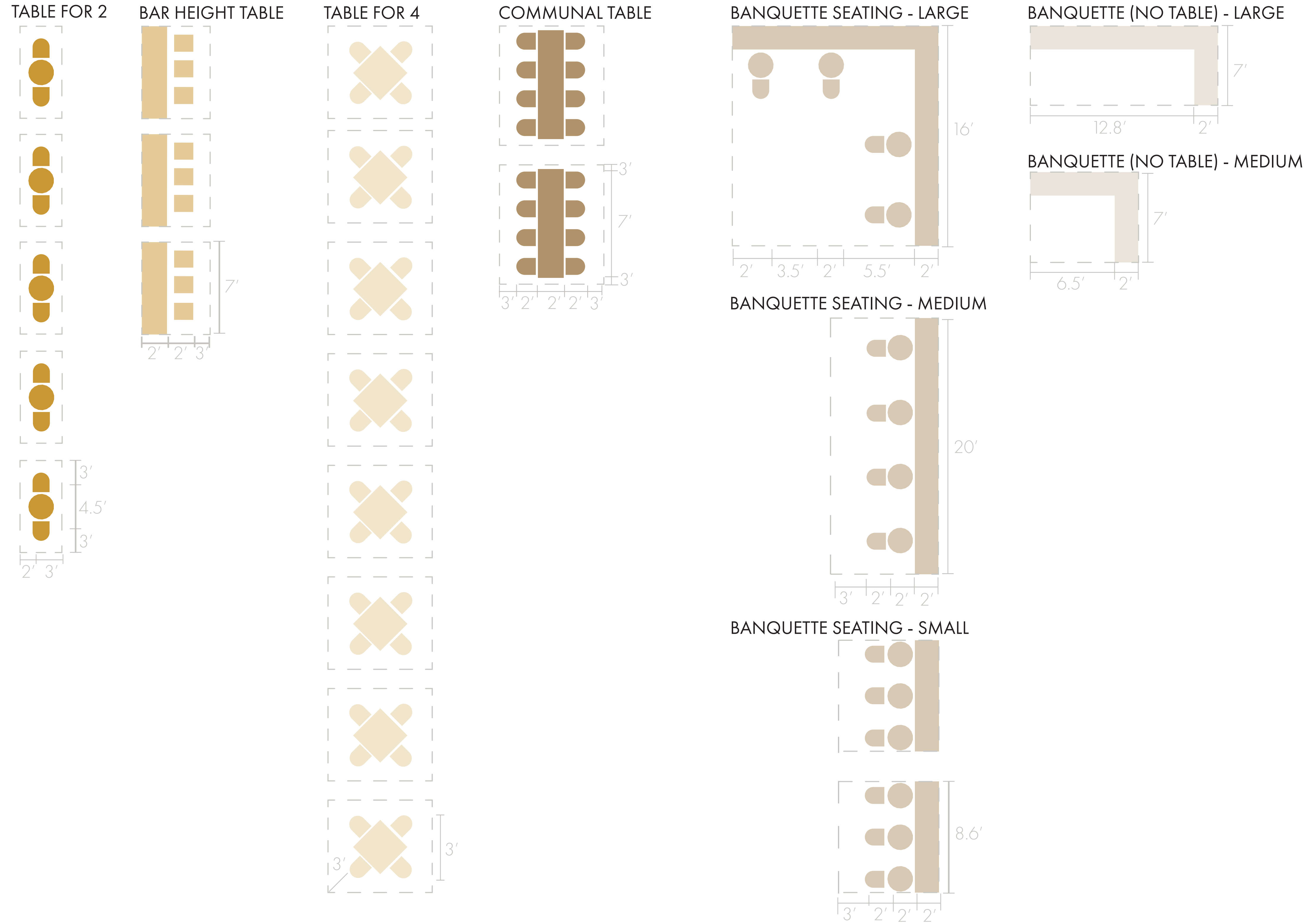
TABLE FOR TWO: 3 SF
BAR HEIGHT TABLE: 14 SF
TABLE FOR FOUR: 9 SF
COMMUNAL TABLE: 17 SF

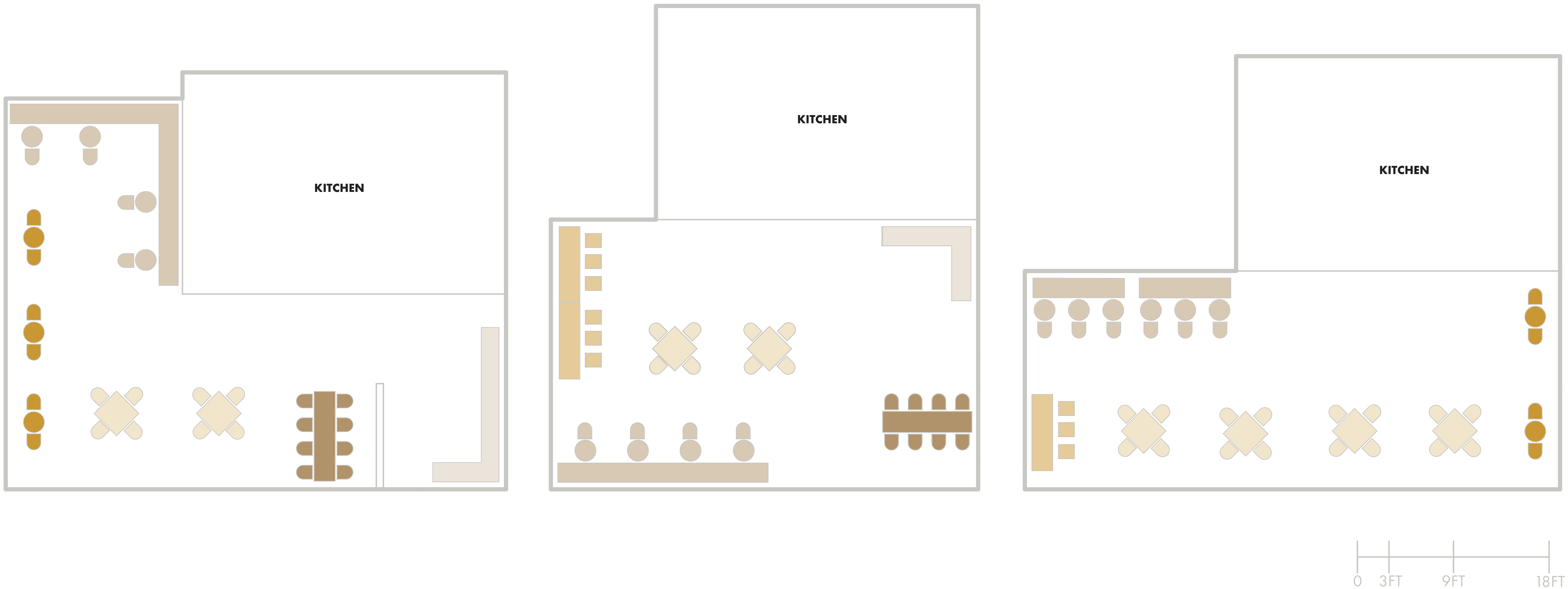
BANQUETTE
LARGE: 57 SF
MEDIUM: 36 SF
SMALL: 16 SF

BANQUETTE (NO TABLE)
LARGE: 38 SF
MEDIUM: 18 SF

*CHAIR: 2 SF
*BAR HEIGHT STOOL: 4 SF







PUBLIC TO PRIVATE

- 1100 Square feet
- 20x43 and 15x16 floor plan
- Various seating types
- From communal table (public) to private banquette
- obstructed view to cows

OPEN SPACE

- 1000 square feet
- 25x40 floor plan
- Various seating types
- Open plan allows people to interact
- Unobstructed view to cows

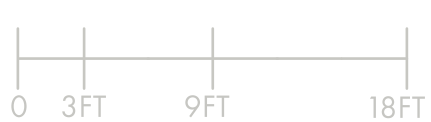
FLEXIBLE SPACE

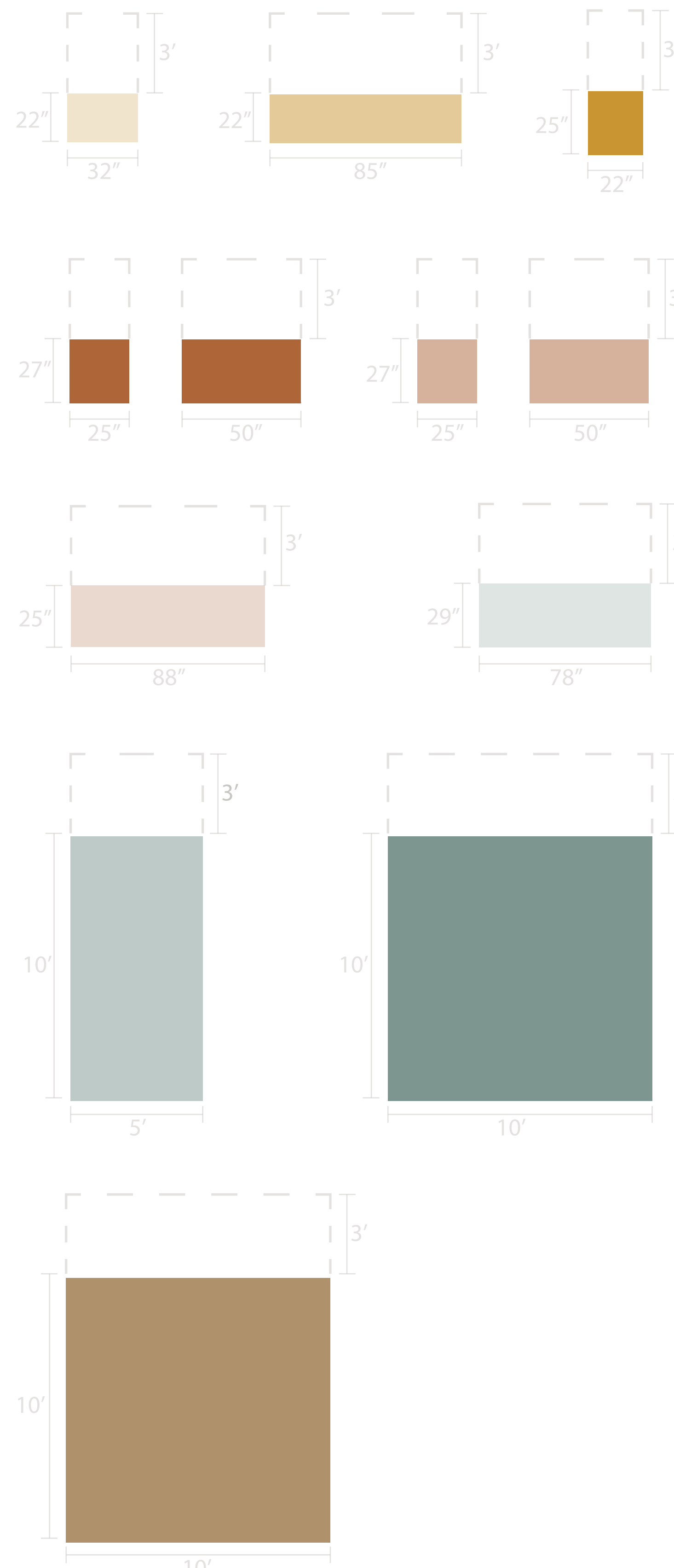
- 1000 squre feet
- 20x50 floor plan
- Limited seating types
- Can accommodate for different group sizes
- Unobstructed view to cows

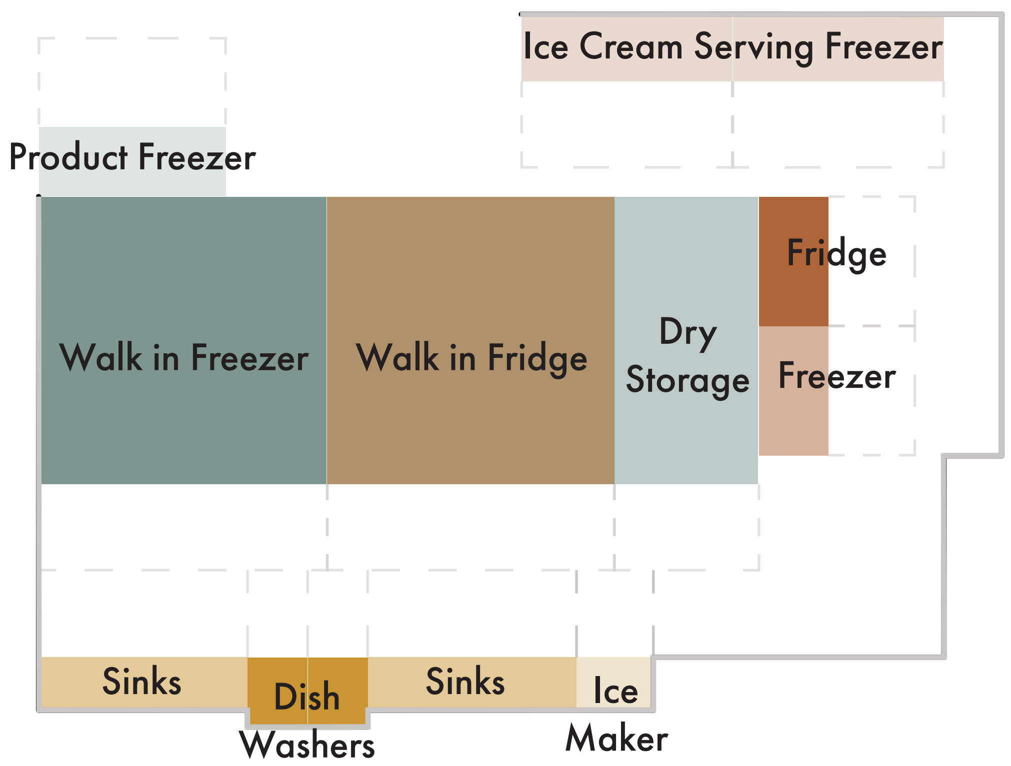
KITCHEN
PROPOSED AREA

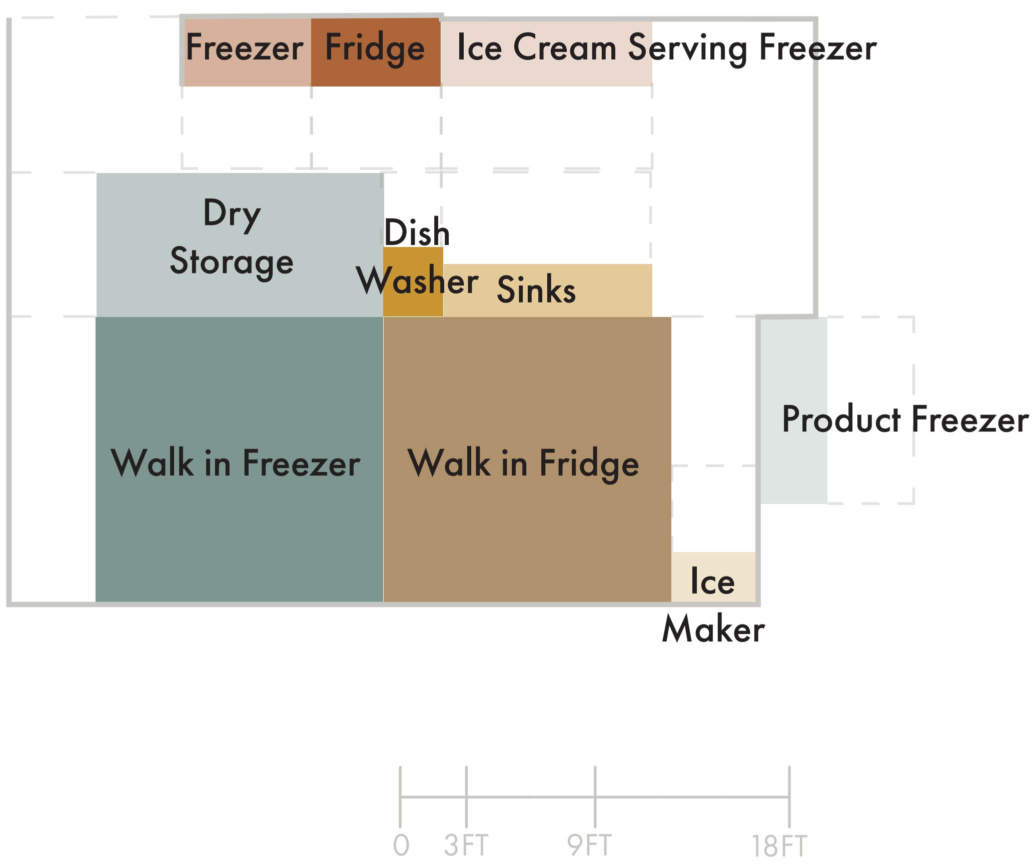
OCCUPANCY: 3
SF PER PERSON: APPROX. 239SF/186SF
TOTAL SF EXAMPLE 1: 717 SF
TOTAL SF EXAMPLE 2: 558SF

ICE MAKER: 5 SF
3 SINKS: 12 SF
DISH WASHER: 4 SF
SINGLE UNDER COUNTER FRIDGE: 4.5 SF
DOUBLE UNDER COUNTER FRIDGE: 9 SF
SINGLE UNDER COUNTER FREEZER: 4.5SF
DOUBLE UNDER COUNTER FREEZER: 9 SF
ICE CREAM SERVING TUB FREEZER: 15 SF
TWO DOOR PRODUCT FREEZER: 16 SF
DRY STORAGE: 50 SF
WALK IN FREEZER: 100 SF
WALK IN FRIDGE: 100 SF









L SHAPED DESIGN

- Provides more storage and circulation space
- Includes a larger serving counter
- Total SF: 717
- SF per person: 239 SF

U SHAPED DESIGN

- U shaped circulation for workers
- Still incorperates serving counter but is smaller
- Total Sf: 558
- SF per person: 186 SF

1. https://www.darpro-solutions.com/media/blog/commercial-kitchen-layout

CLASSROOM DESIRED QUALITIES

ATMOSPHERE

DIVERSITY

ENHANCED

Providing students with valuable learning opportunities and engaging course structures are of utmost importance within each classroom setting. Kitchen classrooms for the culinary arts encourage students interested in food processes and science to practice utilizing dairy products in different ways. Traditional classroom settings include providing an enhanced educational setting where students can be inducted into various learning environments. The open seminar space provides a versatile and multipurpose seminar style classroom with a multitude of desks for studying, breakout lounges, and flexible seating.

- Light and Natural Feeling
- Future Focused
- Everchanging and flexible
- Promotes studious behaviors and collaboration

1. https://www.sitonit.net/designplan/education.html

KITCHEN CLASSROOM

PROPOSED AREA

OCCUPANCY: 15
SF PER PERSON: APPROX. 126 SF
MAIN FOOD LAB: 1,890 SF

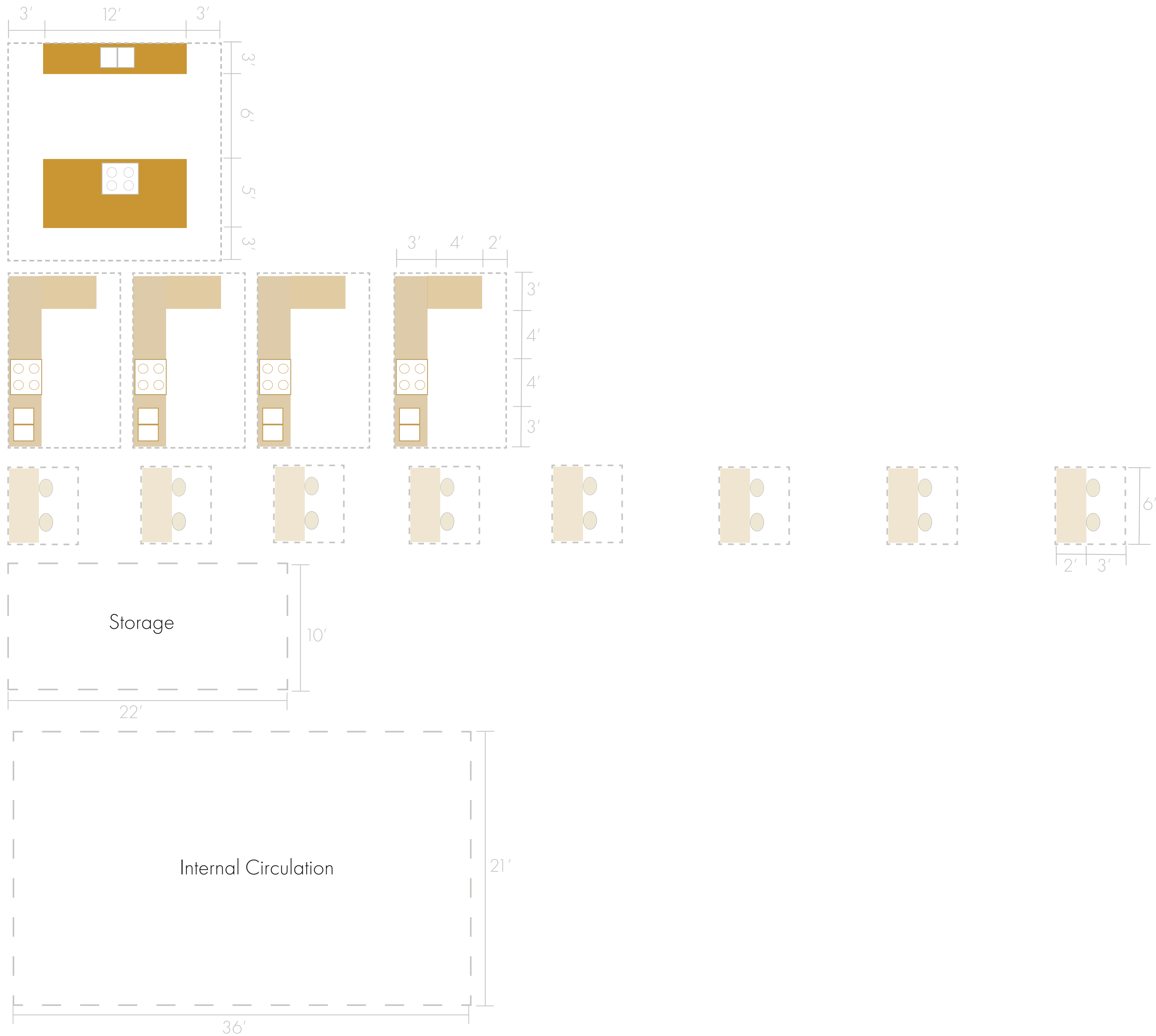
DEMONSTRATION KITCHEN(1): 235 SF
+STOVE (1)
+SINK (1)
+COUNTER SPACE

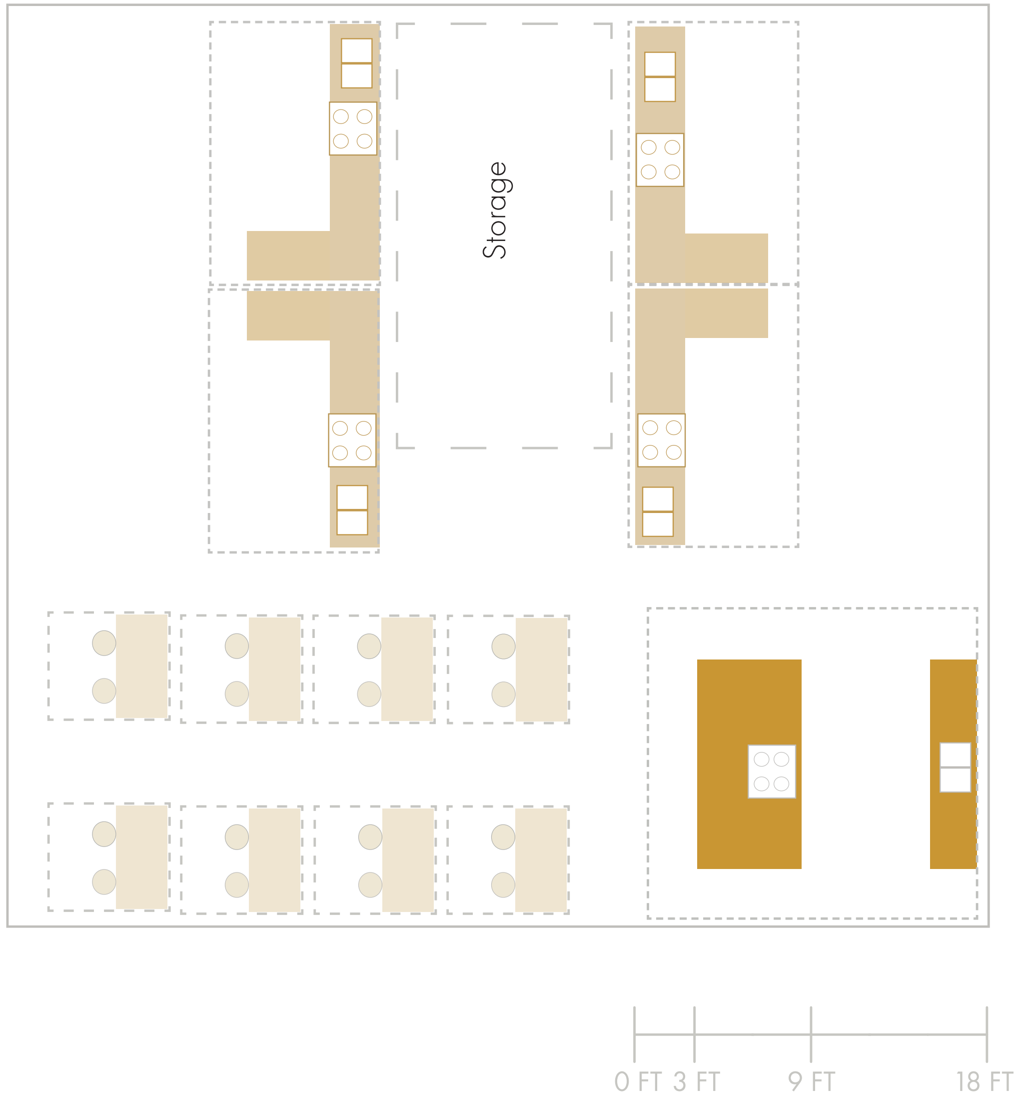
STUDENT KITCHEN (4): 100 SF
+ STOVE (1)
+ SINK (1)
+ COUNTER SPACE

STUDENT SEATING AREAS (7): 27.5 SF
+ DESK (1): 12.5 SF EACH
+ CHAIRS(1)

REFRIGERATOR AREA: 37 SF
+ REFRIGERATOR AREA :18 SF
+ MOVEMENT SPACE

STORAGE: 150SF





LINEAR

-Symmetrical approach dividing student kitchens and desks
-Demonstration kitchen facing student desks
-Smaller storage options on either side of student kitchens

SYMMETRICAL

-Mirrored reflection splitting demonstration kitchen, student desks, and student kitchens
-Demonstration Kitchen facing student desks
-Larger storage options in corners

SECTION 2

-Demonstration Kitchen facing student desks
-One larger central storage option separating student kitchens

1. https://www.sitonit.net/designplan/education.html

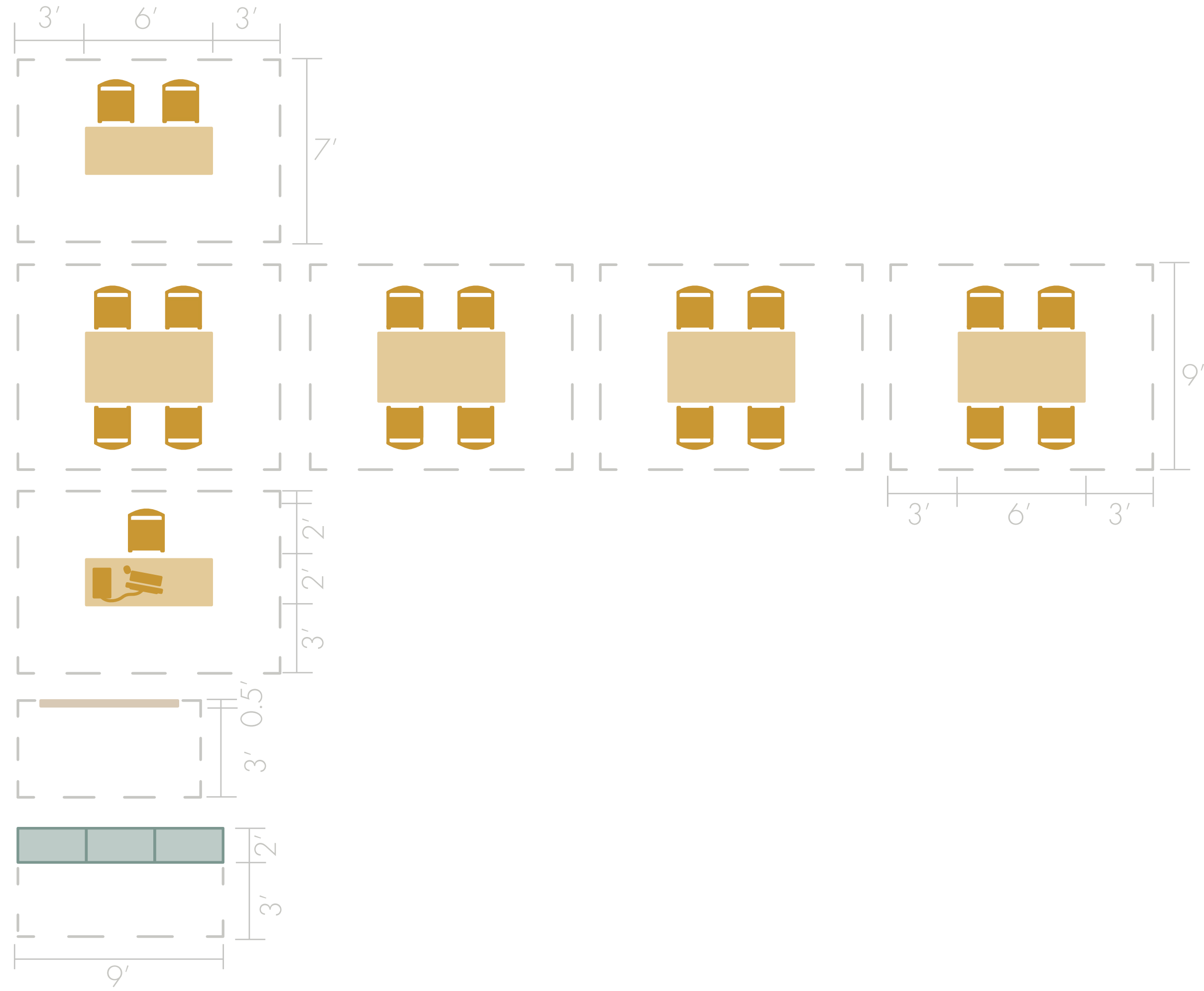
SMALL CLASSROOM (2)

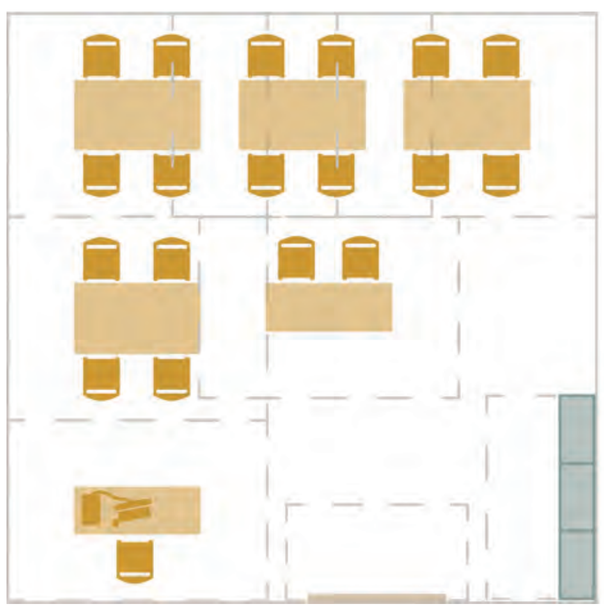
PROPOSED AREA

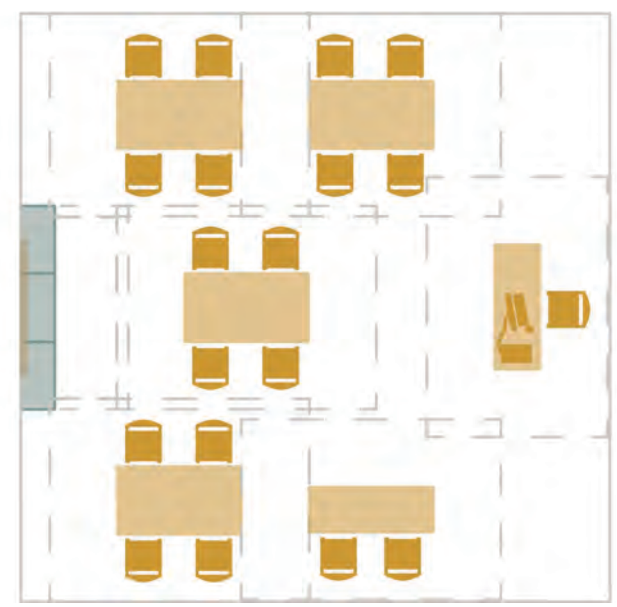
OCCUPANCY: 18
SF PER PERSON: APPROX. 28SF
SMALL CLASSROOM (1) : 600 SF

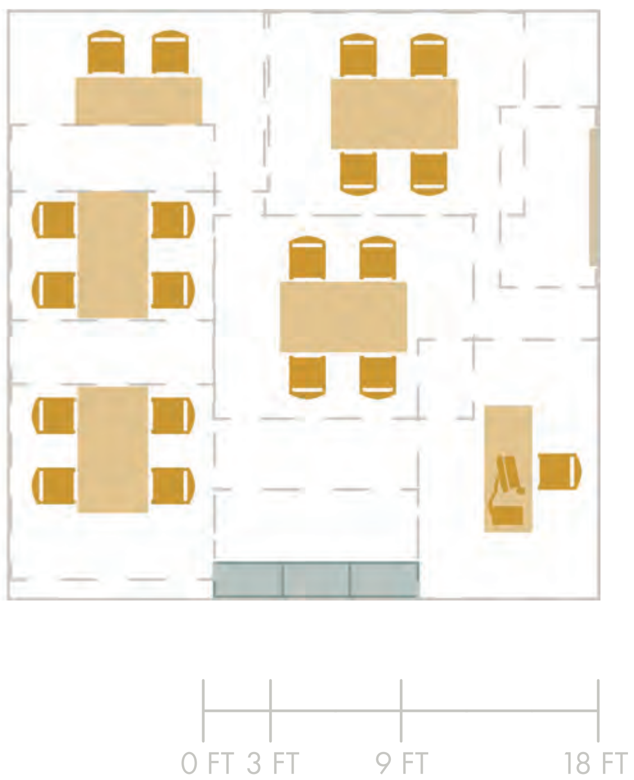
DESK FOR TWO: 9.45 SF
DESK FOR FOUR: 14.1 SF
CHAIR: 2.1 SF
PC TABLE: 11 SF
TV: 3 SF
CABINET: 13.5 SF

0 FT 3 FT 9 FT 18 FT









SOUTH SIDE

-Traditional forward facing desks
-PC desk adjacent to TV
-Classroom storage near front of room

CENTRALLY LINEAR

-Symmetrical approach to desks
-TV and storage sharing space
-PC desk dividing middle of classroom

EAST SIDE

-Scattered and random approach to desks
-TV and storage on opposing sides
-PC desk facing desks from all directions

1. https://www.sitonit.net/designplan/education.html

BARN DESIRED QUALITIES

ATMOSPHERE

The desired qualities of the builidng are that it should have more natural elements, such as wood, to make the feeling for inviting and warm. Natural sunlight needs to be present in the barn, not only to have a better environmental footprint by conserving electricity but also to have a warmer more inviting atmosphere. Daylight is especially important for the cows since they will most likely be indoors for their entire time at this facility.

- Natrual Materials
- Soft/ Warm Color Pallette
- Access to Daylight
- Open-Plan
- Inviting
- Peaceful

TRANSPARENCY

Transparency to the public is essential for presenting positive animal care and often shows the process of dairy farming to its fullest extent. There will need to be windows that are kept as clean as possible at all times and a form that has slanted walls could aid in that. Mirrored glass and having windows looking into the barns be placed above the cows could help reduce any stress the cows may feel by reducing physical human interaction. This is especially important with a younger age group who may be a little noisier and startling to the cows.

- Large Glass Windows
- Mirrored Glass
- Close Proximity to Cows
- Little Disruption
- Clarity

INNOVATION

The primary purpose of this facility is to educate people about the production of dairy and how it can be done in a more autonomous way. Having the milking robots as well as any of the other robots behind glass for display will allow for some educational opportunities. There will also be a chance for visitors to interact with the cows without disrupting them by seeing them in the barn environment and witnessing what their behavior is like, especially when around the robots.

- Windows to Robots
- Educational Displays/ Boards
- Interactive Activities
- Durable and Easy to Clean Materials (Stainless Steel)
- Showcase of Each Robot and Their Functions

1.ASAD LARGE DAIRY HERD MANAGEMENT THIRD EDITION

BARN

PROPOSED AREA

OCCUPANCY: APPROX. 30

SF PER PERSON: 100 SF

STALL SPACES: 4,020 SQFT

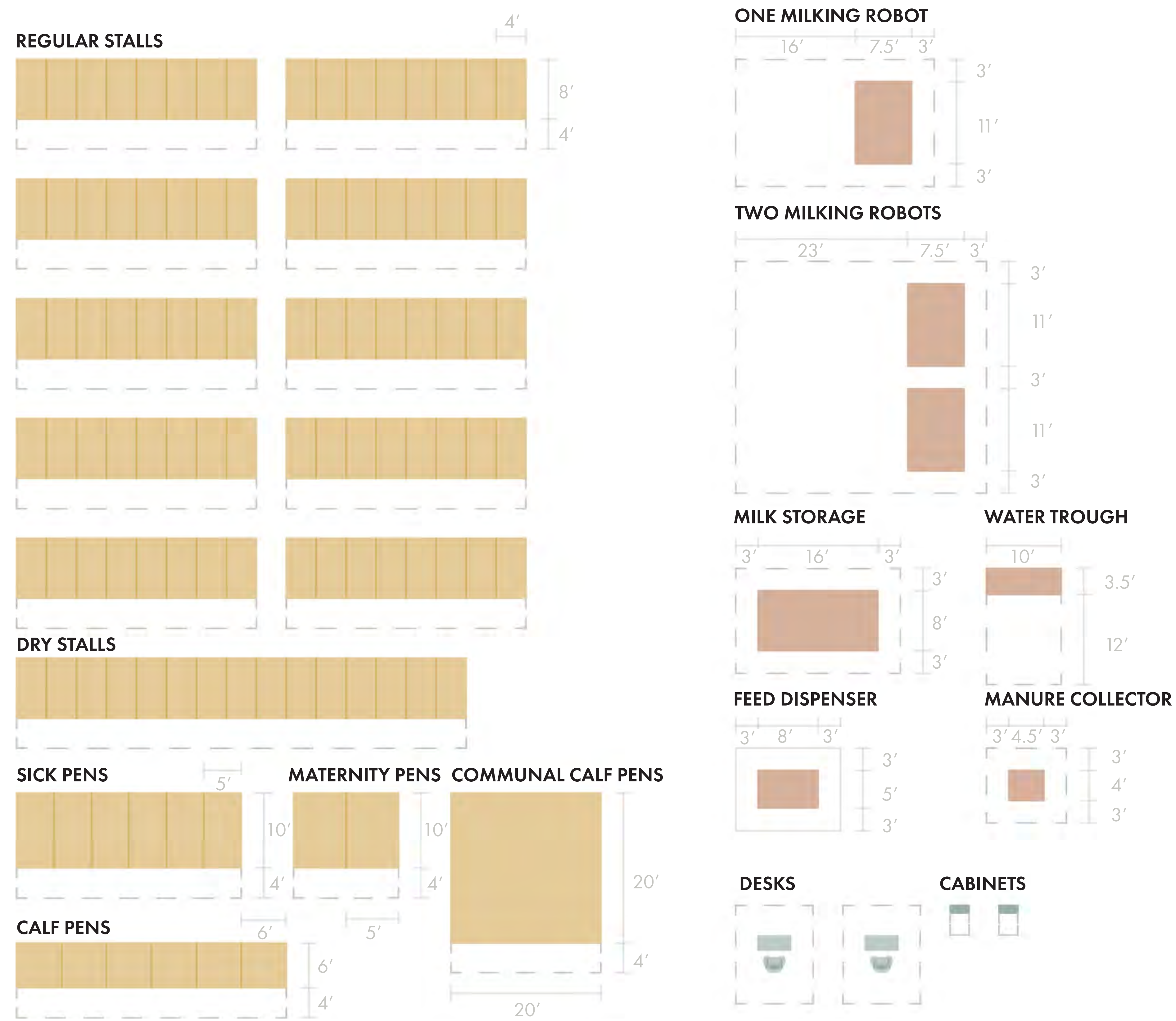
+ STALLS (80)
+ DRY STALLS (15)
+ SICK PENS (6)
+ MATERNITY STALLS (2)
+ CALF PENS (5)
+ COMMUNAL CALF PEN (1)

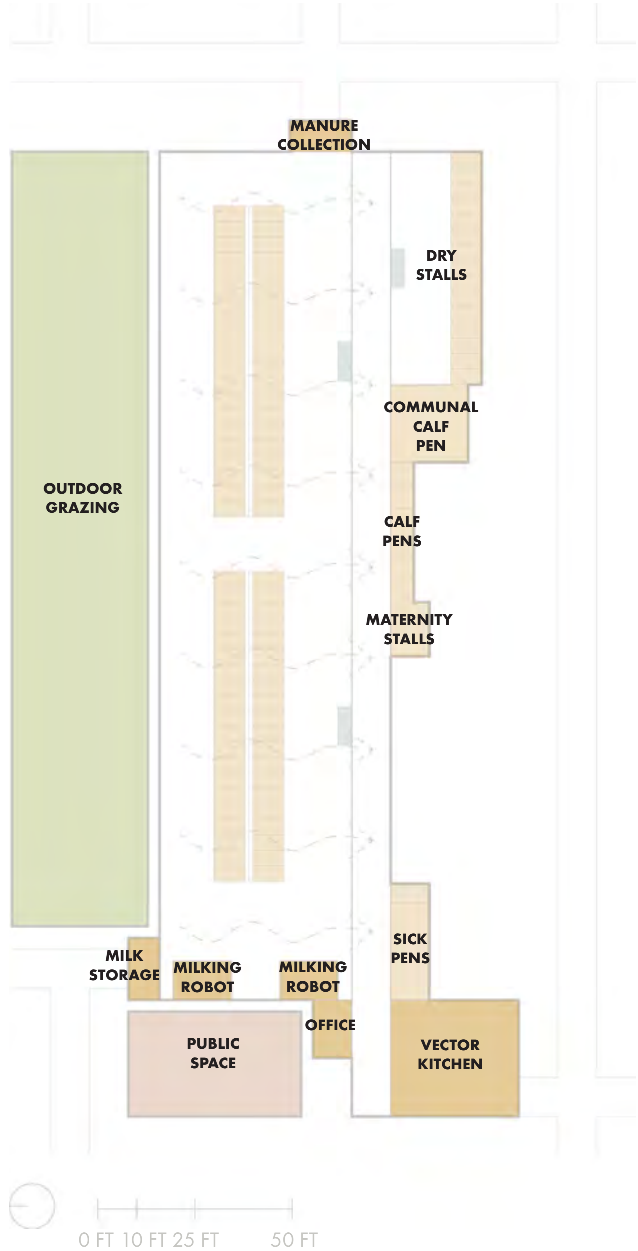
EQUIPMENT: 472 SQFT

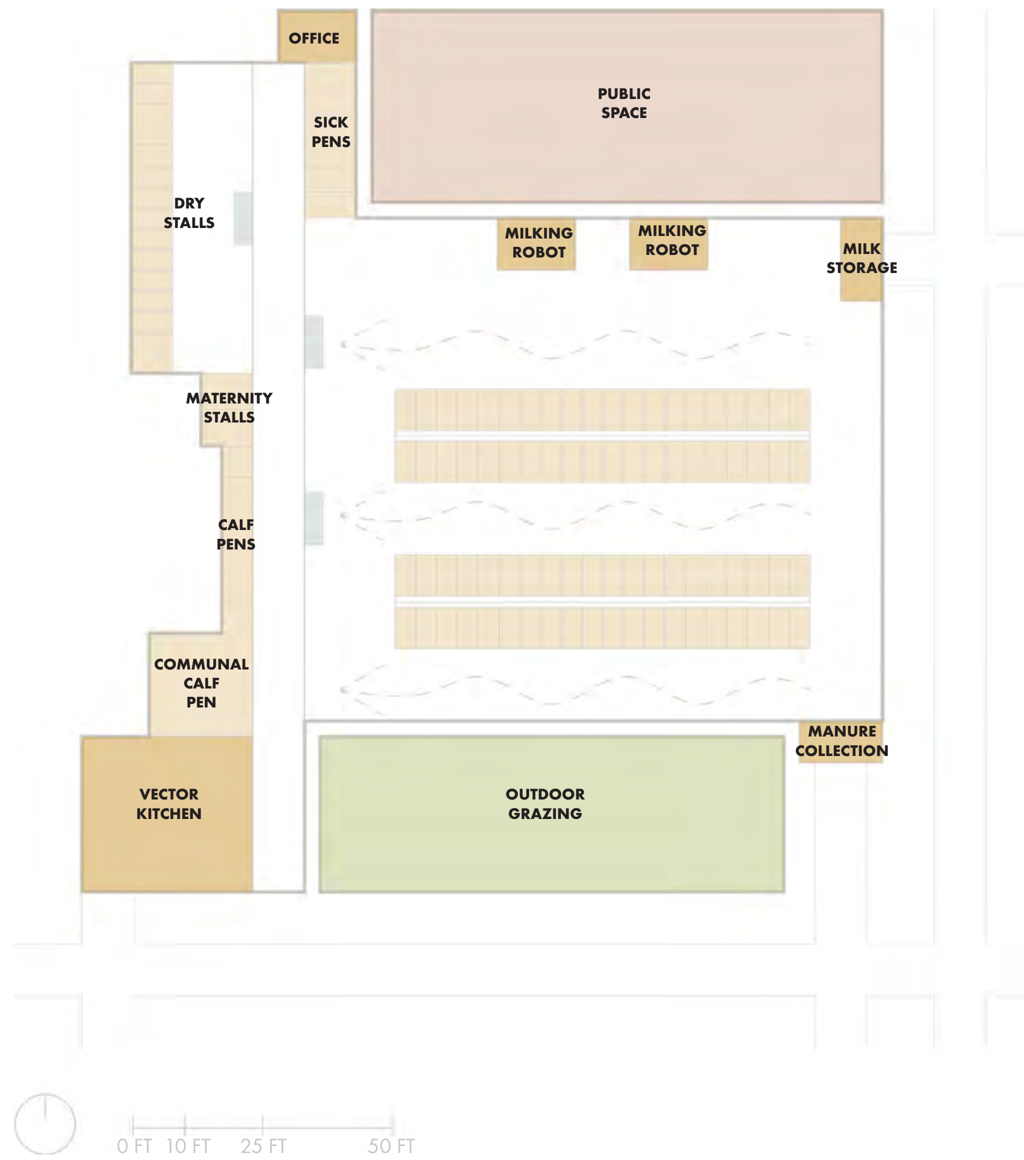
+ MANURE COLLECTOR (1)
+ MILKING ROBOTS (2)
+ FEED DISPENSER (1)
+ WATER TROUGH (3)
+ MILK STORAGE (1)

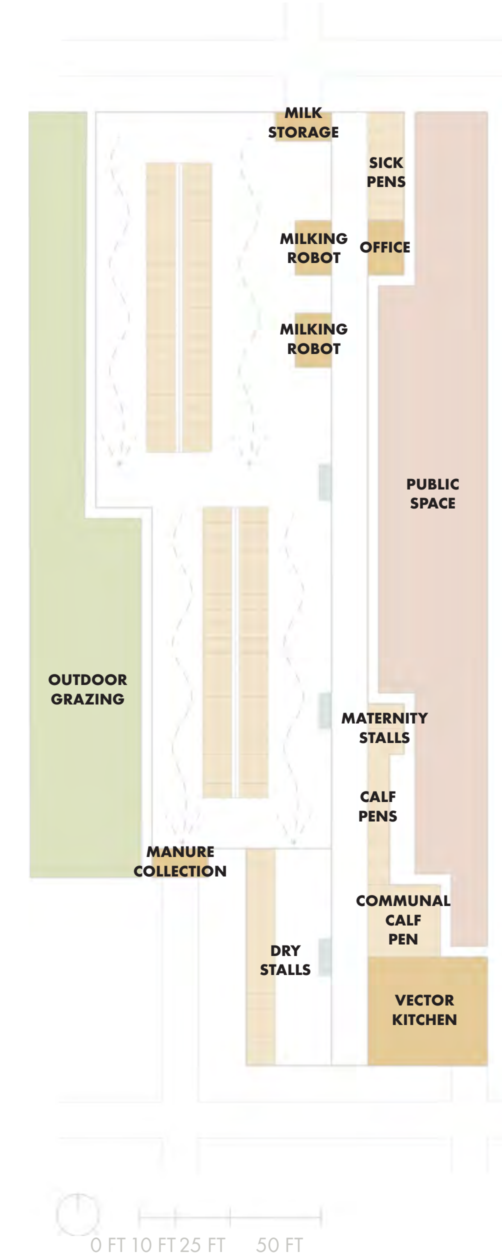
OFFICE: 150 SQFT

+ DESK (2)
+ CHAIRS (2)
+ CABINET (2)









NATURAL VENTILATION

17,162 SQFT

Relies on wind for air flow through sidewall parallel to cows at feed line or in a stall

PROS:

Better air quality, cost efficient, ventiliation, adequate for most of the year

CONS:

Relies on wind, needs temperate climate, east to west barn orientation to avoid solar penetration, fans needed for hot weather, lack of public views

MECHANICAL CROSS VENT.

16,021 SQFT

Velocity goes through cross section side of the barn. Airflow direction is parallel to cow orientation at feed line or in a stall

PROS:

Smaller footprint, any orientation, environment control, air flow at cow level

CONS:

Energy dependent, baffles needed, feed can be contaminated by blown bedding, minimal air flow in cold weather can compromise animal health, lack of public views

MECHANICAL TUNNEL VENT.

18,116 SQFT

Fans are placed at the endwall of the barn and air flow is perpendicular to the cow orientation at the feed line or in a stall

PROS:

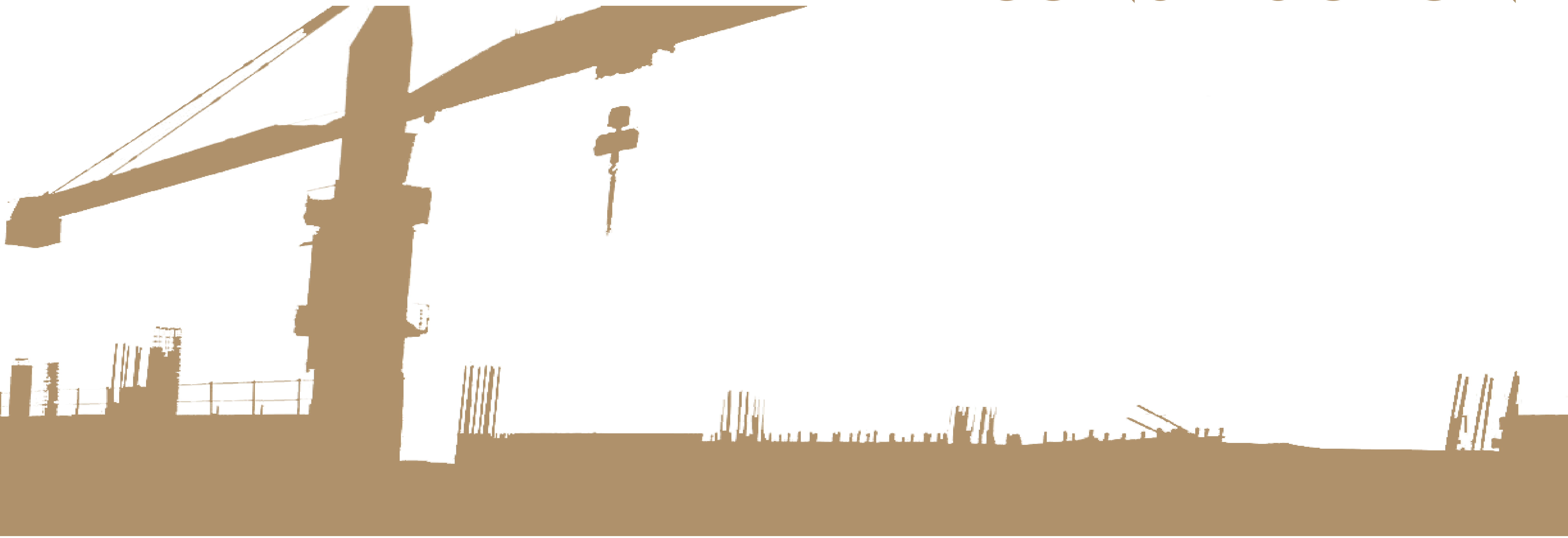
Air flow at cow level, air flows on path of least resistance, more control over environment, great public views

CONS:

Minimal air flow may compromise animal health, baffles needed

1.ASAD LARGE DAIRY HERD MANAGEMENT THIRD EDITION

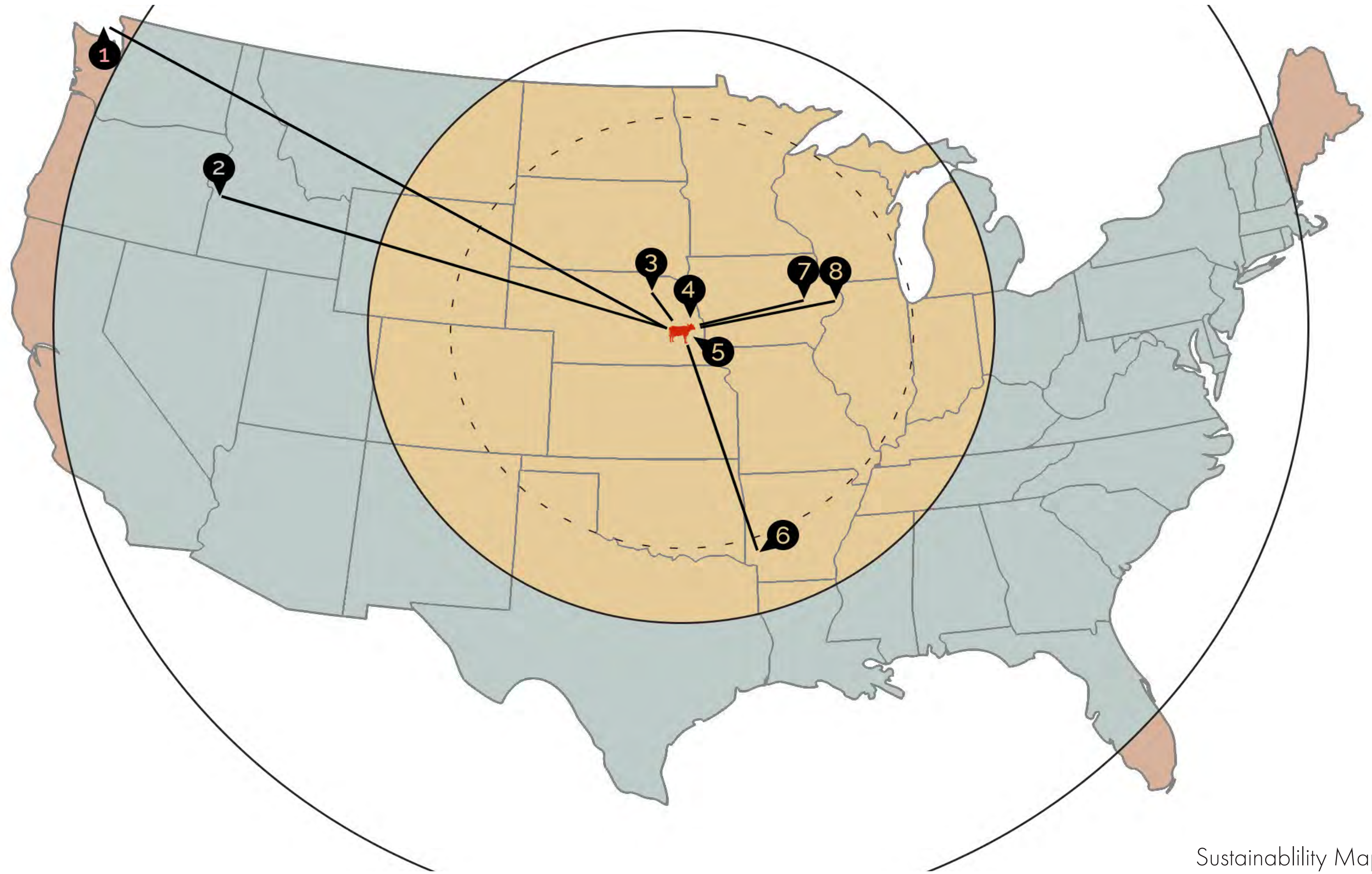
CONSTRUCTION



Construction
Material Study

Overview

When in the built environment one can observe many different materials and textures. These materials are how we perceive the space around us and affect how we feel about the space. Materials have many different properties and many different uses to them. Structural materials are the bones of a building; looking around, these materials usually hidden, but can be celebrated. On the other hand, the visible materials are usually finish materials. Structural materials need to be strong and durable because if they are not the building will not stand for long, whereas, finish materials can be decorative because of the lack of weight they are tasked with supporting. The identity of these materials are not just on the surface. In today's world of global warming, we as designers are becoming aware of embodied carbon and sustainability in the built environment. For those who do not know about embodied carbon, it is a term that looks at all the carbon that is either in the material itself or the carbon that is produced when producing the material, transporting the material, or constructing with the material. The sustainability map shows how far a semi-trailer can travel. The first dotted ring shows the 500-mile radius where materials are considered local, the first solid ring of the yellow color shows the distance of one day's travel, the blue ring shows two days and the red third ring shows three days of travel for a semi. While some of these sustainable tactics may cost more they do make for a healthier earth. When selecting a material it is worthwhile to take into consideration more than just price.



Sustainablility Map

Structure Materials

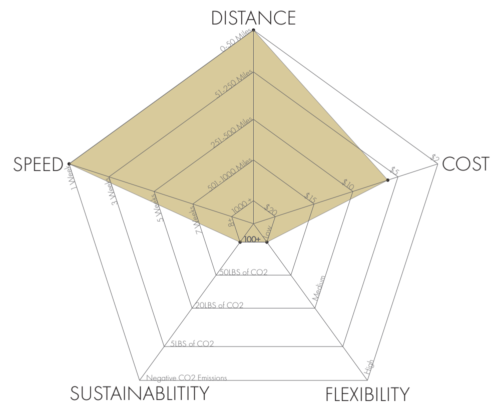
- Concrete
- Ashcrete
- Steel
- Dimensional Lumber
- Glulam
- Brick

Finish Materials

- Glass
- Wood
- Bamboo
- Stone
- Plaster
- Metal

Map Key

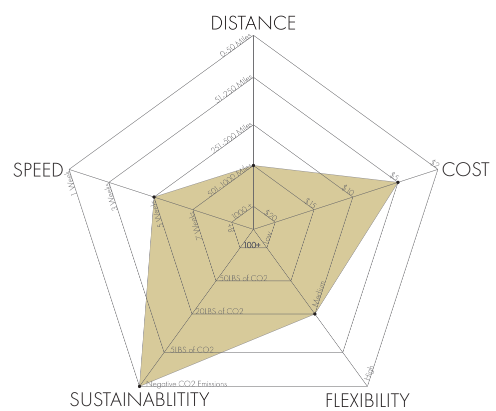
1) Ashcrete
2) Glulam
3)Steel
4)Concrete
5) Brick
6) Dimensional Lumber
7) Stone
8) Glass



Concrete

Distance from Site: 40 Miles

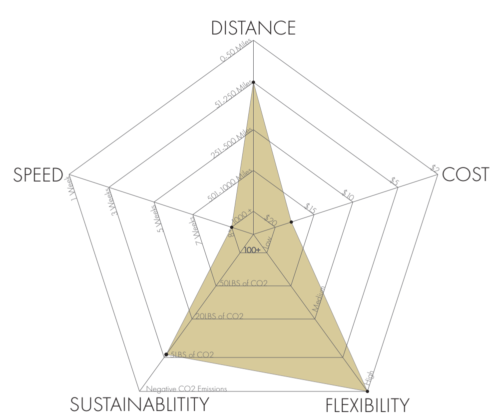
Concrete is a sturdy building material that has been used for years, with that being said concrete produces 4-8% of the worlds greenhouse gases. If concrete was a country it would be the third largest carbon producer in the world.



Dimensional Lumber

Distance from Site: 630 Miles

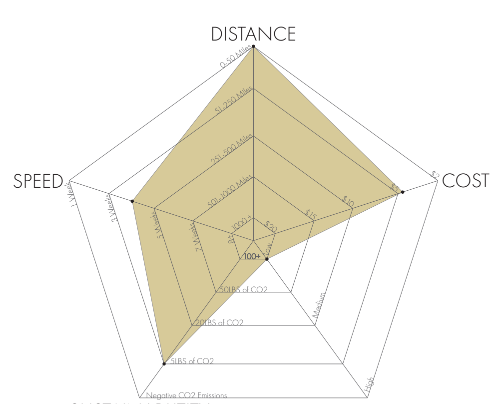
Dimensional Lumber can be very sustainable depending on how the process of obtaining it is handled. Wood is a renewable resource so as long as trees are being planted at or exceeding the rate of trees that are being cut down wood becomes sustainable.



Steel

Distance from Site: 120 Miles

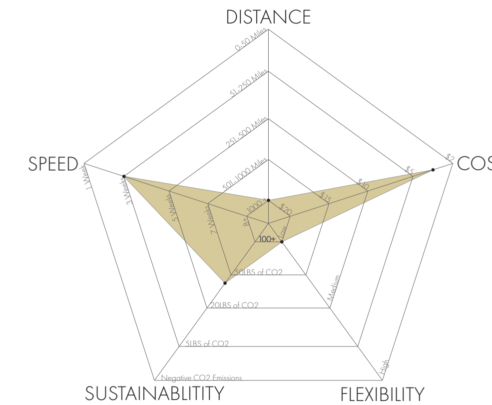
Once made steel is very sustainable it is the most recycled material on the earth, but to produce raw steel is very carbon intensive. The great thing about steel is that once it is made it can be used forever without losing any of its strength integrity.



Brick

Distance from Site: 7 Miles

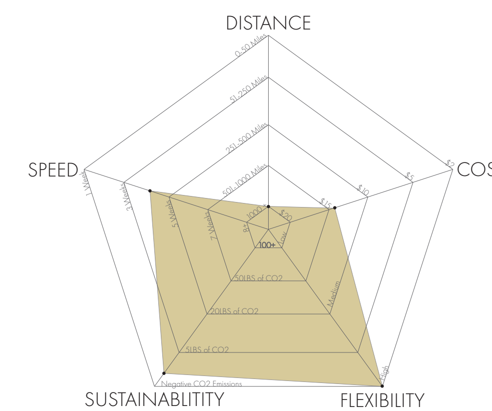
Of course every material will produce some sort of carbon emissions, and brick is no different. Firing the clay bricks is the main reason bricks let of CO_2, but like steel bricks can be recycled and have a very long building life.



Ashcrete

Distance from Site: 1808 Miles

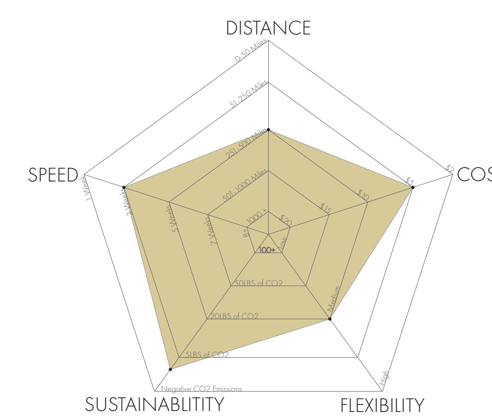
Ashcrete is a very sustainable material that we could be using for building. Ashcrete takes fly ash from the burning of coal and uses that as a core material. Ashcrete also uses less water than concrete in its production which is a plus as water is becoming a focus for many cities around the world.



Glulam

Distance from Site: 1176 Miles

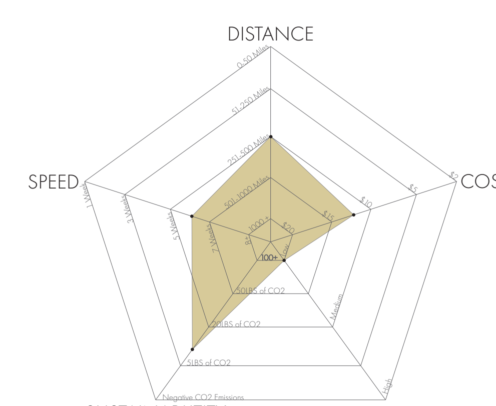
Like dimensional lumber glulam is a wood based product making it a renewable resource. The main carbon emissions that come from glulam is in the foresting process.



Glass

Distance from Site: 370 Miles

Glass, like steel and brick, is very carbon intensive to produce when using raw materials, but glass is recyclable. Producing raw materials for glass is very harmful for the ecosystems that they come from and the smelters have to run 24/7 to produce the glass producing carbon emissions.



Stone

Distance from Site: 338 Miles

Stone is an all natural material so the only CO_2 that is released with stone is in the mining process. Stone does not need any finishes or chemicals to preserve the integrity of the material.

Wooden Structural Systems

Qualities

Wooden Structures in general can typically be perceived as a liability when considering it in a space where the atmosphere contains alot of moisture or material properties preferred are economically feasible and long lasting. Although this can be the initial perception of wooden structural systems, the reality is wood can be applied to nearly every type of build due to the modern methods of treatment. Pressure, oil based penetrative, surface coating are just a few possibilities of treatments possible to protect against moisture and microorganisms.

Although this extra step is necessary if considered for the structural system of dairy cow housing spaces, the possibilities are endless when considered for the public and educational spaces. Wood generally can help spaces feel warmer and more inviting.

Not only is the wooden structural system appealing but it is also sustainable in the way it captures carbon from the atmosphere and stores it for its lifetime.

Generally a disadvantage of wood, especially in the current economical market would be the price especially to fabricate unique members. Any wood used would also need to be transported from other regions because Lincoln is not considered to be a large producer of lumber, adding to the carbon footprint and overall costs.

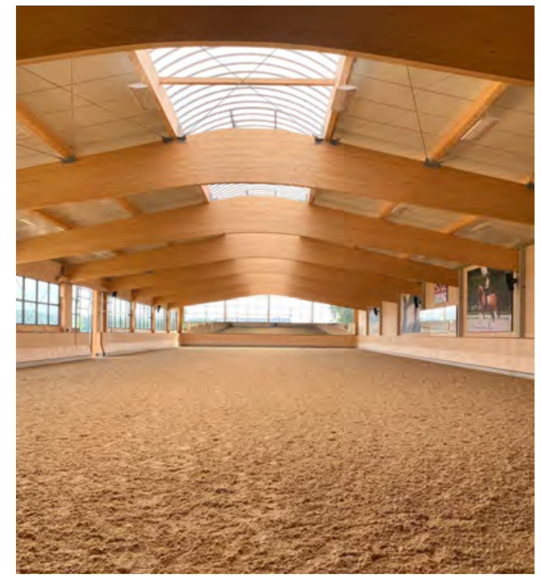
Post & Beam

The conventional post and beam structure is widely popular in the barn building typology today because of its structural stability and functionality. Post and Beam structural systems usually arrive as individual dimensional materials and are constructed on site. It is however, common if there is a truss systems for it to be pre fabricated and transported as an assembled unit.

Pros: Easy to maintain and add onto if necessary, lots of places to tie into
Cons: Limited to spaces between columns.

Perceptions: Most reasonable and cost effective option, would need treated.

Span: 40-60 feet



Pre-Fabricated

Glulam can be considered a pre-fabricated structural type of wood and it is most well known for its sustainability as well as durability. It is popular in any type of build because of its moisture resistant properties as well as its long span reach. During the manufacturing process, wood veneer is bonded together with moisture-resistant adhesives to help glulam products withstand exterior exposure.

Pros: Capable of spanning long distances
Cons: Can be difficult/expensive to fabricate

Perceptions: Aesthetically appealing and inviting but moisture would cause issues.

Span: 100+ feet

Gridshell

The gridshell is a structure type that is composed of segments, typically dimensional lumber or in some cases an engineered system, that connect together to create a doubly curved form. The joints usually consist of a metal clamp bracket allowing for some flexibility. There are also other joint possibilities that stack or weave the members.

Pros: Small members easier to assemble
Cons: Difficult to engineer/maintain, difficult to ventilate

Perceptions: Tall and difficult to tie in any interior program.

Span: 100+ feet (depends of member length and increments)

Vernacular

The vernacular form of the wood structural system is one that is adopted from European building methods. The process included using locally sourced materials to build up the whole structural system, typically hard, heavy wood. This structural system is very aesthetically appealing from the interior and exterior because of its height and overall form. One example of this type of system is the Gambrel Barn.

Pros: Extra space above for lofts/storage
Cons: Could be difficult to work around if structural members are oddly shaped

Perceptions: Aesthetically appealing and inviting but moisture would cause issues.

Span: 30 feet

Steel Structural Systems

Post and Beam

Post and Beam is the most cost-efficient metal structure because it uses short and light steel members to frame the building. Post and beam systems require intermediate columns between walls to support the structure. These columns must be considered in the design and the arrangement of stalls because they take up floor space. The columns may also obstruct camera and sensor reachability throughout the dairy barn as well as they may interfere with the public's view into the dairy barn.
Perception: A short span structure is not ideal because it limits design flexibility

Pros: Cost-efficient, ease of construction

Cons: Least aesthetically appealing, interior columns

Span: 20-50 ft

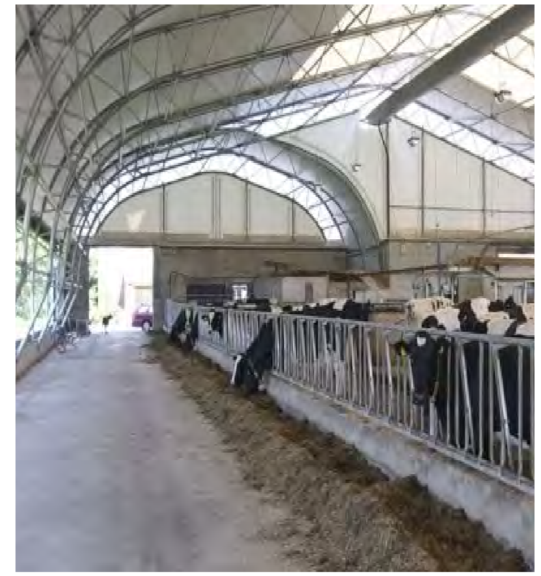
Pre-Fabricated

Prefabricated metal buildings can span long distances without the need of columns. Metal buildings are sold as a kit of parts and can be arranged in many ways to offer different building form and footprints. These metal building kits are the most common type of structures for steel buildings because they offer a high degree of flexibility for an affordable price.
Perception: Most common in agricultural buildings

Pros: design flexibility, can span long distances

Cons: Lacks some aesthetic qualities

Span: 50-300 ft



Arch Structure

Steel arch structures are created by a row of trusses that extend from the ground plane of one wall to the opposite wall in a curved profile, creating a tunnel form. These arch structures can span long distances and propose a specific exterior building form. The curved steel truss also has more aesthetic qualities when compared to other systems, although the form is constrained to a tunnel structure.
Perception: Unique curved interior quality

Pros: Long span, mechanical equipment can easily pass-through truss

Cons: Limited building shape flexibility

Span: 50-250 ft

Open Web Jo ist

Open web steel joists are common structural systems in large industrial and agricultural buildings. They provide roof support for a structure that can span long distances. For longer spans, the depth of the joist increases, but the joist allows air and light to easily pass through, like a truss system. These may be more desirable because they are flexible when it comes to roof slope. Steel joists can be designed with minimal slopes which would decrease the cross section of the building and improve air flow and ventilation.
Perception: works well with other structural material elements

Pros: Long span, many roof design options

Cons: Price, may create ledges for birds to land

Span: 50-300ft

Qualities

Metal building are often used for the structure of agricultural buildings. A steel structure is highly durable and cost efficient, requiring little maintenance. Steel structures are noncombustible and can be protected with paint and primers to avoid corrosion in a moist climate such as a dairy barn. Steel structures come in a wide variety based on the types of main structural members that are used and they each have their own benefits.

Most steel structures can be assembled in a variety of forms to adapt to a building's specific needs and program. A steel structure can be used to support the entirety of the project, including the dairy barn and the public spaces, or steel can be used in combination with other structural types. For example, the dairy barn can be a typical steel rigid frame structure, while the public program can be made up of more appealing structural members, such as glulam beams that are tied into the diary barn's metal structure. All steel buildings require a concrete foundation that can support the vertical structural members.

Although steel is the least costly method, it lacks in aesthetic qualities, which will play a large roll in attracting visitors to the facility. The structural system can play a large part in creating an engaging atmosphere that demonstrates to the public that small robotic dairy farm operations are designed around the welfare of the cow.

Wood & Steel Combination

Qualities

The combination of wood and steel construction is commonly seen in residential and commercial projects. While this combination of wood and steel is common in designed human spaces, the construction type can also be seen in agricultural building types. Steel fabricated buildings are most common for agricultural buildings, specifically dairy farms, because of their strength and durability. Wood can also be seen used as the building material for agricultural buildings for its cost-effectiveness and its availability, while also having properties of durability.

While the use of a single material in the construction of an agricultural building is common, the combination of both wood and steel is regularly overlooked. The use of these two different materials in a structural system can maximize the various structural components depending on the use and material selected.

Not only does the combination of materials allow for the increased potential of the structural components' function, but it also provides an interesting contrast for the users of the space. The strong and dark steel makes a visually interesting combination with the warm tones of wood.

Keeping in mind the dairy barn and other programmatic spaces outside of it, the combination of wood and steel would be a successful option for the construction of this facility.

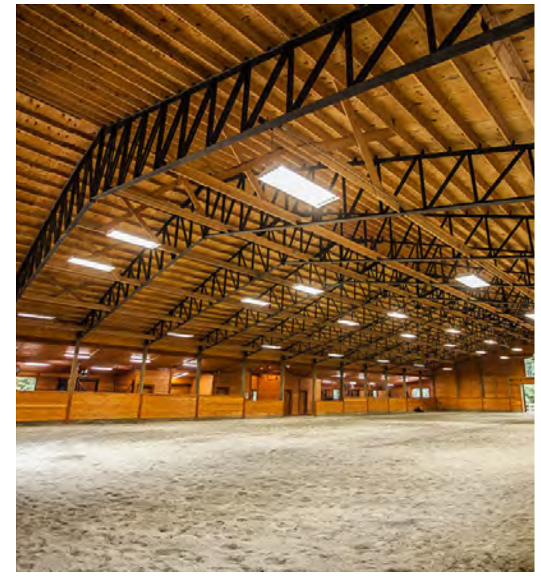
Glulam & Steel Decking

Glulam provides needed durability and sustainability while allowing for a warm-feeling environment. Steel decking is known for being a sturdy material and a long-lasting roofing option. The use of glulam provides unique forms and moisture resistance while the steel decking provides durability and an interesting contrast with the wooden structure.

Pros: Capable of spanning long distances
Cons: Sourcing glulam can be difficult

Perceptions: Warm qualities, moisture treatment would be necessary

Spans: 100+ feet



Steel Joist & Wood Decking

Steel joists allow for long spans as well as durability over years of aging. As seen above, open-web steel joists allow for effective air ventilation through a space. Wood decking is an affordable and lightweight roofing option. Steel joists, specifically open-web joists, provide strong long spans while also being a lightweight load on the lower portion of the structure. The combination of the wood decking with the steel joists creates an appealing blend of materials.

Pros: Capable of spanning long distances
Cons: Roof can be exposed to moisture damage

Perceptions: Appealing material combination, roof prone to moisture issues

Spans: 80+ feet

Wood Framing & Steel Decking

Wood framing is an affordable and effective roofing option. This option provides a warm-feeling environment to the users surrounding the structure. Steel decking is known for being a sturdy material and a long-lasting roofing option. The combination of wood framing and steel decking provides an affordable curvature structure form while being covered with a strong and durable material.

Pros: Building materials are easily accessible and cost effective
Cons: Lightweight and moisture damage

Perceptions: Cost effective option, though moisture would cause issues

Spans: 40 feet

Glulam & Steel Framing

Glulam provides needed durability and sustainability, while allowing for a warm-feeling environment. Steel framing is a common and effect structural system for dairy barns and other agricultural buildings. Glulam used for joists provides unique forms and moisture resistance while steel framing creates a strong, tied together structural system.

Pros: Steel framing provides moisture protection
Cons: Can be an expensive combination

Perceptions: Aesthetically appealing, moisture treatment would be neccessary

Spans: 100+ feet

Conclusions
Material & Technique Studies

Each structural type mentioned; wood, steel and a combination, have their advantages and disadvantages but each could be used depending on aesthetic preference and economical impact.

In the built environment one can observe many techniques and materials that focus on cow comfort, sustainability and public engagement. While some of the structures that we have observed are better in some areas, different materials and techniques perform better based on the specific values in mind.

It is important to also consider the different ways to implement structural systems beyond the dairy farms we have observed. The options provided give some insight into each material type as well as some structural systems that range from basic to complex.

"Wood engages the public and is modern, sustainable and aesthetically appealing"

"Too industrialized barn aesthetic could discourage perception"

"Cow public perception should be the most important, not the production"

Based on the information presented we can suggest that the wooden structural system gives designers the most flexibility as well as it ranks highest in public perception. It is important to note that in order to be utilized in the dairy cow housing spaces, the wooden structural systems would need to be treated for moisture exposure. It is also important to consider not using any web systems as they can become nesting places for unwanted animals.