Reconsidering the Slab:
The Concrete Sidewalks of Minneapolis
and Their Hidden Landscapes

A Thesis
SUBMITTED TO THE FACULTY OF THE
UNIVERSITY OF MINNESOTA
BY

Laura J Meyer

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE

Advisor: Kristine Miller Ph.D

December, 2020

ACKNOWLEDGMENTS

ACKNOWLEDGMENT:

I would like to express my deepest appreciation to my illustrious thesis committee: to my advisor Kristine Miller who first suggested this track and has stood by me on the walk, to Karen Lutsky who made the first phase of this process a period of creativity and delight, and to Mae Davenport in whose environmental planning class I learned to conduct the interviews that became such an integral piece of this thesis. I also extend my deepest gratitude to my unofficial committee members - my life partner, Brooks Cashbaugh and my “lab partner”, Sonali Devarajan - my tireless proof-readers, coconspiritors, and academic champions. I extend my sincere thanks to my expert interviewees: Andrew Caddok, Catherine Vennewitz, Craig Pinkalla, Nic Jelinski, Blake Bartelma, and Jeremy Uchtman, all of whom generously offered their time and insights and whose contributions brought the ideas in this thesis to life. I offer a special thanks to all the friends and family who adventurously took to the streets during an uncertain time to contribute their experiences and perspectives to *Walking Through the Pandemic*. A very special thanks to my therapist, Jeff, who encouraged me to both find a new path and stay the course, and to my father, Warren, who funded my last semester of graduate school so that I could complete this meandering journey.

LAND ACKNOWLEDGMENT:

My daily walking area resides on Dakota Homelands ceded in the unjust Treaties of 1837 and 1851. This area, which encompass roughly nine square miles, from Franklin Ave SE to Lowry Ave NE and Interstate 94 to NE Stinson Blvd, is centered around Haha Wapka (River of Falls) where the Dakota have lived for generations. The sidewalks I walk everyday take me past sites that are sacred to the Dakota people, including Owámniyomni (Falling Water) Wita Wanagi (Spirit Island) and Wita Waste (Beautiful Island). Some of these sites are visible to passing pedestrians, some have been destroyed, all have been irreversibly altered as a consequence of colonial occupation of this land. I recognize that the brutal history of stolen land is an often overlooked aspect of landscape design and landscape research and that it is my responsibility as a landscape designer to acknowledge and include these histories in practices that touch indigenous landscapes.

TABLE OF CONTENTS

FIGURE LIST

FIGURE 1 :THE SURFACE TITLE PAGE

Consider the sidewalk you're walking on. What do you see when you stop to gaze at it unfurling in front of you? A uniform ribbon of gray concrete expanding towards the horizon? Look again. Is the surface really uniform? Or, is it a patchwork of panels, each holding the distinct patina of a different age. Are the panels intact or are there cracks that cut diagonally across the slab? Look down at the surface of the sidewalk. Touch it. Is it smooth? Or, does it feel rough against your fingers with ridges like an elephant's skin? Is the finish consistent, like hardened pudding? Or, is it pocked, pitted, or worn unevenly, exposing its rocky insides? Trace the edges of the slab you're standing on. Are they sharply delineated, still showing evidence of the forms that held them as they cured. Or, are they weathered by time, slowly crumbling back to their raw components? Next examine the gaps between the panels. Are they clear of debris? Or, are they filled with water? Sand? Soil? Is there moss growing in the shade of these tiny troughs or are there weeds sprouting toward the sun? Are ant hills exploding from the cracks and joints like miniature mushroom clouds? Turn your attention to the ground that runs alongside the walk. Is it verdant or bare? Can you see the soil? Is it compacted or encrusted with salt? Now consider the individual slabs before you. Do they lay evenly upon the land or do they undulate haphazardly? How does the slab feel under your feet as you walk? Stable or slippery? When you step down, do you hear the crackle of autumn leaves? Is the surface slick with powdery snow or a treacherous lacquer of reflective ice. Look closely at the surface now. Can you see evidence of human hieroglyphics in chalk or spray paint? Did you notice the ephemeral trace of a cast shadow? Can you see impressions stamped in the concrete? A foot, paw, or hand print? Maybe the tracks from a renegade bike tire? What else can you see as you walk slowly and observe? A caterpillar? A discarded chicken bone? A lost earring? Creeping blooms of lichen? Can you move slowly enough to spot the slight impression of a fallen leaf, faintly fossilized in the hardened concrete surface?

Every trace on the sidewalks surface tells a story. Each mark is a record of a social, material, or ecological system that interacts with the physical sidewalk slab. For the last year, I've been observing sidewalks - their surfaces, slabs, edges, cracks, and heavings, while tracking their individual histories and overlapping narratives. This thesis is the result of those investigations.

Sidewalks are one of many largely unconsidered elements of the urban landscape - a hand-me-down design from an era when people were less aware of or concerned with how human-designed artifacts interacted with the natural world. In order to combat this inherited carelessness, this thesis proposes a landscape design process that closely examines and strives to understand the complex systems and processes at play in the landscape. I believe a design process that prioritizes observation and research of interconnected systems will enable a more complex understanding of how sidewalks are operating within the landscape, and ultimately lead to sidewalk design that is more sensitive and responsive to the other systems that interact with the sidewalk slab.

The thesis you are about to read is an effort to reconsider the common urban sidewalk and rethink the way these objects are designed. As a ubiquitous element of our everyday infrastructure, sidewalks are often a taken for granted element of the landscape. But sidewalks are also an integral part of an extended network of urban systems. What else is obscured when we take them for granted? How can we start to understand these systems through closer inspection of the sidewalk's surface? What can we learn about our landscape beyond the slab through deeper consideration of the sidewalk itself?

PURPOSE AND APPROACH:

From the beginning, the purpose of this thesis was to look at ways to utilize and expand upon the typical design research process in order to gain a better understanding of the many systems that interact with the urban sidewalk network. The goal was not to deliver a design for the ideal sidewalk. Part of what my research has taught me is that sidewalks are already diverse, necessarily responding to a variety of specific factors on the ground. This is a good thing. Future sidewalks should be even more diverse, in order to respond to a wider range of systems and conditions. Each sidewalk should be sensitive to the specific conditions of where it is placed. Therefore, this thesis will not conclude with a single best sidewalk solution, because there is no single best sidewalk solution.

Instead, this thesis lays out a process of exploration and uses that process to build a better understanding of urban sidewalks and their connected systems. This knowledge can be used to identify the oversights in the existing process of sidewalk design. This thesis is intended to expand the understanding of sidewalks within the field of design. I offer this document as a reference for others to use to design better sidewalks and for pursuing related research. Additionally, this thesis serves as a model for positioning research as the primary purpose of a design project. Specific suggestions for this are presented in the conclusion of this thesis.

Throughout this thesis process, I have tried to set aside preconceptions I might have about sidewalks and explore the slab with an open mind. In order to allow a deeper understanding of sidewalk systems to develop, I first had to confront the prejudice that sidewalks were a banal and lowly subject, not deserving of serious study. To counteract this false perception, I've purposefully approached the research of contemporary urban sidewalk as I would any designed object worthy of consideration. At the same time, I've tried to avoid the aesthetic fetishization that can sometimes result from a reactionary glorification of urban infrastructure.

CONTEXT/SIGNIFICANCE:

This thesis research was conducted during a period of growing interest in sidewalks. While I started these explorations before the COVD-19 Pandemic, much of this work has been conducted during the first wave of the pandemic in the United States. When I became interested in urban sidewalks and set the scope of this thesis in a pre-COVID world, I felt I had wandered into extremely esoteric terrain. But the pandemic has shed a bright light on the inadequacies of our urban infrastructure. With sidewalks in particular, I have read scores of articles from a variety of sources including the *ArchDaily*, *Harvard Political Review*, *Business Insider*, and *Bloomberg CityLab* highlighting three key issues: (1) In general, urban sidewalks are too narrow for people to keep a safe social distance when passing another person.[1] (2) The narrowness of urban sidewalk is in large part due to the fact that so much of our American urban landscape has been ceded to automobiles, greatly reducing the possibilities for sidewalks to serve as outdoor gathering spaces.[23] (3) Even where pedestrian friendly "safe streets" do exist, they are not necessarily safe spaces for people of color to occupy. [4]While my research does not explicitly explore these topics, I see this thesis as belonging to a larger rethinking of urban sidewalks. As we recalibrate these social spaces to better support the needs of people, we should also reconsider the way they are constructed to ensure that they also account for the needs of the nonhuman environment. Ultimately, the health of these natural systems directly impacts the well being of humans who use sidewalks, whether we recognize it or not.

SCOPE OF WORK - WHAT THIS THESIS EXPLORES:

This thesis is a small collection of stories about the interconnected systems that intersect with the sidewalk slab. All these systems are integral to the form and performance of the sidewalk in the physical environment. Yet, they are also systems that often go unacknowledged in sidewalk design and landscape architecture in general. At 100+ pages, this document is by no means a brief study, but it still only examines a handful of the important systems and processes within the broad network that intersects with urban sidewalks. For this thesis, I have limited my focus in two ways. First, I restricted my research to the systems and processes responsible for the physical object of the concrete slab (i.e. how it's made, what it's made of, where the component parts come from, as well as the global impact of construction and the effect of the physical slab on its immediate surroundings). Second, all the explorations in this thesis were initially prompted by things that I personally observed on daily walks around my Minneapolis neighborhood. Although, I allowed myself space to branch out as much as needed in order to understand how these processes operate.

SCOPE OF WORK - WHAT THIS THESIS DOES NOT EXPLORE:

Because of these restrictions, there are many sidewalk systems not explored in this thesis. For example, outside of the *Walking Through the Pandemic* project in the postscript, I did not look at the complex social dynamics of the sidewalk, thereby excluding the very significant systems that make the sidewalk a complicated social and cultural space. I have also only included sidewalk history where it was relevant to my argument about the sidewalk's physical nature, although these systems are equally integral to the way the sidewalk functions in the urban environment. Luckily, others have addressed these important topics. In *Sidewalks: Conflict and Negotiation over Public Space*, Anestasia Loukaitou-Sideris and Renia Ehrenfeucht provide an excellent and thorough social history of the sidewalks of Los Angeles and *The Road Taken*, by Henry Petriski offers a more broad history of the evolution of urban infrastructure in America.

Even within the narrow topics I have looked at: sidewalk construction, landscapes of extraction, and soil systems, there are many uncharted pathways for different and deeper research. Research of the material slab would naturally extend to slab grading/water flow dynamics, ADA guidelines, and designing for winter/winter snow removal. (I believe that this last topic often goes criminally ignored when designing for the frigid landscape of the Twin Cities and this could provide enough research and design opportunities to support multiple theses and dissertations.)

THESIS OVERVIEW:

There are four sections, or parts, that comprise the body of the thesis. In order, these sections are titled: “Part 1: Leaf Impressions,” “Part 2: The Slab,” “Part 3: The Concrete Landscape,” and “Part 4: The Underside.” These four sections all follow the same five step “Methods” structure, which is further outlined below. The “Leaf Impression” section looks at the process of creating relief prints from sidewalk leaf impressions. It also explores how these impressions were first created on the concrete sidewalk surface. This exploration was my reintroduction to urban sidewalks as new questions and a deeper relationship with sidewalks developed through the printmaking process. “The Slab” section examines the construction of a new sidewalk on campus. The information that supports this section was collected at a site visit where I observed and documented a sidewalk pour. While on site, I also interviewed the sidewalk construction crew. “The Concrete Landscape” considers the landscapes from which the concrete ingredients are extracted and the environmental effects of that process. This section mixes traditional research methods with an urban walk that connects to examples of these landscapes in my Minneapolis neighborhood. Site drawings of these landscapes provided an opportunity to learn these spaces in a more intimate way. “The Underside” section explores the urban soil landscape upon which these sidewalks sit and the complex relationship between the sidewalk and the soil. This is the most science-heavy section of the thesis, composed largely of information found in soil science studies and photo documentation of sidewalk observations. The specific areas of focus in this section were guided by conversations with my soil science professor, Nic Jelinski.

I consider each of these sections of the thesis an individual urban sidewalk exploration, first prompted by observations of the sidewalk surface. Each section represents the sum total of the multimodal research I've collected on a particular topic. The four explorations were conducted independent of one another and focus on different aspects of the interconnected sidewalk system. Each section may be read as a separate deep-dive into a particular subject, or, when read together they create a more holistic picture of the object and its systems.

The body of the thesis concludes with a summary of the key findings from each section and suggestions for future research. Another outcome of this process is a methodology, a body of methods or rules that allow for a deep understanding of a particular object or system in the landscape. Therefore, the conclusion also includes a discussion of the methodology that resulted from these sidewalk explorations.

Following the conclusion, I have added a participatory walking project titled, *Walking Through the Pandemic*. I conceived of this project while I was working on my thesis and with the help of willing collaborators was able to implement it over the spring and summer of 2020. This project was not intended to be part of the body of the thesis and does not contribute directly to the conclusion as much as it is a separate product of my growing interest in sidewalk space. However, the project's themes of walking and observing are related to the work of this thesis so I have included it in this document as a postscript, without the methods structure of the other four sections. I have also included it because it was a joy to create and I hope it will feel like a reward to read it at the end of the thesis.

METHODOLOGICAL PRECEDENTS:

While research focused design projects, such as this, are not as common as product focused design projects, there is a long history of challenging this particular status quo.

Two texts from this cannon were especially inspirational to this thesis: (1) *Distance and Engagement: Walking, Thinking and Making Landscape* by Alice Foxley (Vogt Landscape Architects) and (2) *Learning From Las Vegas* by architects Robert Venturi, Denise Scott Brown and Steven Izenour.

In *Distance and Engagement*, the author describes the research-heavy design practice of Vogt Landscape Architects. Their research process, in particular, is expressed in painstaking and luscious detail as Foxly describes "[e]xcursions into landscapes" that "take on the guise of scientific surveys...what usually begins as a general interest in specific phenomena, whether geological, biological or man-made..."[5] Accounts of these excursions constitute the majority of the book's text. The book also includes copious site photos, field sketches, diagrams and models in a range of scales and finishes - all beautifully formatted and integrated into the text. The methodology described in *Distance and Engagement* is experiential at its core, advocating for a research process that is a shift away from "a more academic-scientific viewpoint...to the contemplation of select themes of landscape and design of varying intensity and from different points of view."[6] A similar contemplation of multiple scales, intensities, and perspectives became a central tenet of my own research approach. This book has been by my desk-side since I started this thesis process and I have returned to it many times for everything from philosophical to formatting inspiration.

First Published in 1977, *Learning From Las Vegas* is an influential text of postmodern architecture theory, but without the heaviness that description implies. The playfully polemic book takes energetic swipes at modernist design values while arguing for deeper consideration of the common aspects of the built environment. Focused around a studio design project that analyzed the architecture of the Las Vegas Strip, the book challenged what was conventionally conceived of as important and worthy of academic study. The authors argue that "[a]rchitects are out of the habit of looking nonjudgmentally at the environment because orthodox modern architecture...is dissatisfied with the existing conditions. Modern architecture has been anything but permissive: Architects have preferred to change the existing environment rather than enhance what is there."[7]

Through their research the authors advocated for "learning from the commonplace" through non judgmental observation of the existing landscape.[8] I reread this book cover to cover as I embarked on this process and it has served as an important spiritual and methodological guide for this thesis.

In addition to the two texts described above, my approach to this thesis research closely parallels the observational methods defined by John Zeisel, in his influential essay "Observing Physical Traces," from the book *Inquiry by Design* (2006). In this essay, Zeisel explains how researchers can look at traces in their "physical surroundings to find reflections of previous activity." [9] From observation of these traces "researchers may begin to infer how the environment got this way" by asking questions about what caused the trace and "what sequence of events led up to the trace."[10] This process of trace observation and question asking is very similar to the first two steps of the methods I created for this thesis. Additionally, the devices Zeisel suggests for recording observed traces, especially photos, drawings, and diagrams are consistent with my own methodological approach. The key difference between the methodology laid out in "Observing Physical Traces" and my own research is that I have expanded beyond a focus on human-caused traces to also consider traces left by non-human processes and actors.

Distance and Engagement, *Learning from Las Vegas*, and "Observing Physical Traces," all describe design practices that use phenomenological methods to instigate research. These methods are phenomenological in that they begin by considering phenomena, or "things as they appear."[11] Generally, this is a "descriptive rather than explanatory"[12] process relying on "knowledge based on intuition and essence" that "precedes empirical" understanding.[13] For phenomenological research, "[a]ny phenomenon represents a suitable starting point for an investigation" and can serve as "the essential beginning" of scientific research.[14] In the three design methodologies described above, phenomenological observation is followed by further research and analysis, either in the lab or studio. This analytical or explanatory research falls outside of phenomenology and belongs to other research practices. For example, giving "causal or evolutionary explanations" of the observed phenomena, "would be the job of the natural sciences."[15] My own approach to this thesis research aligns with this trajectory from intuition to reason, from descriptive observation to explanatory analysis.

In addition to these three design research precedents, the art practices of two influential American artists, Ed Ruscha and Sol LeWitt, have also been inspirational to my research approach. Ed Ruscha is a living artist who works in a variety of mediums including painting, drawing, printmaking, and photography. He has been associated with both the Pop and Conceptual Art movements of the later half of the 20th century, although Ruscha has described himself as an "abstract artist ... who deals with subject matter."[16] It is Ed Ruscha's photo books from the 1960's such as *26 Gasoline Stations* and *Every Building on the Sunset Strip* that are particularly relevant to this thesis. For *26 Gasoline Stations*, the artist photographed petrol stations, along the highway between his home in Los Angeles and his parent's house in Oklahoma City.[17] Each photograph was taken from the highway and "appear to be simply factual records of the petrol stations" and captions consist only of the station name and location.[18] This approach to consistently cataloging objects and traces influenced my leaf impression project as well as the photo documentation that occurs throughout this thesis. Additionally, Ed Ruscha's focus on under considered objects and landscapes has been influential. Ruscha eloquently explains this preoccupation this way, "[t]here are things that I'm constantly looking at that I feel should be elevated to greater status, almost to philosophical status or to a religious status. That's why taking things out of context is a useful tool to an artist. It's the concept of taking something that's not subject matter and making it subject matter."[19] This artist's philosophy of reconsidering the importance of everyday objects has also informed the methodology of the thesis.

Sol Lewitt (September 9, 1928 – April 8, 2007) was a pivotal figure in the Minimalist and Conceptual Art movements. He is perhaps best known for his *Wall Drawings*, where he had other people apply lines to a blank wall in different variations following a "rubric of formal instructions" which were first created by the artist.[20] In his seminal 1967 essay, "Paragraphs on Conceptual Art*,"* LeWitt explains his approach this way "[w]hen an artist uses a conceptual form of art, it means that all of the planning and decisions are made beforehand and the execution is a perfunctory affair. The idea becomes a machine that makes the art."[21] Like Sol LeWitt, I am interested in applying formal instructions to creative endeavors as a strategy for giving shape to abstract ideas. Stated more simply, I often come up with guidelines before making so that the process of making can happen more freely. Instructions can also serve as a way to allow collaborators to enter easily into the creative process, as with LeWitt's *Wall Drawings*. The influence of Sol LeWitt on this thesis is most obvious in the *Walking through the Pandemic* postscript, where I created a six step rule set for participants to follow, keeping the instructions simple yet vague, in order to allow for individual interpretation and variation. Though perhaps less obvious, his influence is equally essential to the methods I created for myself to guide me through each section of the thesis.

In order to bring structure and consistency to my meandering phenomenological tendencies, I created a five step "Methods" outline, a series of the same specific steps to follow for each section. I also found this template to be a useful way to start to pull apart and organize the information within each section. In designing my own research methods, I borrowed from conceptual art rule-setting practices as much as any existing research methodology from science, social science, or design. However, since I have also been passively absorbing those other methods for years, I am aware that they are also influential to how I think about organizing research, even if I'm not referencing them directly as precedents for my own methodology.

METHODS:
The four sections that comprise the body of the thesis follow the structure outlined below.

Observe:
This step provides a brief description of observations of the sidewalk surface which have prompted the research for each section - things I noticed when out on walks that initiated a particular line of inquiry.

Wonder:

This step is simply stating the question, or set of questions prompted by the in situ observations. These questions either state something I do not know about sidewalks or something I would like to better understand. These questions are often straightforward and seemingly simple but they enable a line of complex investigation.

Explore:

This step describes my specific approach to answering the questions prompted by my sidewalk observations. These descriptions include significant aspects of the research - key sources, modes of research, and the order in which the research was conducted. In this thesis, I frequently use the term “exploration” as a way to expand the definition of research to include traditional academic research methods (literature analysis, interviews) as well as art and design research methods (printmaking, site visits, photo documentation, observational drawing, and diagramming).

Report:

This step is the sharing of the research, i.e. what I discovered by exploring the questions through various modes. This tends to be the largest written component of each section. Additionally, this section typically connects directly to the visual elements (prints, collages, photos, diagrams, and drawings) included in each section. In some cases these visual elements illustrate key findings in the text, or provide insight that is difficult to express with words alone. Other times, the visuals take the lead, containing more information than the writing. In this case the text functions as a way to tie images together.

Reflect:

The final step of this process involves synthesis and analysis of the research. Specifically, this section explores how the research changed the way I understand urban sidewalks. It also connects this new understanding back to sidewalk design. This process of analysis often initiates new, more complex or philosophical questions, laying the ground for further consideration in the conclusion and future paths of research.

The methods for this thesis were not actually created beforehand, but emerged during my reflections on the “Leaf Impressions” process described in the first section of the thesis. The making of the leaf prints was initially intended to be a discrete project so it had a more limited set of guiding instructions that are discussed in the “explore” step of “Part 1: Leaf Impressions.” The above methods were extrapolated from the leaf printing process and developed further after the fact, in an attempt to codify this more intuitive, singular endeavor into something reproducible for myself and others.

THE ROLE OF WALKING:

All of the sidewalk explorations in this thesis started with idle wondering, prompted by observations from my quotidian walks. Walking is essential to this kind of observational research because it happens at a slow pace that facilitates bringing attention to the fine details and subtle nuances of the physical world. It allows for spontaneous pausing, backtracking, bending, and crouching to get up close. Multiple meanderings past the same location also allow for observation of how conditions are changing over time. This wandering approach can lead to unexpected information and chance observations that you couldn’t get another way. The distance traveled tends to be small but there is a depth to the input of sight, sound, smell and sensation that can’t be collected through faster modes. Walking also allows for a unhurried sense of connectedness to one’s surroundings. While walking, you belong to the landscape you observe: you see it, hear it, smell it, feel it.

WHO GETS TO WALK:

Sidewalk access in American cities is not equitable. Race, gender, and mobility biases, as well as poor planning, design, and maintenance, can all affect the safety and accessibility of the sidewalk infrastructure. A 2017 transportation study showed that, “the distribution of active transportation [walking, biking] infrastructure in the United States often favors” wealthier neighborhoods.[22] Since infrastructure improvement projects are not equally distributed, not everyone has the same access to quality sidewalks. This systemic underinvestment in certain areas has lead to heightened pedestrian crash risk in Minneapolis neighborhoods with “lower household incomes and higher populations of minorities" [23]Additionally, people of color, especially black men, are disproportionately stopped by the police in public spaces. Black people "account for more than 60% of the 'use of force' victims in the past decade by Minneapolis police" although they are only "19% of the city's population."[24] This racial targeting results in sidewalks that are more dangerous for pedestrians of color.

In general sidewalks can also be unsafe spaces for women. A 2017 study of women using public transportation infrastructure to travel to and from urban campuses found that, "while sexual assault of female students in public transport may be sporadic, sexual harassment is a day-to-day reality for them, especially in the urban environment where the activity spaces of victims and perpetrators converge."[25] The same study also found this daily harassment to be "particularly troubling for low-income and minority women."[26]

Access to the sidewalk is further limited by method of mobility. Despite advances in sidewalk accessibility, sidewalk design still favors pedestrians on foot over pedestrians who use mobility devices such as wheelchairs, walkers, and canes. "Unfortunately, accessibility is often seen as a 'you have to,' rather than a desirable component of the planning, project development, design, and construction processes."[27] This accessibility gap widens in the winter when snow and ice block curb cuts, shrink the passing width of sidewalks, and make the sidewalk surface treacherous. According to *Our Streets Minneapolis*, a pedestrian advocacy organization, "...in Minneapolis, many sidewalks and crossing areas are not cleared of snow and ice promptly in the winter. Even when sidewalks and crossings are cleared, they are not consistently maintained for people who are walking and rolling."[28] In this way careless design and poor maintenance can also greatly reduce the number of people who are able to freely wander urban sidewalks.

As a petite, bespectacled, white woman, I am aware that I am perceived as a nonthreatening presence to many of my fellow pedestrians. This specific collection of traits allows me room to explore the urban environment with few restrictions and inhibitions because I am not perceived as a threat. Not only can I loiter freely and explore areas that are off the beaten path, I can even block pedestrian flow while making casts of sidewalk leaf impressions without being questioned. Bystanders barely noticed me at all and on the rare occasion that someone did comment on my sidewalk research, it was to inquire about the artwork that they had rightly guessed I was creating. Not everyone is granted the same right to explore public space unimpeded. I have colleagues who do not share my particular cocktail of physical characteristics who have been hassled while participating in similar explorations and I know others, people of color in particular, who have been harassed on the street for doing far less.

While my own daytime wandering mostly went unhindered, an alarming rise in armed robbery and sexual assault in my Minneapolis neighborhood, generally kept me off the sidewalks at night, or at least I chose to restrict my pedestrian activity through "routine precautions," such as hurried walks along well lit, high traffic, streets.[29] Therefore, the observations in this thesis have also been restricted to the daylight.[30]

Unfortunately, safe access to urban sidewalks is not universally granted. That does not mean that the methods of exploration in this thesis couldn't be adapted to account for a diversity of users with a variety of access requirements. But it does mean that different users will have different observations depending on when, where, how, and if they have safe access to public space. My own access to and exclusion from safe sidewalks is also inherently reflected in the data I was able to collect.

RESOURCES:
In addition to the methodological precedent texts listed above, a range of literary sources were essential in the construction of this thesis. The literature sources I referenced can be roughly divided into 6 categories: (1) environmental science literature, (2) concrete industry/engineering publications, (3) government guidelines and specifications, (4) nonprofit and think tank resources, (5) architecture and landscape design literature, and (6) news articles.

Environmental science sources, especially soil science and geology studies, were fundamental to my understanding of sidewalks and their connected systems. This scientific research was especially relevant to “The Concrete Landscape” and “Underside” sections. The sources that were most influential to my overall understanding of these natural systems were: *Soils of the Twin Cities Metropolitan Area and Their Relation to Urban Development*, by Lowell D. Hanson, “Urban Soils Part 1: Understanding Compaction,” by James Urban, “A description of urban soils and their desired characteristics,” by Phillip J. Craul, and *Environmental Geology of the Twin Cities Metropolitan Area*, by R.K. Hogberg.

Research for the “Leaf Impressions” and “The Slab” sections were supported by a host of concrete industry and engineering sources. Especially useful was the Portland Cement Association’s website (cement.org) which provides a detailed overview of concrete construction, materials, and processes tailored to a practitioner audience. I also referenced concrete engineering sources, often published by engineering departments at various universities, in order to enrich my understanding of the science of concrete curing.

Government Publications were also essential in understanding the national and local guidelines and regulations for sidewalk access and construction. Publications from the City of Minneapolis, Minnesota Department of Transportation (MnDOT), and the United States Access Board are referenced throughout this thesis.

Nonprofit and think tank websites such as *Center for Earth, Energy & Democracy*, *Our World in Data*, and *Union of Concerned Scientists*, were useful resources for accessing data about specific issues including global water use, climate change, and local pollution.

In order to tie this technical information back to the realm of design, I consulted a number architecture and landscape design books and journals including *Architect’s Journal*, *Landscape Architecture Magazine, Urban Omnibus* and Adrian Forty’s book, *Concrete and Culture: A Material History*. These design sources were essential to my understanding of how each subject I explored relates to the design profession and practices.

News articles were the final category of literature used to build this thesis. Similar to the design sources, these articles helped me to understand the other research in an applied, real world context. These articles covered topics as far ranging as reimagining sidewalks, boardwalk construction, water scarcity, and impervious surfaces. One article that was particularly influential to "The Concrete Landscape" section and the thesis conclusion was, "Concrete: the most destructive material on Earth" published in *The Guardian* on February 25, 2019.

In addition to these literature sources, research for this thesis was conducted through interviews and various art and design explorations. Interviews, both formal and informal, were a central means of gathering data for these sections. The formal interviews I conducted with Andrew Caddok (UMN Campus Planner), Catherine Vennewitz (Concrete Superintendent for Facilities Management U Construction), and Craig Pinkalla (the Forestry Preservation Coordinator with Minneapolis Parks) are vital contributions to the "Leaf Impressions", "Slab" and "Concrete Landscape" sections of the thesis. My informal, on-site discussion with Blake Bartelma (UMN Construction Project Manager) and Jeremy Uchtman (UMN Concrete Foreman) added vitality and technical detail to "The Slab" section. The content of "The Underside" was guided by an ongoing conversation with Nic Jelinski (Assistant Professor in the Department of Soil, Water and Climate). Interviews with these experts provided focus and depth to the research in this thesis.

In concert with literary analysis and interviews, I have conducted my thesis research through various art and design explorations. For example, the thesis process began with a printmaking project which initially sparked my interest in urban sidewalks. Throughout this process I conducted site visits and utilized photo documentation as a way of capturing observations in situ. For "The Concrete Landscape" section, I drew a geological block diagram in order to understand the underlying geology of my Minneapolis walking area. I also sketched the material landscapes of the same walking area to get to know the above ground portion of that landscape more intimately. The *Walking Through the*

Pandemic postscript uses individual observations and reflections to create a collection of personal sidewalk experiences. These approaches, borrowed from the art and design disciplines, offer insights that the other forms of research do not. They facilitate tactile and experiential knowledge of the landscape and offer opportunities for engagement and interaction.

A NOTE ABOUT IMAGES:

Because this is a design thesis, this document contains a multitude and diversity of images. The visual components included in the thesis are as much a part of the research process as they are illustrations or expressions of the text. Some of the visuals were created before the text, as is the case with the "Leaf Impression" prints and drawings for "The Concrete Landscape." The photo documentation of sidewalk surface traces was collected over the course of many months, and these photos were often the impetus for further research, this is especially true for "The Underside" section. For "The Slab" section, a visual narrative, made from compiling photos taken on site, was built in tandem with the written narrative and together they are mutually reinforcing. For these reasons, I do not consider the visual components to be secondary to the text of this thesis, but equals in research. However, the formatting of this thesis must follow strict University guidelines built for a thesis where the text has prominence. Because of this, it has been a challenge to format the thesis in a way that shows parity between text and images. In an effort to make the document as visually consistent, clean, and legible as possible. I have organized the sections with text at the beginning, followed by a collection of visual research for each section. Where necessary I have added parenthetical notes in the text to direct the reader to a particular visual/figure.

The exceptions to this are in "The Slab," "The Concrete Landscape," and *Walking Through the Pandemic*, where images and texts naturally commingle in places without creating an obstacle to legibility and flow.

WAYS TO READ THIS DOCUMENT:

Finally, the information in this thesis builds upon itself in two different ways. First, as each section moves through the "Methods," from Observe to Reflect, research of a specific process or system will evolve and expand. I have made an effort to keep each section as concise and readable as possible. However, the Report is often less succinct, expanding as much as necessary for me to gain an understanding of how the process or system being explored is operating. In the final step of the methods process - Reflect - I try to reduce the information to what is most relevant to sidewalk design and expand upon the ideas that were the most illuminating to my understanding of each sidewalk system. Therefore, this thesis can also be read across the four sections, through this final step, as each reflection will provide the reader with a broader, if somewhat shallow, sense of how sidewalks are operating across systems. When read this way, the Report can be seen as the long-hand math of the section, "showing the work" of the "solution" presented in each reflection.

The practices of observing, wondering, exploring, reporting and reflecting, reveal taken-for-granted landscapes like sidewalks as complex systems with local and global environmental impacts. Moving through each step in the sequence leads to new paths of inquiry and opportunities to practice new modes of research. The process is not necessarily linear, nor are the steps essentially discrete as wondering can lead back to observation as easily as it progresses towards exploration, which itself can be a form of observation. Therefore, these methods are not a strict protocol, but meant to serve as a loose guide for wandering through everyday landscapes with renewed consideration and wonder.

ENDNOTES:

1 Harrouk, "New York Map Highlights Sidewalks with Social Distancing Possibilities"

2 Garfield, "This ingenious illustration reveals how much space we give to cars"

3 Imbrie-Moore, "Reclaiming the Built Environment"

4 Thomas, "Safe Streets' Are Not Safe for Black Lives"

5 Foxley, Distance & Engagement, 7.

6 Foxley, Distance & Engagement, 9.

7 Venturi, Learning from Las Vegas, 3.

8 Venturi, Learning from Las Vegas, 3.

9 Zeisel, “Observing Physical Traces”, 159.

10 Zeisel, “Observing Physical Traces”, 161.

11 Moustakas, “Transcendental Phenomenology”, 2.

12 Internet Encyclopedia of Philosophy, “Phenomenology.”

13 Moustakas, “Transcendental Phenomenology”, 2.

14 Moustakas, “Transcendental Phenomenology”, 3.

15 Internet Encyclopedia of Philosophy, “Phenomenology.”

16 Gagosian. “Ed Ruscha.”

17 Tate. “Twentysix Gasoline Stations.”

18 Tate. “Twentysix Gasoline Stations.”

19 Gagosian. “Ed Ruscha.”

20 Artnet. “Sol LeWitt.”

21 LeWitt, “Paragraphs on Conceptual Art,” 80.

22 Lee, Sener, and Jones, “Understanding the Role of Equity, “ 211-212.

23 Lindsey, Tao, Wang, and Cao, “Pedestrian and Bicycle Crash Risk,” Executive Summary.

24 Sheree R., Curry. “George Floyd’s Minneapolis.”

25 Natarajan, Schmuhl, Sudula, and Mandala, “Sexual Victimization of College Students,” 178.

26 Natarajan, Schmuhl, Sudula, and Mandala, “Sexual Victimization of College Students,” 179.

27 Axelson, Kirschbaum, and the United States. *Designing Sidewalks and Trails for Access*, 4.

28 Our Streets Minneapolis. “Making Winters Walkable.”

29 Spewak, Danny. “MPD to do more safety walks in Marcy-Holmes.”

30 Natarajan, Schmuhl, Sudula, and Mandala, “Sexual Victimization of College Students,” 176.

INTRODUCTION SOURCES:

Artnet. “Sol LeWitt.” Accessed Dec 12, 2020. http://www.artnet.com/artists/sol-lewitt/

Axelson, Peter, Julie B. Kirschbaum, and United States. Federal Highway Administration. *Designing Sidewalks and Trails for Access*. 1999.

Berg, Amber, and Gregory L. Newmark. “Incorporating Equity into Pedestrian Master Plans.” Transportation Research Record 2674, no. 10 (October 2020): 764–80. https://doi.org/10.1177/0361198120936256.

Foxley, Alice., and Vogt Landschaftsarchitekten. *Distance & Engagement : Walking, Thinking and Making Landscape*. Baden, Switzerland: Lars Müller Publishers, 2010.

Gagosian. “Ed Ruscha.” Accessed Dec 12, 2020. https://gagosian.com/artists/ed-ruscha/

Garfield, Leanna. “This ingenious illustration reveals how much space we give to cars.” *Business Insider,* Apr 28, 2017. https://www.businessinsider.com/car-illustration-karl-jilg-2017-4

Harrouk, Christele. “New York Map Highlights Sidewalks with Social Distancing Possibilities.” *ArchDaily*, Aug 27, 2020. https://www.archdaily.com/938303/new-york-map-highlights-sidewalks-with-social-distancing-possibilities

Imbrie-Moore, Will. “Reclaiming the Built Environment.” *Harvard Political Review*, Jun 30, 2020. https://harvardpolitics.com/reclaiming-the-built-environment/
Internet Encyclopedia of Philosophy. “Phenomenology.” Accessed Dec 12, 2020. https://iep.utm.edu/phenom/

Lee, Richard J, Sener, Ipek N, and Jones, S. Nathan. “Understanding the Role of Equity in Active Transportation Planning in the United States.” Transport Reviews 37, no. 2 (2017): 211-26.

LeWitt, Sol. “Paragraphs on Conceptual Art.” *Artforum*. (Summer, 1967): 79-83. https://www.artforum.com/print/196706/paragraphs-on-conceptual-art-36719

Lindsey, Greg, Tao, Tao, Wang, Jueyu, and Cao, Jason. “Pedestrian and Bicycle Crash Risk and Equity: Implications for Street Improvement Projects.” Pedestrian and Bicycle Crash Risk and Equity: Implications for Street Improvement Projects, 2019.

Moustakas, Clark. “Transcendental Phenomenology: Conceptual Framework.” In *Phenomenological research methods*, 25-42. Thousand Oaks, CA: SAGE Publications, Inc., 1994. http://dx.doi.org.ezp2.lib.umn.edu/10.4135/9781412995658.

Natarajan, Mangai, Schmuhl, Margaret, Sudula, Susruta, and Mandala, Marissa. “Sexual Victimization of College Students in Public Transport Environments: A Whole Journey Approach.” Crime Prevention and Community Safety 19, no. 3-4 (2017): 168-82.
Our Streets Minneapolis. “Making Winters Walkable.” Accessed Dec 12, 2020. https://www.ourstreetsmpls.org/making_winters_walkable

Sheree R., Curry. “George Floyd’s Minneapolis: Multicultural facade hid decades of simmering racial inequality.” *USA TODAY,* June 11, 2020.

FIGURE 2 : SIDEWALK SURFACE TRACES - IMPRESSIONS

FIGURE 3 : SIDEWALK SURFACE TRACES - HIEROGLYPHS

FIGURE 4 : SIDEWALK SURFACE TRACES - SALT BRINE STREAKS

FIGURE 5 : SIDEWALK SURFACE TRACES - CAST SHADOWS

PART 1: LEAF IMPRESSIONS

Learning from the landscape is a way of being revolutionary for an architect, not in the obvious way which is to tear down Paris and begin again...but another more tolerant way; that is, to question how we look at what we see.

-Neil Denari

FIGURE 6 : LEAF IMPRESSIONS TITLE PAGE

OBSERVE:

Scattered among the many markings that cover the surface of urban sidewalks, you can find impressions of leaves. These embossed images are left by leaves that fall into wet concrete when sidewalks are newly poured. Some are faint and barely visible while others are deep and clearly defined. I can't remember when I first noticed the leaf impressions but I've been photographing them for over three years now and I have been transfixed by these impressions since I first discovered them imprinted on the surface of the sidewalk. Ever since, my daily walks have become an absent minded search for these spontaneous urban fossils cast in concrete. And every stretch of sidewalk, in every town, has become a potential record of the annual cycle of growth and loss of the urban forest canopy.

WONDER:

How can I make art from these artifacts? How are these impressions created in the first place?

EXPLORE:

In fall of 2019, in an effort to jump-start my thesis process, I participated in an independent study with Karen Lutsky, assistant professor of landscape architecture at UMN. Under Karen's guidance, I explored how design interventions can change a person's relationship to the landscape without significantly altering the physical landscape. In particular, I focused on projects that use mapping, marking, recording, way-finding and story telling, or projects where design functions as a form of research. Through this independent study, I investigated these themes through a series of case studies and my own explorations while building a catalogue of related ideas, quotes and questions. Concurrent to this research with Karen, I conducted my own exploration of the sidewalk leaf impressions which I had been informally documenting for years. This leaf print project became the centerpiece of this independent study (FIGURE 7-9).

This project really began back in 2018, when I was still living in New York. I had started noticing and photographing sidewalk leaf impressions on daily walks near my apartment in upper Manhattan. (Technically, these impressions are not restricted to leaves. I've documented and printed impressions of tree seeds, catkins, and bracts as well, but since the vast majority of the impressions are leaves, I've given them all this title for the sake of simplicity.) Cast just millimeters below the concrete surface, the impressions seem to beg to be freed from sidewalk captivity. So, in July of 2018, I turned my attention to making relief prints of the impressions I found.

I first attempted to print the leaves as rubbings. I experimented with charcoal, graphite and conté on various gages and types of paper. All these methods proved painstaking and somewhat disappointing, with conté on rice paper offering the clearest detail and least aggravating printing process. The issue with the rubbing attempts overall was an unsatisfying lack of definition, resulting in an insufficient expression of the specific essence of the leaf that was captured so well in the concrete. Noticing the leaf impressions in the first place happens by recognizing the presence of the leaf apart from the concrete. The presence of each foliage stamp emanates with surprising clarity, even from impressions that have registered with little detail or have eroded over time. I wanted the unambiguous identity of the impressions to transfer to the prints. It wasn't until spring of 2019, while I was playing with ink and plasticine, making relief molds of tree bark, that I had the idea that this process might also work to capture the concrete leaf impressions. So when the opportunity presented itself in my directed study with Karen, I set out on a meandering quest, in search of Minneapolis sidewalk leaves.

My exploration of the leaf impressions for the independent study can be broken into three primary parts:

Part one: Noticing

The first step involved noticing and recording the impressions. During my regular pedestrian commutes (from home to school, class to class, home to grocery store, etc.), I kept a close eye out for the comparatively smooth leaf outlines carved into the surface of the rough concrete. When I encountered an impression, I would stop, photograph, record the location, and try to identify the tree species. If possible, I also documented the source tree and the date the concrete was poured.

Part two: Printing

In the second step of the process, I created relief molds of the leaf impressions by rolling plasticine clay directly into the sidewalk impressions. I would then take the imprinted plasticine squares back to my studio where I would make black and white relief prints by rolling black printing ink onto the surface of the plasticine. The final step of the printing process was gently pressing paper onto the inked surface, much like wood block printing, just squishier (FIGURE 10).

Part Three: Marking

The third step of the exploration derived from my desire to call attention to the leaf impressions in situ by making them more visible to others. I was fortunate enough to discover a beautifully articulated hackberry leaf impression about a half a block from my apartment. In October 2019, I experimented with using gold leaf to highlight the impression. I began by painting the impression with a terracotta base. After letting that dry, I covered the terracotta in a thin layer of rabbit skin glue and laid down a 26-karat sheet of gold leaf, gilding the hackberry leaf's print. The real pleasure has been watching the gold leaf weather over time - from a brilliant almost garish gold to soft amber. In the winter it can be found happily glinting out from under a layer of snow, ice and sleet (FIGURE 11).

REPORT:

The more time I spent noticing, printing, and marking leaf impressions, the more I began to wonder how they are created in the first place. At first, there seemed to be an obvious answer. Leaves fall on newly poured concrete and leave behind impressions. Leaves are, after all, well known for falling, and the sidewalks in the Twin Cities are well regarded for their considerable street tree canopy cover. (Minneapolis alone has approximately 30% tree canopy cover and has been ranked in the top five urban forests in the US by the American Forests organization.)[12] But when you consider how feather-light leaves are and how little force they exert upon contact it seems surprising that they would be capable of leaving behind a detailed imprint.

And yet, sidewalk leaf impressions are common. While I still find them to be slightly magical when I come upon them, they are not exactly rare. Once you know what you're looking for, the impressions are fairly easy to spot - in Minneapolis, it's typical to find them on every walk, in some parts of the city they can be spotted on every block. I can't say that they are ubiquitous in every city, but they were common in New York where I first noticed them. And when I was visiting family in Monterey, CA, I found a lovely olive impression. In Seattle, a cypress. I'm currently living in Iowa City where sightings are frequent and the impressions seem especially well delineated. Last week I discovered a sycamore leaf, so large and perfectly articulated, I briefly questioned whether it had been placed intentionally.

So despite its lack of heft, somehow urban foliage is imprinting sidewalks across the country, if not the world. When I presented this project in the review for my directed study, my committee and I spent some time speculating about exactly how this occurs. It was Karen Lutsky who first suggested the probability that water is involved. Because of its molecular structure and partial negative charge, water is sticky.[3] Water molecules stick to themselves through a process called cohesion and stick to other substances through adhesion. Therefore, it is sensible that water would help the fallen leaves adhere to a newly poured concrete surface. As I moved forward with thesis research, I learned that concrete requires a substantial amount of water to harden. In fact, it actually doesn't dry - it cures, through a chemical reaction with cement called hydration.[4] During hydration free water not used in the reaction, rises to the surface of the concrete.[5] This shallow pool of "bleed water" stays on the surface of the slab until it evaporates. Learning this, it seemed plausible that a fallen leaf might be held in place by bleed water long enough to imprint in the concrete.[6]

This theory was supported by Catherine Vennewitz, the UMN Concrete Superintendent. According to Catherine, the leaf impressions must happen "right when [the concrete is] poured, because you can walk on [the sidewalk] in 24 hours." Depending on weather conditions, sometimes you can walk on the surface after only six hours, "so," Catherine mused, “I have to think it happened when there is still bleed water on top…”[7] Catherine went on to hypothesize that weather could also be a contributing factor, suggesting the leaf impressions would be most likely to occur in the spring or fall when the air outside is cool because “the cooler the temperature, the longer it takes for the bleed water to dry.” She explained that when the crews pour in the heat of summer, the bleed water can evaporate after a very short period of time. “Like, when they do something in July... by the time they get ten feet down it’s getting dry, so they have to pour less concrete at a time so that it doesn’t dry out.” Catherine also posited that rain might increase the likelihood that the leaf print would register. While she believed the bleed water was a possible explanation of how the leaves might stick to the concrete, she was skeptical that it would provide enough pressure to leave an enduring trace. She postulated, “even a leaf sitting on there wouldn’t press in.” But, she speculated that if “moisture was on top of that leaf and pressed in and the concrete took a really long time to dry,” that might do it. “I bet that’s what it is. I bet it’s rain in the fall and cool temperature. (But don’t quote me as saying for sure.)”

A few months later, I brought this same question to Craig Pinkalla, the Forestry Preservation Coordinator with Minneapolis Parks. I asked Craig if he had noticed the leaf impressions in his many years working in the field as an urban forester. “Yes,” he responded, “I have seen them, and I know exactly when it happens.” Craig went on to explain that after the concrete slab is poured and leveled, a finisher works the surface with a float. Floating helps the aggregate settle and gives the slab a smooth top surface. Craig explained that floating actually occurs after the majority of bleed water evaporates but working the slab in this way brings a thin watery layer of “cream” to the surface. After floating, the finisher will let the cream set up for a short period of time before brushing a parallel venation into the surface. “When they finish brushing, for about an hour, that cream is not set and it’s very very delicate,” Craig explained that “something as delicate as a leaf landing on it, it’s like it’s landing in wet watery pudding…[the leaf’s] surface area can get in just a little bit before it solidifies chemically to a point where it’s not impressionable anymore by something that small.” According to Craig, the window of time when this is possible is “very finite,” typically closing within an hour of being brushed.

Craig's description of the pudding like surface cream seemed to address Catherine's concern that the leaf would need additional pressure to register an imprint in the concrete. And the all leaf impressions that I printed *had* fallen on brushed surfaces that are evident in the prints, further supporting Craig's observations. Additionally, on a dry day in October 2019, I found a bract from a linden tree, still embedded in a newly poured and brushed slab of concrete (FIGURES 12). But I still wondered about Catherine's theory that cool weather would extend the length of time that the material would facilitate an impression and I wanted to see if I could corroborate this through research. Most of the time, when a new concrete walk is poured, the company or institution responsible, marks it with a date stamp and insignia. (According to city specifications, the date should be stamped once "every 50 lineal feet" or in one or two places if a lesser amount of concrete is poured.[8]) However, these date stamps are not always present, especially if only a single panel has been poured. But in my search for leaf impressions, I had found a couple of large stretches of sidewalk that each had accompanying date stamps and numerous leaf impressions. I looked up the climatological data from the dates stamped in the slab, hoping this might shed more insight on which conditions are most accommodating to the creation of leaf impressions.

The first patch of sidewalk I visited was in Northeast Minneapolis, just southwest of Northeast Park (near the corner of NE 13th Ave and NE Fillmore St). On this stretch of sidewalk, poured on October 20, 2017, I discovered an abundance and diversity of impressions, including Cottonwood, Elm, Oak and possibly Katalpa. According to the climatological data, the average temperature for that day was a mild 66 degrees, with trace amounts of precipitation. The sky was mostly sunny with a slight breeze (AVE SPD 13 MPH) from the northwest.

Moving on to my second destination, I headed south to a very shady stretch of residential sidewalk in Southeast Minneapolis. The sidewalk along SE 4th Ave is a patchwork of new and old slabs, possibly a result of heaving from the roots of the many mature trees that grow along this corridor. The Cottonwood, Hackberry and Pin Oak impressions here can mostly be found between SE 7th St and SE 5th St. The most recent panels were poured on November 15th, 2015. The Average temperature that day was 50 degrees and it was mostly sunny, with a very slight breeze (AVE SPD 8.5 MPH) from the northwest. My third and final site visit was an extensive portion of sidewalk on the University of Minnesota East Bank Campus, flanking both sides of West River Parkway, from the Education Sciences Building to Arlington St. There are scores of leaf impressions here, some are deeply inscribed and some are barely a trace. Poured on October, 4th, 2019, this is the most recent sidewalk of the three I visited - the brushed surface lines are sharp and you can still find dried leaf remnants clinging to some of the impressions. The average temperature the day this sidewalk was constructed was 47 degrees. The sky was cloudy with a very slight breeze (AVE SPD 9.1 MPH) from the north. Although there was no precipitation recorded that day, there was fog or mist, indicating some moisture was present in the air.

What can this date and weather info tell us about how leaf impressions form? Obviously, this is too small a sample size to draw any definitive conclusions, but some commonalities between these three sites can still help to expand upon the theories and speculation. First of all, it is clear that rain is not a requirement for the genesis of the leaf impressions, since only one of these dates had any precipitation and even then, only trace amounts. On the other hand, moisture might help facilitate the impressions, since one of the dates was also foggy or misty. This would corroborate something else Catherine had told me - that a cool and misty day is the ideal weather for sidewalk finishing because the concrete can cure slowly. Cool, or at least mild, weather is consistent among all three sidewalk sites on the dates they were poured. The average temps on those dates ranged from 47-66 degrees. As Catherine had guessed, none of the three sites I visited had been poured in the heat of summer, all were autumn construction. This makes intuitive sense. While spring construction might also provide ideal surface conditions for the formation of leaf impressions, at that time deciduous trees are still in the process of growing their annual leaves. It’s no surprise that more leaves would find their way to the wet concrete in autumn, when the trees are in their leaf shedding phase. One thing that did surprise me about the dates of these sidewalk pours, was that none of the three dates were particularly windy. The National Weather Service defines breezy as 15-25 MPH and windy as 25MPH or more. The highest average wind speed of any of the dates I looked at was 13 MPH, not even strong enough to qualify as breezy. This indicates that temperature, time of year, and possible moisture play a more significant role than wind in leaf impression formation.

So, based on the climatological data, it would appear that Craig Pinkalla's theory is probably correct. The leaf impressions are likely made when a leaf lands in the wet surface cream of a newly poured concrete slab. At the very least, his theory is not disproved by the climate data I looked at. It's also possible, as Catherine suggested, that this window for creation, before the cream hardens, can be expanded by cooler temperatures and possibly moisture in the air. In order to prove this theory, the next step would probably require testing in a controlled environment. Although this is a worthwhile pursuit, conclusively proving how leaf impressions formed did not become my goal. Instead, exploration of this specific phenomenon, guided me away from a narrow focus on leaf impressions and towards a holistic understanding of sidewalks and their intersecting systems.

REFLECT:

For years I have admired sidewalk leaf impressions and I was confident they would make captivating prints, if only I could figure out how to extract them. What surprised me though, after I finally made the prints and shared them with others, was how interested people seemed to be about the genesis of the impressions. I did not have ready answers which led me on an unexpected exploration of urban sidewalks - getting to know them through site visits, expert interviews, analysis of scientific research, and additional artistic investigations. The potential for an artistic endeavor to instigate research is often overlooked. Art making can be an integrated part of a research practice and does not merely have to serve as an illustration of research after the fact. In my case, the process of making and sharing the leaf prints enabled me to ask questions I would otherwise not have thought to ask.

For me, this outcome is far more important than any definitive answer about how leaf impressions are formed. I'm not a scientist, I don't ask questions in search of an exact answer. As a designer, I ask questions as a means to think about a landscape differently, as a way to elicit more questions and to direct further exploration. Although I did not arrive at a conclusive explanation of leaf impression formation, the process of research led me to something better: a broader understanding of a landscape feature and the systems interacting with it.

For me, this is the point of research - to gain a richer understanding of the systems at play in the landscape in order to ultimately design with these systems in mind, to be "more understanding and less authoritarian" in future design interventions.[9] Questions and answers are not the beginning and end of the process, neither are research and design. Rather all are part of a circuitous relationship with the landscape. The most important result of this process is the discovery of connections between seemingly unrelated things, like the chemical processes of concrete and the natural processes of trees. Like the links between climate data and construction methods, between engineers and foresters, art and infrastructure. Understanding these connections changes my relationship to things I might otherwise take for granted. It enables me to ask deeper questions, questions I wouldn't know to ask at the beginning. This process of non judgmental analysis is geared towards fostering a greater understanding and relationship with the landscape rather than a discrete end product. This kind of meandering experimentation can lead to unexpected places. It can begin with noticing a leaf impression in concrete and end with a graduate thesis about sidewalks.

ENDNOTES:

1 City of Minneapolis, "Minneapolis and the Urban Tree Canopy."

2 American Forests, "The Best Urban Forests."

3 USGA, "Adhesion and Cohesion of Water."

4 Popular Mechanics, "How It Works: Concrete."

5 Goguen, "Concrete Bleeding."

6 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

7 Ibid.

8 MnDOT, *Standard Specifications for Construction*, 9.

9 Venturi, Brown, and Izenour, *Learning from Las Vegas*, 6.

LEAF IMPRESSIONS SOURCES:

American Forests. “The Best Urban Forests.” February 5, 2013. https://www.americanforests.org/blog/the-best-urban-forests/

City of Minneapolis. “Minneapolis and the Urban Tree Canopy.” Last updated Oct 26, 2017. http://www2.minneapolismn.gov/sustainability/trees/canopy-map

Goguen, C. “Concrete Bleeding.” *National Precast Concrete Association*, September 17, 2014. https://precast.org/2014/09/concrete-bleeding/

Minnesota. Department of Transportation. *Standard Specifications for Construction : Special Provisions for the Construction of Concrete Sidewalks, Curb, Curb and Gutter, Alleys and Drive Approaches,* 2007. http://www2.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_278509.pdf

Popular Mechanics. “How It Works: Concrete.” October 1, 2009. https://www.popularmechanics.com/home/how-to/a3214/1275111/

United States Geological Survey : Water Science School. “Adhesion and Cohesion of Water.” Accessed November 10, 20202. https://www.usgs.gov/special-topic/water-science-school/science/adhesion-and-cohesion-water?qt-science_center_objects=0#qt-science_center_objects

Venturi, Robert, Scott Brown, Denise, and Izenour, Steven. *Learning from Las Vegas : The Forgotten Symbolism of Architectural Form*. Cambridge, Mass.: MIT Press, 1977.

FIGURE 7 : LEAF PRINTS 1

FIGURE 8 : LEAF PRINTS 2

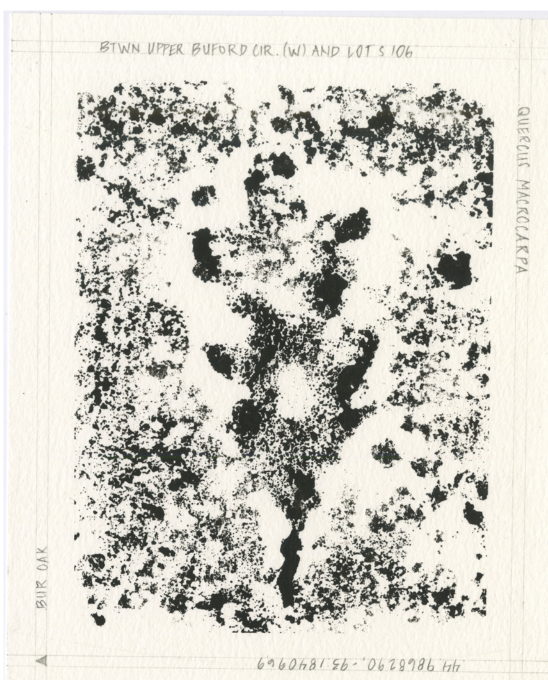


FIGURE 9 : LEAF PRINTS 3

FIGURE 10 : LEAF PRINT PROCESS

FIGURE 11 : GOLD LEAF PROCESS

FIGURE 12 : LINDEN BRACT W/ CONCRETE RESIDUE

PART 2: THE SLAB

The discovery of the unknown requires engagement and proximity to the investigated object. It is the searching rather than finding that creates this proximity.

- Alice Foxley

FIGURE 13 : THE SLAB TITLE PAGE

OBSERVE:

The practice of searching for leaf impressions trained me to carefully observe the sidewalk surface, which in turn, made me more aware of sidewalks in general.
Unless you're paying close attention, city sidewalks can feel relentlessly uniform and unremarkable. By looking more closely, I began to see many sidewalk details for the first time - the inconsistently hued panels, the different styles of seams that separate them, the precisely brushed ridges of the newly poured slabs, and the multifarious forms of sidewalks on campus. Through closer inspection, the footpaths I walked everyday started to seem less predictable, which sparked my curiosity about how sidewalks are made. So I set out to observe a sidewalk construction to learn how this under-considered pedestrian world is created.

WONDER:

How are concrete sidewalks made?

EXPLORE:

My journey into the world of sidewalk construction began with a coffee date. Way back in January of 2020, when the world was still normal and in-person meetings were safe and maskless, I met with Andrew Caddok, a UMN Campus Planner and a graduate of the school's Landscape Architecture program. Andrew was the first person to chat with me about concrete sidewalk construction, so I was grateful for his apparent alacrity to discuss the subject. In his official role as planner, Andrew scopes potential capital projects and campus improvements at UMN, which regularly involves planning for sidewalk construction. Talking to Andrew helped me understand how sidewalk construction relates to many priority projects on campus. A great deal of effort goes into coordinating construction so that projects are done in a thoughtful and efficient manner. For example, we discussed the extensive one and a half year planning process for redesigning circulation and updating utilities for the historic Knoll area. In order to upgrade the Knoll's underground utilities, its sidewalks had to be removed and replaced. I did not know at the time of our conversation that six months later I would observe a sidewalk pour at that site, the final step in a years long campus planning and construction process.

In order to answer my more technical questions about concrete, Andrew sent me to Catherine Vennewitz, the Concrete Superintendent for Facilities Management U Construction. On a frigid day in February, Catherine welcomed me to her office where she shared her vast knowledge of concrete and her infectious enthusiasm for construction methods and material. In addition to describing the concrete construction process in vivid detail, Catherine expanded on Andrew's description of the underlying philosophy of sidewalk construction at UMN. "Our priorities are for transit, the common good and aesthetic," she told me. This means "we're a replacement crew, more than a patching crew" because "the goal of the hardscape committee is to have everything [in] very good or excellent [condition]." So, "If we do grinding, [or] heavy patching, we do that with the intent that we will go back and replace it." From my conversation with Catherine, I learned that the concrete mixes and construction specifications for sidewalks on campus often mimic the MnDot guidelines for Minneapolis, because the campus connects to so many city streets. However, the University crew is working toward a more ambitious standard of best practices, "the city is kind of on a constant run of moving through different areas of the city and we're kind of looking at the quality index and the transit ways and creating a better environment."[1]

After a surreal spring semester, I reached out to Catherine to ask permission to observe a socially distant campus sidewalk pour. She connected me with Blake Bartelma, the Construction Project Manager with the University's Capital Projects Division who invited me to the Knoll to see a sidewalk constructed first hand. My meetings with Andrew and Catharine had heightened my curiosity about this process, so I excitedly accepted his offer.

REPORT (FIGURE 14 -19):

On a perfect morning in mid July, I arrived at the Knoll, a historic pedestrian crossroads on the northwest corner of University of Minnesota East Bank campus, to witness the construction of a new sidewalk. I had an appointment to meet with Blake, the Construction Project Manager. It was a cool morning, the first mild day after a sweltering stretch. I had learned from Catherine Vennewitz, that concrete cures best when it is not too hot and that cool humid days are best for producing slow and even cure (If the top layer dries too fast, it can separate and cause scaling.)[2] The chemical reaction that hardens concrete also gives off heat as the concrete cures. So for many reasons, the temperate morning was welcome by the construction crew. By the time I arrived on site at 9:30am, one member of the crew, a stoic older man named Richard, was already finishing the surface of a section of new sidewalk that had been poured earlier that morning. I stopped to watch Richard smoothing the slab to a buttery finish with a long-handled tool that I would later be told is called a "heifer", or bull float. I was mesmerized by the way the long trowel-like tool gracefully skimmed across the still wet surface of the slab. Equally enthralled by the balletic movements of Richard, I paused to take an obscene number of photographs as he delicately pushed and pulled the heifer back and forth across the fluid concrete surface.

As I made my way across the lawn to meet Blake, I noticed a large section of the Knoll's heavily used sidewalk system had been readied for replacement and was blocked off with orange safety fencing and police tape. Signs on either end of the sidewalk patch further blocked the entrance to the construction site and redirected traffic to other accessible sidewalks around the Knoll. The day before the concrete pour, the old sidewalk had been excavated and removed. A thin layer of aggregate base course (a standard mix of gravel and sand) had been laid down in the shallow trench that remained. While Blake and I waited for the cement truck to arrive, we chatted with Jeremy, the young and gregarious concrete foreman, while he pounded stakes to secure metal flatwork forms with muscular swings of a mallet. Maybe it was the lovely weather or the timing of my arrival at a break in the on-site action but both Blake and Jeremy seemed genuinely pleased, even proud, to share their considerable knowledge of construction materials and methods with me. Over the course of the next half hour they treated me to a meandering and unhurried Q&A.

I learned that the forms that Jeremy had just finished installing contain the concrete while the slab is wet and are removed after the material sets. The four inch steel flatwork forms are installed on top of the aggregate base and inset along both edges of the excavated trench. The UMN crew told me they choose steel over more common and less expensive wood forms because they do not warp when wet and can be reused pour after pour.

After discussing the forms, we turned our attention to the layer of aggregate that had been deposited in the base of the trench and raked into a level plane. The aggregate base is an essential component of concrete construction and must be installed with precision in order to get the best results from the slab. Before the concrete is poured, a four inch layer, or "lift" of aggregate is compressed and vibrated with a steel plate to 100% compaction. This compacted layer of gravel and sand serves two important roles in concrete construction, most critically providing the "necessary uniform support conditions for the concrete slabs."[3] In cold landscapes like Minnesota, "aggregate bases also help to insulate the pavement surface from freeze/thaw cycles" which can crack the slab when the underlying soil shifts.[4]

When we moved on to discussing the concrete mix, Jeremy enthusiastically grabbed a handful of the leftover wet material from the earlier pour, holding out his gloved hand so I could examine the mix up close. The basic components of the concrete are much the same as they have been for centuries: cement, aggregate, and water. The exact proportions of the mixture used by UMN includes entrained air, which creates bubbles in the concrete, giving water that seeps into the slab a place to expand when it freezes.[5] A fibrous admixture bonds with the concrete and helps hold the material together.[6] The epoxy coated fibermesh is non corrosive and acts in place of rebar, becoming "part of the structure of the slab" when the concrete dries.[7] However, Blake pointed out that traditional rebar pins are still used in between the panels that connect different pours, to hold the sections of concrete together, so they will move in unison, when the ground inevitably shifts during the freeze-thaw episodes that occur throughout the long Minneapolis winter.

Blake and Jeremy also described the soil preparation that must happen even before the aggregate base is set. Because the sidewalk that the crew was putting down the day of my visit was replacing an existing walk, the soil was already sufficiently compacted from previous construction to support the slab and the gravel base. But if the sidewalks were being poured on a fresh piece of ground, or if the soil under a stretch of old walk had been saturated with water, the "bad soil" would have to be dug out, replaced, and compressed with a vibrating steel plate compactor. The construction crew confirmed what I had heard from the sidewalk planners and engineers - the preparation of the soil and aggregate base is essential. Jeremy laid it out clearly in our conversation on site, "if the base isn't good, it doesn't matter what I do."

Word came down to the site that the cement truck we were waiting on was running behind on deliveries, so I left and returned about an hour later - fully primed for the main event. When I got back to the Knoll the pour was already in process. The site of the sidewalk construction was near the center of the Knoll's massive lawn, so the cement truck was too large and heavy to access the site directly and had to park on the road, 200 feet away. Instead, a small "power buggy" (basically a stand-up scooter with a 5.5 gallon plastic tub mounted to the front) was used as a sprightly go-between, transporting 1/2-3/4 cubic yards of concrete at a time from truck to site.[8] Once the buggy driver arrived at the trench, he tipped the concrete-filled tub and the waiting crew sprang into action, spreading the viscous load between the forms with their flat-headed hand trowels and long-handled floats, then flipping the empty tub upright, as the buggy embarked on its return trip to the truck. Despite the bursts of action, building the sidewalk was a slow and meticulous process. On that day 20 cubic yards of sidewalk was poured, meaning the buggy had to make a total of 30-40 trips. But cubic yard by cubic yard, the buggy driver dumped and the crew swiftly spread each load. After every 3 or 4 loads, when the crew instinctively determines it's time, Richard and Jeremy would simultaneously drop to their knees on either side of the trench to pull a wooden screed (a flat board that spans the width of the walk) across the surface, smoothing the wet concrete to a level slab.[9]

There was a captivating rhythm to this process, minutes of attentive waiting were punctured by seconds of artfully choreographed activity. It was lovely and relaxing to stand in the shade and watch people working in collective flow, communicating through body language, moving by embodied memory, and chatting good-naturedly between pours. There's an almost ancient simplicity to the methods and tools, yet each tool has a purpose, some very specific. For example, the channel that dumps the concrete from the drum of the truck to the buggy has a special u-shaped trowel that fits it exactly, helping to push the sticky mixture down the shoot.

Once a large enough section of wet sidewalk was poured, Richard resumed his delicate work with the heifer, leveling the ridges and filling the voids left by the screed with trademark grace. I didn't watch most of the finishing process. After a couple of hours on site, I started to feel conspicuous, like I was overstaying my welcome. So I left the site when the slab was still raw, without the final smoothing or the brushing and edging of the surface that happens 2-3 hours after the initial pour.[10] I left the capable crew behind to do their jobs in peace and I went home to decipher the hundreds of photos I'd exuberantly snapped of the construction process.

It's a rare privilege to watch a familiar thing get made. We're often content to take our surrounding infrastructure for granted - to assume that a concrete sidewalk is inevitable, somehow magically, mechanically extruded without the labor of human hands. But as I contemplated my multitude of photographs of sidewalk construction, I was struck above all else by the hand-made nature of the work. And standing in the shade, on that perfect morning, I was genuinely moved by the undeniable care and craftsmanship of the concrete crew, working together on hands and knees, tenderly coaxing a new stretch of sidewalk into existence.

REFLECT:

It occurred to me, after watching a sidewalk pour in person, that every sidewalk is bespoke. Each panel is made custom, in consideration of its context. While there are strict regulations, there is no standard sidewalk unit. It was clear from talking to the planners, engineers, and construction crew, that the University sets an especially high standard for construction, a goal that is supported by a seasonal sidewalk budget of one million dollars.[11] But even the city crews (whose ad hoc funding comes from the property owners who abut the sidewalk) must design and construct one-off panels that accommodate complicated soil conditions, tree roots, and specific ADA regulations. Additionally, every piecemeal section of city sidewalk that is laid must align with existing panels on either side, poured at an earlier date. So regardless of monetary restrictions or municipal priorities, every sidewalk is always a custom operation.

This might seem like a trivial or whimsical point. After all, why does it matter how something is made? Why does it matter if a sidewalk is made by hand instead of by some magic machine? It matters because how something is made has implications for what that thing can become and speaks to its capacity for change. Variation is already built into the process of sidewalk construction. The methods of construction as well as the materials and form of each slab are already tailored to the requirements of the site. As a result, we should expect sidewalks to be a particularly adaptable element of our urban infrastructure. Over time, the medium has had to accommodate a variety of climate factors and has become increasingly responsive to accessibility needs as well as the surrounding flora. So there is reason to be optimistic that sidewalk construction could evolve to more robustly consider soil and water concerns, or allow for greater changes in form and material. This adaptable nature is important to keep in mind as subsequent sections of this thesis will show the far-ranging ecological impact of sidewalks and the need for extensive changes in sidewalk design.

Furthermore, it's clear that sidewalk construction crews are not inconsiderate, button-pushing industrial workers (if such a thing even exists), they are artisans in a responsive relationship with these methods and materials. These practitioners are constantly adjusting to conditions on the ground and have already learned to skillfully incorporate complicated climate requirements, ADA guidelines, and existing street trees. So, while on the surface sidewalks might appear unchangeable, a fundamentally fixed feature of our urban infrastructure, the inherent flexibility of both the construction process and its crews are actually uniquely well suited to create sidewalks that address the ever-shifting spatial and environmental needs of our cities.

ENDNOTES:

1 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

2 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

3 Pavement Interactive, "A Solid Base Is Rock Steady."

4 Pavement Interactive, "A Solid Base Is Rock Steady."

5 Interview with Jeremy Uchtman, UMN Concrete Foreman, July 23, 2020.

6 Ibid.

7 Interview with Jeremy Uchtman, UMN Concrete Foreman, July 23, 2020.

8 Email from Jeremy Uchtman, UMN Concrete Foreman, September 2, 2020.

9 Email from Jeremy Uchtman, UMN Concrete Foreman, September 2, 2020.

10 Interview with Blake Bartelma, UMN Concrete Foreman, July 23, 2020.

11 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

THE SLAB SOURCES:

Pavement Interactive. "A Solid Base Is Rock Steady." Accessed: November 11, 2020. https://pavementinteractive.org/a-solid-base-is-rock-steady/

Concrete Network. "Concrete Bull Floats and Darbies." Updated: June 16, 2020. https://www.concretenetwork.com/concrete/concrete_tools/bull_floats_and_darbies.htm

PREPPING THE SITE

Before a new concrete sidewalk slab is poured, the site is prepared for construction. Safety fencing blocks the site and signs direct pedestrians to an alternative ADA route. If the sidewalk is placed in a new location, soil must be excavated down to 11" and compressed with a vibrating plate compactor. A 6" layer of class 5 aggregate (gravel and sand) base course is placed above the soil and compacted to 100%.

ABOVE LEFT: A safety fence and sidewalk closed signs block construction area and redirect pedestrians.

ABOVE RIGHT: A plate compactor used for compacting the aggregate base.

BELOW: An aggregate rake is used to level the top of the 6 inches of class five crushed aggregate and sand base mix.

FIGURE 14 : PREPPING THE SITE

LAYING THE FORMS

Steel sidewalk forms are used to define the edges of the sidewalk and contain the wet concrete when the new slab is poured. The reusable 12- gauge steel flatwork forms used for campus sidewalk construction are 4 inches tall. Single use plywood forms are used for custom applications such as curves or slabs higher than 4 inches.

ABOVE LEFT: A steel mallet is used to drive a steel stake into a pocket on the form.

ABOVE RIGHT: A 4" x10' steel form rests on the aggregate base, held in place by a stake.

BELOW: Steel forms laying off to the side, awaiting use.

FIGURE 15 : LAYING THE FORMS

THE MIX

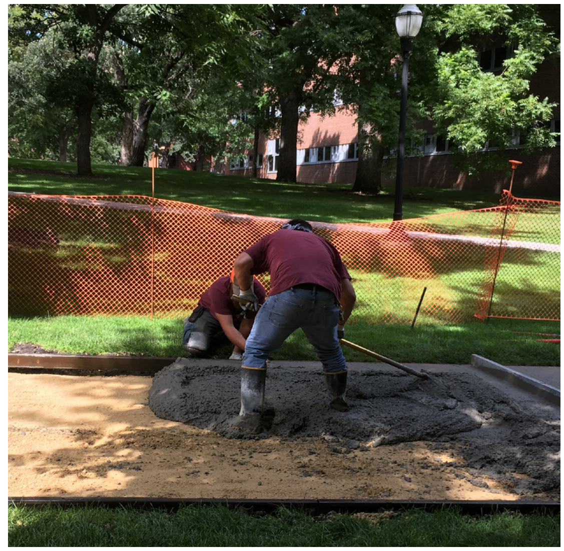
Concrete is made up of aggregate (60-75%), cement (7-15%), water (14-21%), and up to 8% air. The exact proportions of the concrete mixture used by UMN is based on MnDOT specifications (0.40 water/cement ratio requirement, 5-8% entrained air). The mix includes a fibrous admixture which bonds with the concrete and helps hold the material together in place of traditional steel rebar.

ABOVE LEFT: Concrete is transfered via shoot from the drum of a cement truck into the tub of a power buggy.

ABOVE RIGHT: The wet concrete mix.

BELOW: The power buggy hauls concrete to the site of the sidewalk pour.

FIGURE 16 : THE MIX



THE POUR

When the buggy arrives at the construction site, the concrete-filled tub is tipped into the trench. The crew spreads the load between the forms with their flat-headed hand trowels and long-handled floats. After 3 or 4 loads of concrete is poured, a wooden screed (a flat board that spans the width of the walk) is pulled across the surface, smoothing the wet concrete to a level plane.

ABOVE LEFT: Concrete is poured from the power buggy, between the steel forms, over the layer of aggregate base.

ABOVE RIGHT: The wet mix is spread between the forms with a hand trowel and a long-handled float.

BELOW: A wooden screed is used to level the concrete even with the tops of the 5” forms.

FIGURE 17 : THE POUR

FINISHING

After the wooden screed levels the slab. A heifer, or bull float is used to further refine the surface, smoothing the ridges and voids left by the screed. Before the final texture is broomed into the surface, 2-3 hours after the concrete is poured, an edger is used to shape the top edge of the slab, helping the wood forms to pull away easily after the concrete hardens.

ABOVE LEFT: A long handled “heifer” is used to smooth the ridges left by the screed.

ABOVE RIGHT: A heifer and a float.

BELOW: An edger leaves a clean a clean outer edge.

FIGURE 18 : FINISHING

SLAB DETAILS

While the pouring of a concrete slab is an relatively straightforward process, many small details go into creating a finished and durable sidewalk that will hold up to heavy pedestrian use, time, and the unforgiving natural elements. Proper joint work between panels and pours is essential in the battle against cracking and a broom textured surface improves traction under wet and icy conditions.

ABOVE LEFT: A saw cut joint relieves pressure and controls cracking.

ABOVE RIGHT: The surface of the concrete is scored with a broom, creating a ridged texture to increase traction.

BELOW: Steel rebar is used to pin together different pours so slabs don't separate during freeze/thaw.

FIGURE 19 : SLAB DETAILS

PART 3: THE CONCRETE LANDSCAPE

I like walking because it’s slow, and I suspect that the mind, like the feet, works at about three miles an hour. If this is so, then modern life is moving faster than the speed of thought, or thoughtfulness.
- Rebecca Solnit

FIGURE 20 : THE CONCRETE LANDSCAPE TITLE PAGE

OBSERVE:

When I walk around my Minneapolis neighborhood, I study the concrete sidewalks. My eyes are often drawn to edges where a monolithic slab has eroded and concrete's constituent parts reveal themselves. As sidewalks degrade, the sand and rough aggregates become dislodged from their hard cement binder. In these places the illusion of concrete as a "man-made" material dissolves and you can see the slab for what it is - elements of the natural landscape relocated.

WONDER:

Where do the materials that make up concrete come from? What do these natural landscapes look like before they become concrete? Where does this metamorphosis from raw materials to concrete occur? What do the urban landscapes of concrete production look like and where in the city do they hide? What are the ecological implications of manufacturing concrete?

EXPLORE:

Initially, I hoped to find the places where the materials used in Minneapolis sidewalks are extracted and then to visit these landscapes of extraction in person. I was curious about their shape and scale. However, the concrete experts I talked to didn't know exactly where the materials were sourced and I was never able to connect with a concrete supplier. While traveling around the region this winter, I did start to notice gravel (aggregate) pits around the metro area and many limestone mines between Iowa City and St. Louis. I made a note of these places, thinking I might be able to request site visits. Unfortunately, COVID-19 has limited travel and halted in person meetings. So, I began to wonder if I could at least find intact material landscapes of limestone, sand, and water within the boundaries of my daily walking area. Having read about the geology of the Twin Cities in R.K. Hogberg's *Environmental Geology of the Twin Cities Metropolitan Area*, I suspected I might have some luck along the banks of the Mississippi, where the river cuts deeply through layers of geological history. After locating potential concrete material landscapes on google maps, I set out to document them through photos and drawing. Finally, I visited a Cemstone concrete batch plant in North Minneapolis, a landscape where the extracted materials are sorted and mixed to make concrete.

GEOLOGICAL LANDSCAPE OF THE TWIN CITIES
(Between Broadway Ave NE and Franklin Ave SE)

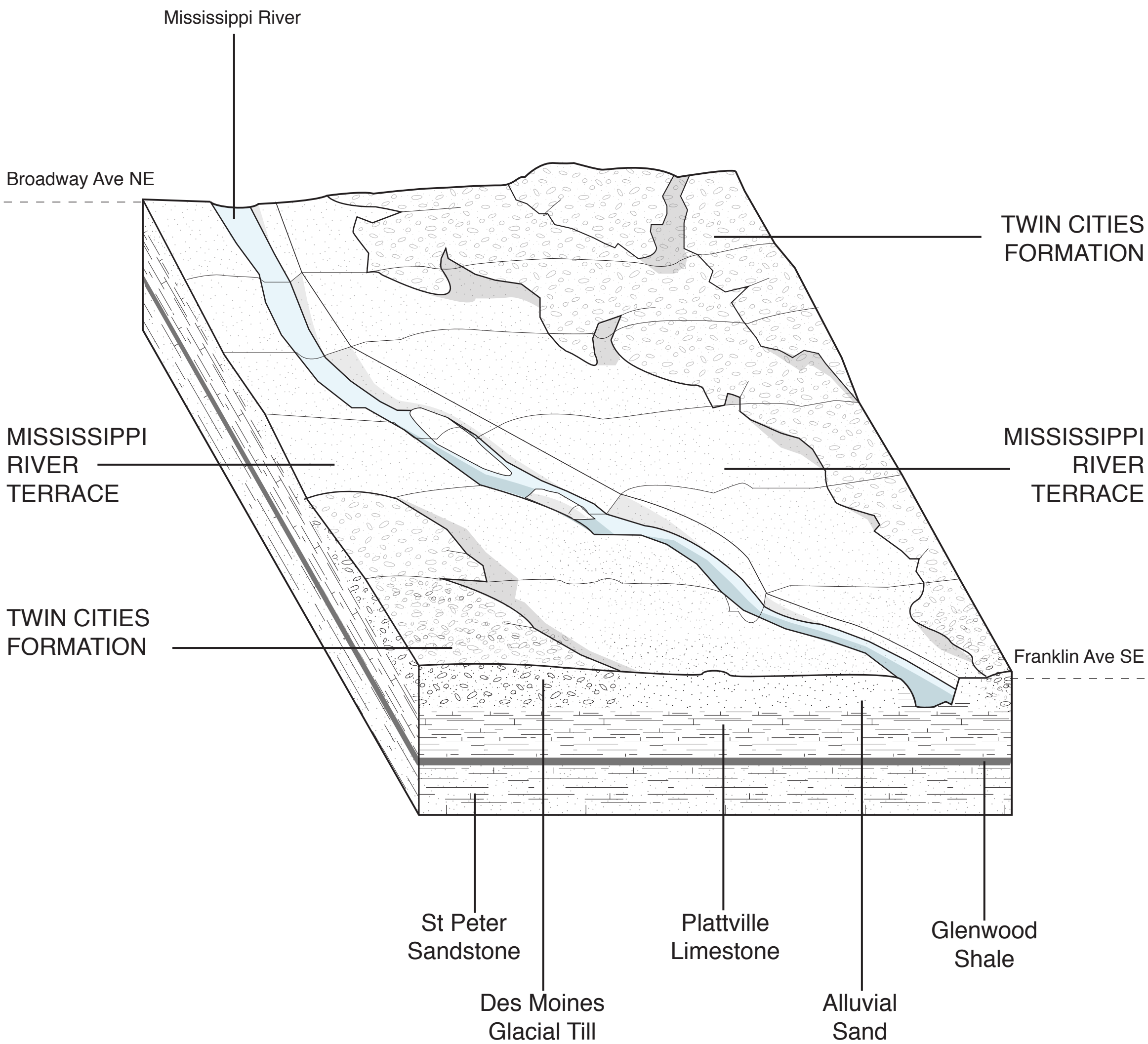


FIGURE 21 : THE GEOLOGICAL LANDSCAPE OF MINNEAPOLIS - BLOCK DIAGRAM

THE CONCRETE LANDSCAPE OF MINNEAPOLIS
(Between Broadway Ave NE and Franklin Ave SE)

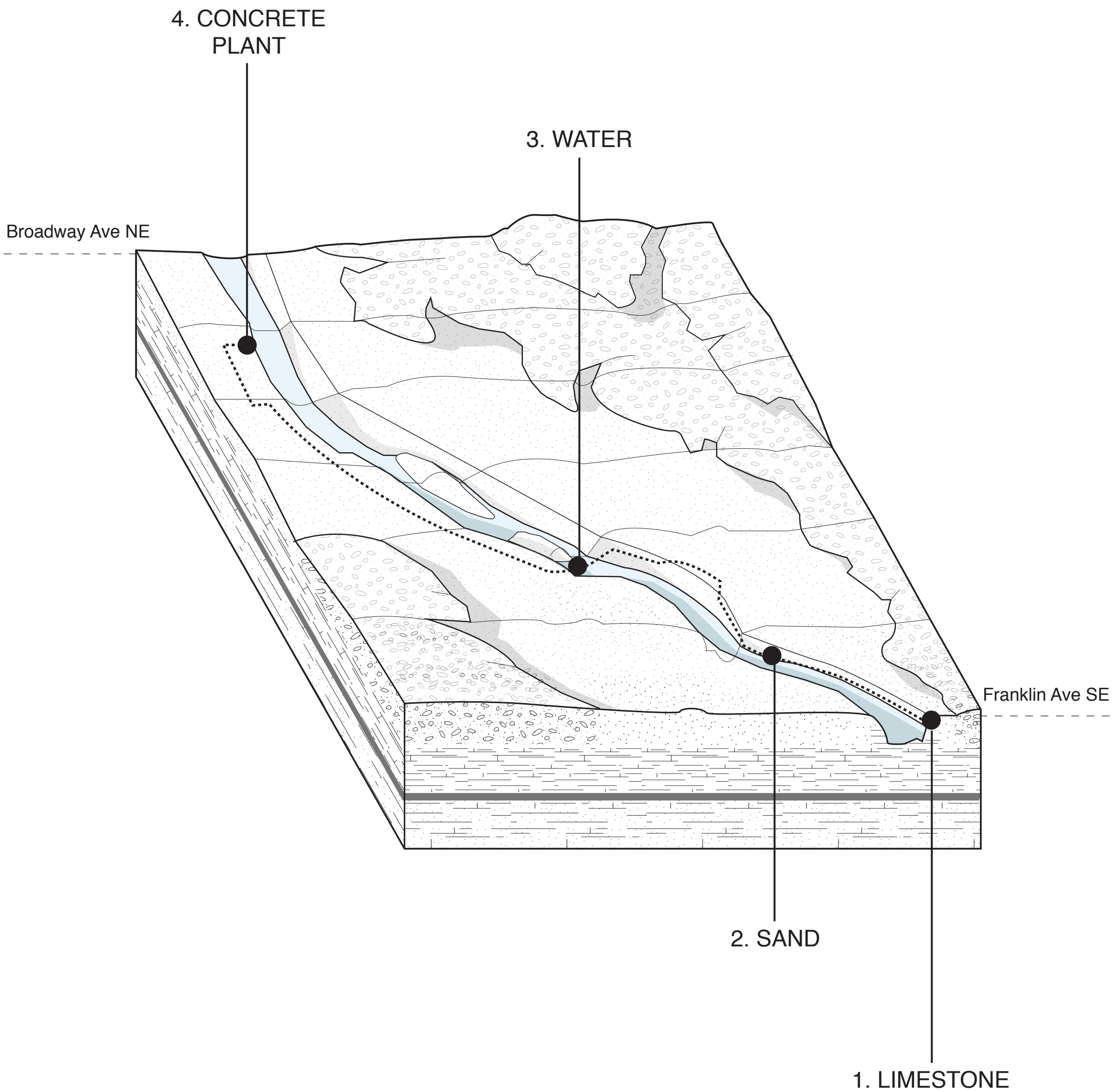
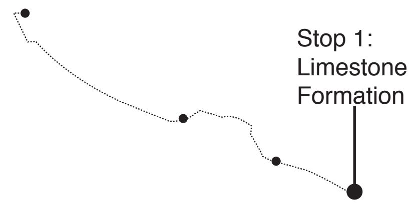
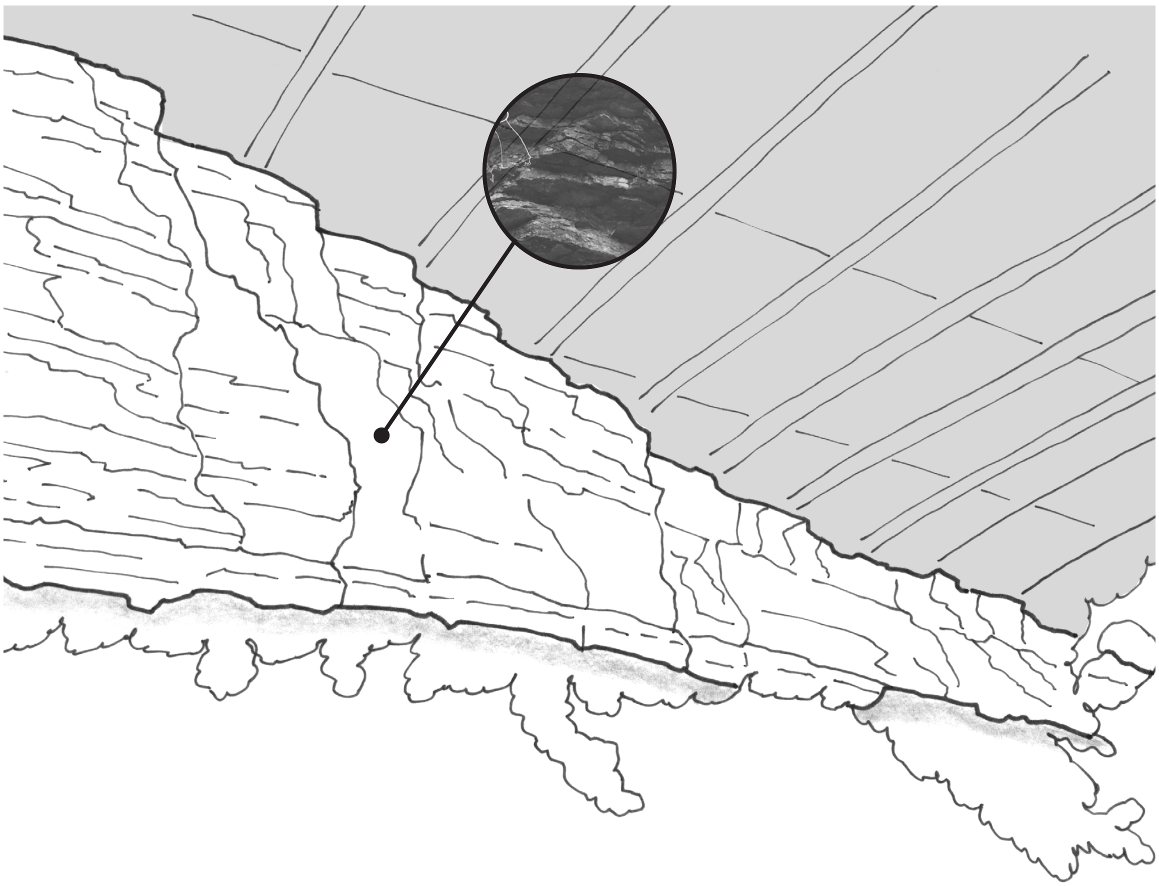


FIGURE 22 : THE CONCRETE LANDSCAPE OF MINNEAPOLIS - MAP

1. LIMESTONE:





REPORT:

Limestone as a Landscape:

Nestled below the Franklin Avenue Bridge, on the east side of the Mississippi river, you'll find an exposed limestone outcrop about fifty feet long. Flat-topped stone outcroppings such as this, dot both sides of the river as it flows past the Twin Cities. In some places the limestone formations appear as large exposed ribbons, such as the one at Franklin Ave. Other places, the rocky cliff-like columns are partially or wholly obscured behind the thick vegetation of the steep river gorge.

FIGURE 23 : LIMESTONE FORMATION, BENEATH THE FRANKLIN AVE BRIDGE

From about 500 million to 440 million years ago, the part of Minnesota that now contains the Twin Cities Metro Area was covered by an inland sea. The landscape surrounding this sea was an environment similar to the present day Atlantic coast of Florida.[1] During this *Ordovician* period, "animal life was particularly abundant within the tropical, near-shore, reefal environments."[2] As Ordovician shell-forming species that inhabited this shallow water died, their shells accumulated on the sea floor where they eventually lithified into columns of Platteville limestone.[3] Today, these dramatic Platteville outcroppings shape the portion of the Mississippi River gorge that falls within my daily walking area.[4] The jagged limestone cliffs are separated from the softer sandstone below by a thin layer of dark shale. The columns above the shale are stratigraphic, with the oldest rock on the bottom and youngest rock on the top, and each of the flakey limestone layers has its own unique chemical and physical properties.[5] The stratigraphic formations that give the river gorge its distinct appearance are rugged relics of the forces that shaped the Twin Cities and the underlying geology of my daily walks.

Limestone as a Concrete material:

Limestone is a sedimentary rock composed primarily of calcium carbonate. (by definition, limestone is a rock that contains at least 50% calcium carbonate).[6] It is most commonly formed in marine waters from the "consolidated equivalent of limy mud, calcareous sand, or shell fragments." [7] In concrete production, calcium carbonate is best known as the key ingredient in *cement* - the all important concrete binder. (Quick PSA: Concrete is not the same thing as cement, although the terms are often used interchangeably. Cement is a component of concrete in a similar way that four is a component of cake but not the cake itself. Perhaps more accurately cement is the egg of the concrete mix, necessary to bind the other ingredients together.) But in addition to serving as an essential cement component, limestone has an enormous diversity of uses in concrete construction.[8] For example, the majority of extracted limestone is actually crushed into small pieces and used as an industrial aggregate. Crushed limestone can be one of the many rock types used as a base for below the sidewalk slab as well as an aggregate in the concrete mix.[9] However, limestone is uniquely suited to its role as an ingredient in cement. While cement comprises only a small percentage of the total concrete mix (10-15%), it is the material's essential glue.[10] Portland cement, the most common type of cement, is formed when powdered limestone is heated in a kiln. "As a source of calcium, it joins with powdered clay to produce a product called *clinker*, which is then ground with a source of sulfate, like gypsum" to form cement.[11] When combined with water, cement binds together the loose aggregate pieces that make up the body of concrete, forming a strong, rock-like mass.

Ecological Implications:

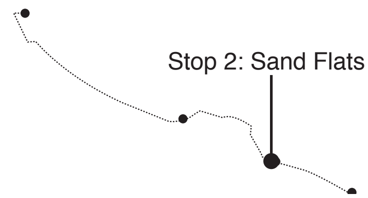
Limestone is exceptionally versatile and useful for construction. But unfortunately, the mining of limestone is also ecologically harmful with lasting impacts on the landscape. Opencast mining of limestone involves the removal of topsoil and overburden (rock or soil overlying a mineral deposit) through drilling and blasting.[12] This process destroys the organically rich surface layer of the soil as well as the ecosystems that soil supports. This loss is irrecoverable because the excavated topsoil, essential for maintaining soil health, can take thousands of years to reform.[13] Additionally, limestone mining can lead to large-scale changes in the land use and land cover. This reshaping of the landscape ultimately results in the destruction of the existing habitat. Habitat loss, especially in environmentally vulnerable areas, leads to losses of local native and unique species, and an overall reduction of species diversity.[14] Because species-rich habitat plays a key role in keeping air and water clean, these losses, especially "the process of clearing trees and vegetation in preparation for mineral excavation" is also associated with increased pollution in the landscapes altered by limestone extraction.[15]

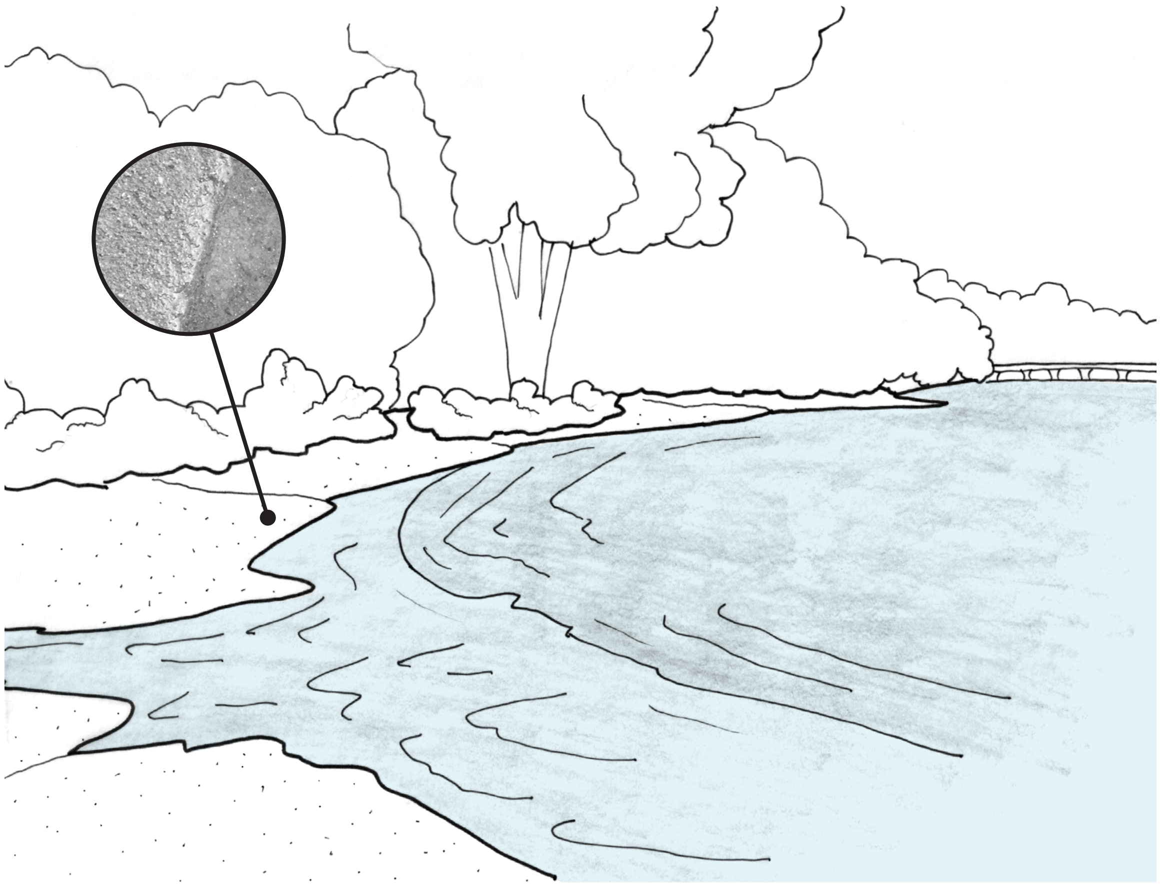
Additionally, the blasting, drilling and crushing of limestone that occurs during the extraction process causes an increase in dust emissions and a reduction of water quality in and around mines. "Air-blown particles from the stockpile of excavated material... raise the content of particulate matter in the air."[16] Heavy earth moving machinery emits gaseous pollutants such as sulphur dioxide and oxides of nitrogen which reduce air quality.[17] At the same time, water systems around limestone mines can also become polluted with “effluents from quarries” (oil, fuel, wastes) as well as dissolved chemicals from limestone mining and processing.[18] When it rains, the effluents and chemicals are introduced into the groundwater system, resulting in mine-adjacent water bodies with elevated levels of “pH, electrical conductivity, total dissolved solids, hardness, alkalinity, calcium and sulphate concentrations.”[19] The presence of these pollutants makes the affected water “unfit for potable use,” reducing the local supply of drinking water.[20]

The drastic landform changes caused by mining exacerbates these water issues. Quarries alter the natural topography and cause water to move differently across the surface of the land. This is especially consequential at the watershed scale where the rerouting of recharge water to the aquifer and increased runoff leads to “localized reduction in groundwater storage”[21]

In addition to the environmental damage caused by limestone mining, the process of manufacturing the limestone-containing cement compound also contributes heavily to global levels of carbon dioxide. Overall, the concrete industry emits 8% of global CO2 and “half of concrete’s CO2 emissions are created during the manufacture of clinker, the most-energy intensive part of the cement-making process.”[22] In this way, the use of limestone in concrete construction has profound ecological implications even beyond the site of extraction.

2. SAND (AGGREGATE):





Sand as a Landscape:

As you walk north from Franklin Avenue, about half a mile upriver, the tall Mississippi Gorge flattens into a wide low-lying river valley. Here, on both sides of the river, the rocky cliffs transition into the broad plains of the Mississippi sand flats. The sand found along the banks of this part of the Mississippi River is a type of *alluvium* - a sediment deposited by rivers. Alluvial deposits are "usually most extensively developed in the lower part of the course of a river, forming floodplains and deltas, but may be deposited at any point where the river overflows its banks."[23]

FIGURE 24 : FIGURE 2: SAND FLATS, LOOKING SOUTH FROM EAST RIVER FLATS PARK

In the 9,500 years since the last ice age, the surface streams of the Mississippi, as well as the Minnesota and St. Croix Rivers have removed the top layer of glacial material in places where they flow, continuously cutting down through layers of the hard bedrock below. This reworking of the stream bed materials in the region has generally resulted in upper valley river terraces of a gravelly sand mixture, with a finer silty sand mix deposited in the lower valley flood plains.[24] Therefore, the low lying river flats of the Mississippi, which lie within my walking area, are generally composed of this finer sandy sediment.[25] The sand grains themselves are formed from the weathering of rocks and biogenetic material over thousands of years before being transported by the river's current and deposited in sinuous bands along its banks.

Sand as a Concrete material:

The majority of sand is composed of strong silicate minerals or rock fragments that result from the slow erosion of quartz by water or wind. Sand lies on a mineral size spectrum between gravel, which is more coarse, and silt, which is more fine. Sand, along with gravel and crushed stone, represents the aggregate component of the concrete mixture. The aggregate materials comprise the body of concrete and are responsible for concrete's strength and durability. Concrete aggregates are divided into two classes: sand (or crushed stone), which is the fine aggregate component, and gravel, which is the coarse aggregate component. Together, the fine and coarse aggregates account for 60 to 75% of the total volume of concrete.[26] The proportion of fine aggregate is typically less than gravel, only occupying about 35% volume in a concrete mix.[27] However, sand is essential for the finish of concrete because the "important qualities of workability and uniformity are found to lie largely in sand."[28]

After water, sand and gravel are the most widely consumed raw materials on earth and "between 64-75% of aggregate mined each year is used for making concrete."[29] Water eroded sand has conventionally been preferred for use in concrete because alluvial weathering - weathering produced by moving water, produces sand with "rounded or cubical particles with smooth surface texture which provide good workability in concrete."[30] However, the insatiable production of concrete has depleted alluvial sand deposits, leading to global shortages of natural sand.

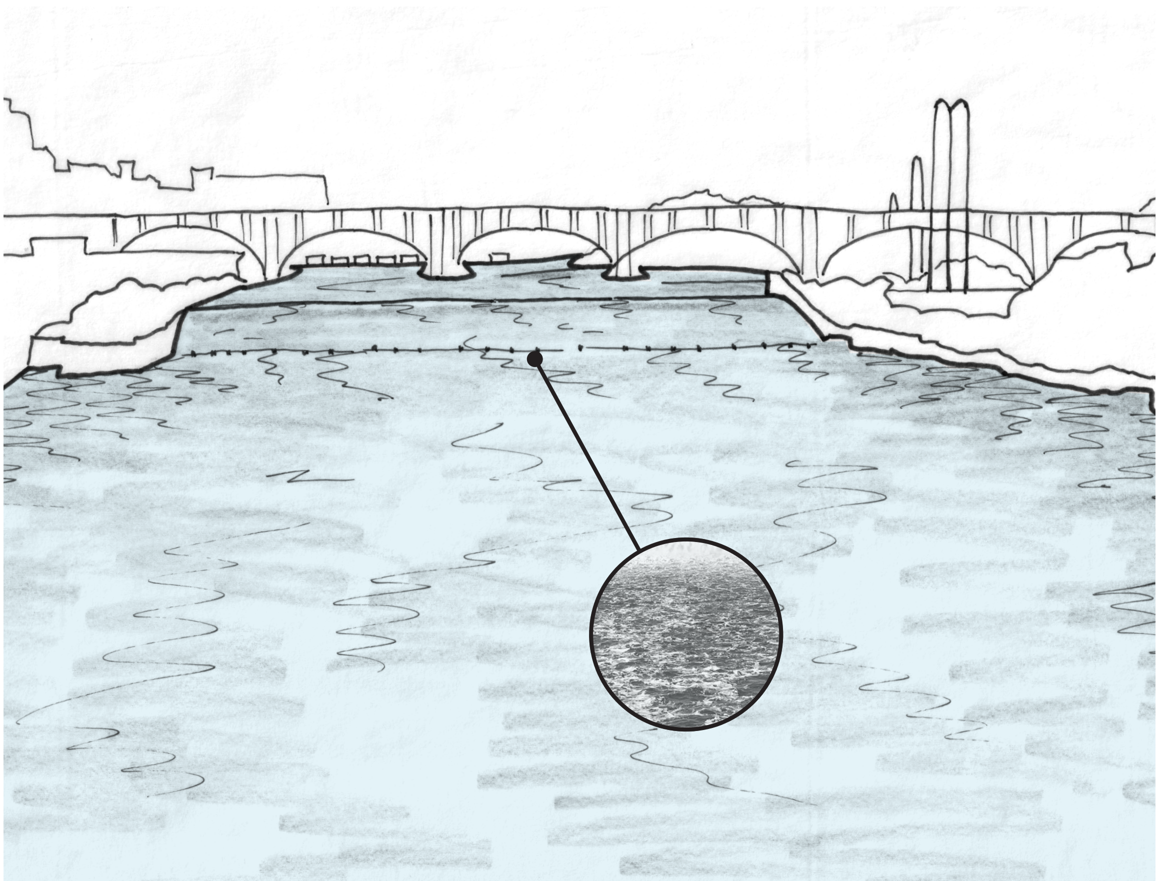
Ecological Implications:

Mining and dredging of natural sand has also resulted in negative environmental consequences for riparian and coastal landscapes. Mining river sand beyond the capacity for natural sand replenishment through erosion can "lead to irreversible and irreparable damages to land, water, and biotic components of the fluvial environment."[31] Sand mining disrupts the delicate sediment equilibrium of river channels. The form of a river channel is dynamic, evolving slowly "depending on the changes in flow energy and sediment discharge through the system. Indiscriminate sand mining is one of the most destructive anthropogenic activities" because it hinders natural stream bed evolution.[32] Alluvial mining of fine to medium sized sand particles can result in a coarsening of river sediment over time.[33] This removal of fine sand from the aquatic environment ultimately reduces river biodiversity by degrading the habitat of organisms that rely on the fine sediment of sandy river beds for feeding and spawning.[34] Additionally, "sand and gravel mining from alluvial reaches imposes serious problems in the surface and subsurface (groundwater) water resources."[35] Suspended particles in the water can "block respiratory structures of fishes and other aquatic animals like bivalves" and impair vital processes of photosynthesis and respiration of instream flora.[36]

Indiscriminate sand mining can also lower the riverbed and accelerate "groundwater lowering" adjacent to the river channel.[37] Lowering of the groundwater table can lead to "adverse hydrologic effects in the nearby areas" and cause the destruction of floodplain vegetation, especially in wetlands and sloughs. The loss of floodplain trees is particularly detrimental because tree roots stabilize river banks. Shoreline trees also provide habitat and temperature regulation for river ecosystems.[38] Lowering of riverbeds can also have deleterious impacts on humans by reducing the drinking water supply. This is a grave concern in regions where groundwater is the primary source of potable water.[39]

Additionally, the depletion of finite sand deposits, in conjunction with rapid global urbanization has led to increased demand for sand. The cost of sand has risen dramatically along with its value. In some regions, sand for construction is so coveted that it has led to illegal sand mining operations that are not subject to the same environmental regulations as official mines.[40] Competition over scarce sand resources has led to the development of criminal gangs in over a dozen countries, who bribe, coerce, and intimidate elected officials for the right to mine sand. Most infamously, so-called "sand mafias" in India have "reportedly killed hundreds of people in recent years—including police officers, government officials, and ordinary people..." all in an effort to gain control of dwindling local sand supplies.[41]

3. WATER:



Water as a Landscape:

Two miles upriver from the East River Flats, you'll arrive at *Owámniyomni* (falling water), or St. Anthony Falls. From the center of the Stone Arch Bridge, just south of the falls, you can gaze down at the water as it slides evenly over what was once the Mississippi River's only naturally occurring waterfall. Prior to its collapse, Owámniyomni was a sacred site for the Dakota people, as well as for the Ojibwa, who called it *Kakabikah* (the severed rock).[42] The "falls" that exist today are really just a concrete apron, which spans the width of the river, capping the ruins of the picturesque limestone falls that once were. The apron (or overflow spillway) controls the flow of

FIGURE 25 : ST. ANTHONY FALLS, LOOKING UPRIVER FROM THE STONE ARCH BRIDGE

water at this early point in the river's 2,320 mile journey from Lake Itasca to the Gulf of Mexico. The apron was first constructed, and is still maintained, by the Army Corps of Engineers after the natural rock formation collapsed in 1865.[43] The catastrophic collapse of the natural falls was caused by the tunneling of a new tailrace for an adjacent flour milling operation, one of the many companies that relied on the power generated by the river passing over the falls.[44] Conflicting accounts of St. Anthony Falls at the time of European colonialism, guessed its former height as anywhere between 20-60 feet, and described the overall effect of the formation as "sublime," "pleasing," and "picturesque."[45] While the diminutive and orderly structure that spans the river today is a diminished memorial to Owámniyomni*,* it is still somewhat sublime to look upon from the bridge, stuck strangely in place between a massive concrete lock to the west and Hennepin Island to the east, itself much changed by industry.

Water as a Concrete material:

According to *Environmental Geology of the Twin Cities Metropolitan Area,* "[p]robably the most important of the Twin Cities' mineral resources is the plentiful supply of water."[46] For centuries, the region's many rivers, streams, lakes and springs have provided a "life-sustaining supply of drinking water" and the local rivers were fundamental to European colonization and the subsequent industrialization of the area.[47] This same "life-sustaining" water is also essential in the formation of concrete. In many ways, water is concrete's magic ingredient. When mixed with cement, water forms a paste that binds aggregate particles. More significantly, water causes the hardening of concrete through a chemical reaction called hydration.[48] During hydration, "a node forms on the surface of each cement particle. The node grows and expands until it links up with nodes from other cement particles or adheres to adjacent aggregates."[49] (In the simplest terms, these "nodes" are calcium crystals that form rapidly when water is introduced to the cement mixture.[50]) It is the hydration process that ultimately gives concrete its rock-like form and strength as a construction material. The cement to water ratio in concrete is extremely important - too much water reduces the strength of concrete, but too little makes concrete difficult to work into different forms.[51] Almost any water that is potable can be used as mixing water for concrete. Water with too many impurities may cause side reactions, which can "weaken the concrete or otherwise interfere with the hydration process."[52]

Ecological Implications:

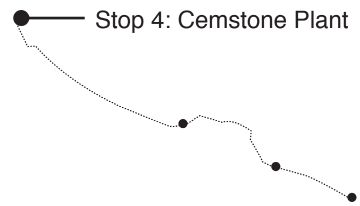
The concrete making process, like most construction processes, uses a momentous amount of water. "Concrete is a thirsty behemoth, sucking up almost a 10th of the world's industrial water use."[53] This can lead to a depletion of water resources in regions where concrete production is high. Construction of concrete has a large water footprint and is associated with water use in both direct and indirect forms.[54] Directly, concrete mixing and construction consumes water through aggregate washing, preparing raw concrete, curing concrete, and the washing of finished surfaces and construction equipment.[55] Indirect water use or "embodied water," is the water that has been consumed in the production of concrete's constituent parts: the mining of limestone, aggregate and processing of cement.[56] Because certain direct water use activities such as mixing and curing concrete require the use of "clean and contaminant free water," concrete construction often directly depletes stores of potable water.[57] This is a significant issue because 75% of concrete water consumption currently occurs in "drought and water-stressed regions."[58]

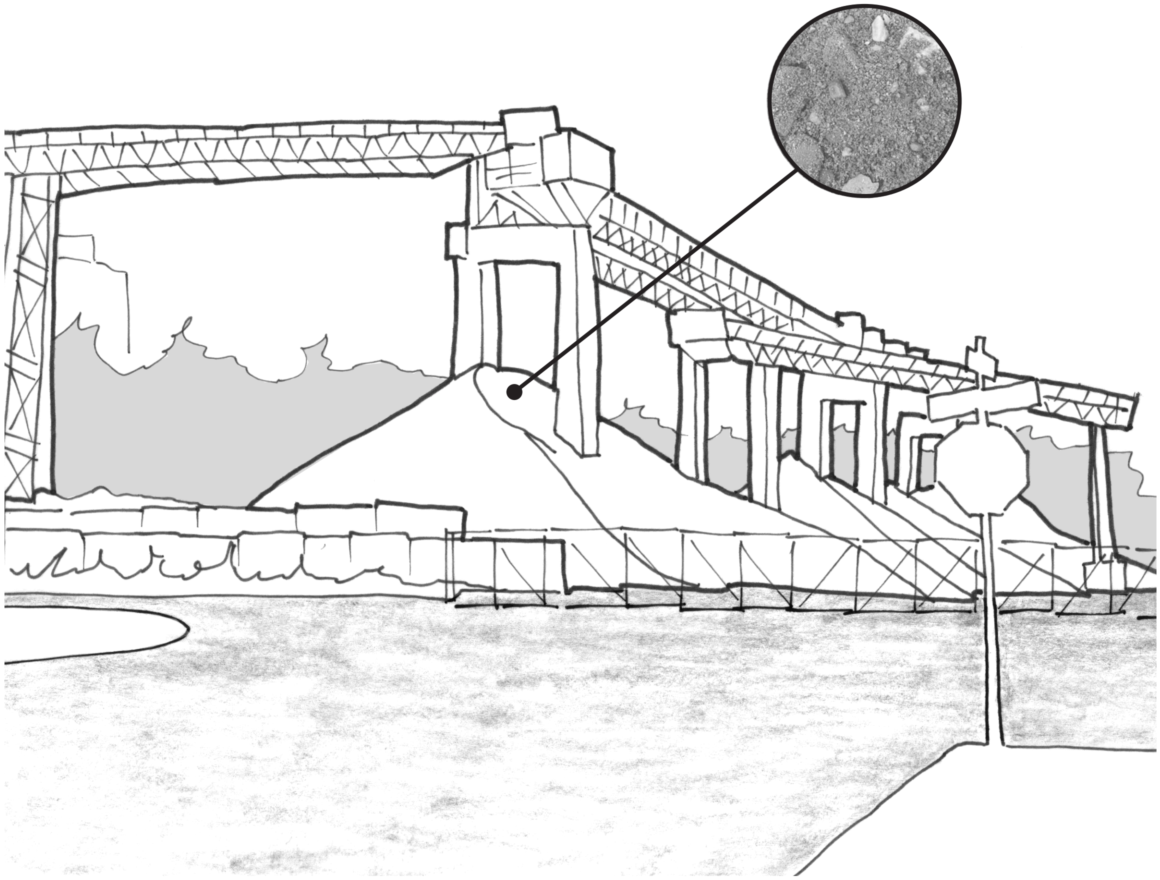
Mining of concrete materials also requires large amounts of water for operation. Mining wastewater and "dewatering activities" associated with mining operations present further water pollution problems. [59] At the same time that concrete production is consuming large volumes of water, concrete construction also generates large amounts of stormwater runoff from impervious surfaces such as sidewalks, roads, and roofs. Water runoff can reduce the amount of water that is infiltrated on a particular site, resulting in an increase in unfiltered runoff which pollutes local waterways.

Although water is a renewable resource, it can be easily depleted if the consumption of water is greater than the earth's ability to replenish it. According to the Water Footprint Network, "we are now consuming water at almost twice the rate that the Earth can renew

[it].”[60] A MIT study from 2014 projected that if the current rate of consumption continues, by 2050, fifty-two percent of the world’s population will live in “water-stressed areas.”[61] However, this stress will not be felt equally across the planet. India, Northern Africa, and the Middle East are predicted to fare the worst. Already, these areas are experiencing disproportionate levels of water scarcity while the US and China are responsible for the highest levels of industrial water consumption. The United States, in particular, consumes the highest levels of water per capita (2842 cubic meter per year per capita in 2010)[62] and is the largest global user of industrial water, withdrawing over 300 billion m^3 per year.[63]

4. CONCRETE PLANT:





Concrete Plant in the Urban Landscape:

If you continue across the Stone Arch Bridge, and walk a couple miles upriver along its west bank, you'll eventually emerge from the park-like landscape that flanks the River from the St. Paul Suburbs to the north edge of Downtown Minneapolis. At the Broadway Avenue Bridge the verdant park-scape along West River Parkway narrows abruptly into a thin grassy strip then suddenly dead-ends. At this point, The space set aside for recreational parkland has been ceded to the interest of industry. Among the many factories here, you'll find the The North Minneapolis Cemstone plant. The concrete plant, also known as a batch plant, is the site where the ingredients that form concrete: cement,

FIGURE 26 : CEMSTONE PLANT, WEST SIDE OF THE MISSISSIPPI RIVER, 26TH AVE NORTH

aggregate and water, are combined. Like many operations of its kind, the concrete plant in North Minneapolis is large, claiming two square blocks from 24th Ave N to 26th Ave S and 2nd street N to the River. The Cemstone parcel falls within an I3 - heavy industrial zoning area, a large industrialized section of North Minneapolis that stretches along the west side of the Mississippi River from downtown to Lowry Ave North.[64] In this zone, access to the river is limited, as are the trees and understory vegetation that have characterized the majority of this riverwalk. Instead, the Cemstone plant sits within a vast landscape of pavement, its overstory defined by towering structures of concrete and steel. Pedestrian access to the industrial zone is encumbered by Interstate 94, railroad tracks, and discontinuous sidewalks. This is not an environment intended for walking. For this reason, the Cemstone plant is the only one of the four sites I visited that I had not encountered before.

Concrete Plant's Role in Concrete:

After the concrete components are extracted elsewhere, the dry materials are shipped to a concrete plant. Batch plants are often strategically located throughout urban areas in order to minimize the concrete transport time from plant to various construction sites.[65] The North Minneapolis plant is one of more than 50 MN Dot certified "ready-mix" concrete providers in the Twin Cities Metro Area and one of more than 20 plants operated by Cemstone.[66] At most commercial batch plants, aggregate arrives loose and is typically stockpiled throughout the site.[67] Premixed cement is stored in tall silos on site to protect it from moisture.[68] For ready mixed concrete, the components are mixed on site at the plant. Concrete mixing or *batching* is simply the process of measuring concrete components and combining them in a mixer to form concrete.[69] In order to "produce concrete of uniform quality" ingredients must be measured accurately for each batch of concrete.[70] Most ready mixed plants are centered around a large industrial mixer connected to a control room and a water supply.[71] The mixer is often surrounded by a large paved lot that allows for easy circulation of trucks and ample storage of concrete ingredients.[72] Belt conveyors are used to maneuver cumbersome aggregates from place to place on site.[73] Contemporary mixing equipment is increasingly advanced, with computerized mixers calculating precise amounts of each ingredient added to a batch.

At the batch plant, the raw concrete materials are mixed in elevated bins where the wet concrete can then be poured directly into trucks for easy transport to construction sites.[74] The cylindrical trucks, often known as *cement mixers* deliver these “tailor-made” batches of plastic (wet) concrete from a central plant, so that contractors do not need to prepare the concrete mix at the construction site.[75] The sophisticated trucks can even digitally monitor the moisture content of the concrete during transport.[76] However, the fundamental process of batch mixing is nothing new. As early as 1909, wet concrete was being delivered to by horse-drawn mixers that used paddles, turned by the cart’s wheels, which mixed the concrete en route to the construction site.[77]

Ecological Implication:

By the time concrete components arrive at the batch plant, the majority of the ecological damage of concrete manufacturing has already been done. Overall, concrete production has a significant ecological impact. Cement production alone accounts for approximately 5% of global anthropogenic CO2 emissions.[78] Cement production also represents 75-80% of total emissions from concrete production, with aggregate processing generating 30-40%.[79] By comparison, the emissions from batching are negligible.

However, both the electric concrete mixer and diesel fueled equipment still contribute to carbon emissions and local air pollution. Airborne particulates can be a concern as well. Particulate matter, in the form of dust, can be released during the “transfer of cement and additive materials to the silos, the transfer of sand and aggregate, truck loading, mixer loading, and sand and aggregate blowing from the piles.”[80] Air pollution, “including carbon monoxide, nitrogen oxides, volatile organic compounds, particulate matter, nickel and formaldehyde,” is generated by on-site combustion engines and diesel trucks driving to and from the plant multiple times a day.[81]

Furthermore, concrete plants are noisy. Trucks with large mixing barrels are often on the street before dawn, spreading noise and diesel fuel as they pass through adjoining neighborhoods.[82] During rainstorms, polluted and muddy wastewater from the site stockpiles and dusty roads near the plant can contribute to elevated levels of hazardous runoff in the neighborhoods and waterways adjacent to concrete plants.

But the environmental impacts can be much greater than the individual plants because concrete plants are small pieces of a greater landscape of harm. Often, large industrial areas such as the one along the riverfront in North Minneapolis, are situated in less affluent parts of the city and adjacent to communities of color. While the Cemstone plant may not be the largest polluter in the area, it is contributing to a greater accumulation of emissions and pollution that disproportionately affects the residents near the plant. Because of its proximity to an industrial zone, North Minneapolis has more contaminated land than the rest of Minneapolis, with 44 contaminated sites per acre, compared to only 8 sites in the prosperous Kenwood neighborhood three miles south.[83] In 2010, an estimated 37 human deaths were attributed to particulate matter pollution within the same zip code as Cemstone plant.[84] Exposure to particulate matter is linked to health conditions "such as asthma, chronic bronchitis, reduced lung function, irregular heartbeat, heart attack, and premature death."[85] The COVID-19 pandemic has made it clear exactly how these types of preexisting conditions can result in elevated health risks. But these conditions can also have detrimental impacts beyond physical health. For instance, people may be forced to miss school and work with more regularity in order to take care of themselves or a loved one with a chronic condition.[86] So, while batch plants may not be the cause of greatest global concern within the concrete industry, local environmental impacts can still be grave. Often taking the greatest toll on already marginalized communities and landscapes.

REFLECT:

Like many designers, I've carried with me an abstract understanding of concrete as a "problematic" material. Like plastic or Ipe wood, I know that the production and use of concrete is not good for the environment. I know that in far away places "sand mafias" kill people over sand, a notion that seems both horrifying and absurd, but ultimately distant from my world and my choices. At the same time, concrete just feels so banal, it surrounds us, almost taken for granted as the obvious material of choice for infrastructure. If something is so ubiquitous, how bad could it really be?

After taking the time to look more closely at the extraction of concrete's ingredients, the negative consequences of the material now seem staggering and inexcusable, the effects of its production on the earth and its inhabitants is anything but banal. Mining for limestone and sand has reshaped landscapes across the globe. Doing particular damage to riparian and coastal habitats. Mining of limestone depletes topsoil and pollutes waterways. Sand mining changes the shape and flow of rivers and leads to catastrophic destruction of floodplains. Observing these same components intact in the familiar landscape of my daily walking area, and taking the time to know them through drawing, has enabled me to better visualize the scale of this loss. Imagine the River Gorge changed by the removal of the Platteville bluffs or the sand flats - or, on the other hand, the irretrievable splendor of Owámniyomni, before the once sacred limestone falls became an externality of an insensitive milling industry.

But the consequences of concrete production go well beyond the physical transformation of the landscape. The cement industry alone emits 2.8 billion tons of carbon per year.[87] If it were a country the cement industry would be the third largest CO2 emitter (following only China and the US).[88] As a whole, concrete production uses a tenth of the world's dwindling potable water supply, exacerbating water scarcity and stress around the globe. This concrete caused water crisis also creates a negatively reinforcing loop. In addition to depleting the clean water supplies necessary for concrete curing, concrete production and the extraction of its component parts also pollutes existing supplies of potable water, thereby compounding water scarcity. The worst of these water shortages unfairly burden countries that are often not primarily responsible for the ravenous consumption of concrete resources. The injustices of concrete production can also be felt close to home where the air, water, and noise pollution caused by concrete manufacturing poses a disproportionate threat to the residents of North Minneapolis. And people *are* being killed over sand. Explicitly, people in India are being murdered by the hundreds by other people desperate to control the valuable and rapidly diminishing stockpiles of sand required for concrete construction across the globe.

Given this, why do we keep designing with concrete? Why would something that causes so much harm be the uncontested material of modern infrastructure? For one thing, concrete is a rather extraordinary material. It is strong and durable while also being plastic. It can support mega structures and be shaped into an endless variety of forms. Compared to other structural building materials such as stone or brick, concrete is relatively inexpensive. Additionally, engineering regulations promote the use of concrete and are often written with that material in mind. For instance, the ADA guidelines for "floors and ground surfaces" do not require the use of concrete for sidewalks but concrete use is encouraged because it is "more reliably compliant" in providing "firm and stable surfaces."[89] Beyond the alluring properties of concrete and the years of precedent use, concrete is also a symbolic material. As author Adrian Forty argues in his excellent book, *Concrete and Culture*, unlike brick and stone, "Concrete is modern. This is not just to say that now it is here, when before it wasn't, but that it is one of the agents through which our experience of modernity is mediated. Concrete tells us what it means to be modern."[90] Therefore, concrete sidewalks are modern sidewalks for modern cities. They reflect and project industrial progress.

The flexible properties and versatile applications of concrete, combined with its symbolic stature as a material of modernity has led to a design industry that is uncritically accepting, if not adoring of the material. Many designers love concrete. For example, Adrian Forty explains, that beyond its symbolic link with Modernism, "it's really difficult to produce a very good exposed concrete building and, for that reason, architects regard it as a virtuous material...if you can do concrete well, you're a good architect."[91]

Frankly, this is a position I understand. I also love concrete construction. I grew up in the rural outskirts of St. Joseph, MN, a leisurely bike ride's distance from Marcel Breuer's extraordinary St. John's Abbey. His enormous modernist cathedral nestled along a wooded lake shore is a cast-in-concrete masterpiece and my all-time favorite work of architecture. To a lesser extent, I even admire the formal language of the humble concrete sidewalk - the way the material curves to form sumptuous curbs and dips effortlessly to meet the street at intersections. But given the grave ecological state of our planet (carbon dioxide levels are higher today than any point in at least 800,000 years)[92] and the harm contributed by concrete production (only coal, oil and gas are a greater source of greenhouse gases), it is past time for designers to ask whether our aesthetic preference for concrete is worth the cost of using the material.[93]

To change the way we design and build infrastructure will be a formidable task. Because concrete has evolved as the default material of modern infrastructure it has been written into the best practices of many engineering regulations. This is an issue for a couple of reasons. For one thing, “there’s a minority of architects pushing alternatives...by and large, architects do what the regulations tell them to do.”[94] At the same time, forward-thinking designers promoting less ecologically harmful alternatives often run into hurdles with regulatory authorities who aren’t familiar with other types of construction.[95] Even more challenging than fighting regulations will be changing the cultural perception that sidewalks *should* be concrete. Traditions are sticky and in addition to embodying modernity, the material also represents stability itself. It is no accident that concrete is used as a synonym for the word *fixed*. But we are in a period of great upheaval. Things that until recently seemed like solid elements of our culture, from handshakes between strangers to our democratic institutions are crumbling before our eyes. As designers, it has always been our job to present new ideas to society. As landscape designers it should be our additional responsibility to act as ambassadors between people and landscape and to advocate for the interests of the landscape. The very least we can do in this time of global instability is rethink the environmentally harmful standards and traditions of our own practice and admit our own culpability in the ongoing degradation of our planet. It is time to take seriously our obligation to the ailing land and offer our sputtering society better options.

ENDNOTES:

1 Hogberg, “Environmental Geology of the Twin Cities,” 7.

2 Hogberg, “Environmental Geology of the Twin Cities,” 7.

3 King, “Limestone What Is Limestone and How Is It Used?”

4 Hogberg, “Environmental Geology of the Twin Cities,” 8.

5 Hogberg, “Environmental Geology of the Twin Cities,” 8.

6 King, “Limestone What Is Limestone and How Is It Used?”

7 Hogberg, “Environmental Geology of the Twin Cities,” 61.

8 King, “Limestone What Is Limestone and How Is It Used?”

9 King, “Limestone What Is Limestone and How Is It Used?”

10 The Shelly Company, “How is concrete made from limestone?”

11 Ibid.

12 Ganapathi & Phukan, “Environmental Hazards of Limestone Mining,” 122.

13 Ibid.

14 Ibid.

15 Ganapathi & Phukan, “Environmental Hazards of Limestone Mining,” 125.

16 Ganapathi & Phukan, “Environmental Hazards of Limestone Mining,” 126.

17 Ibid.

18 Ganapathi & Phukan, “Environmental Hazards of Limestone Mining,” 127.

19 Ganapathi & Phukan, “Environmental Hazards of Limestone Mining,” 129.

20 Ibid.

21 Ganapathi & Phukan, “Environmental Hazards of Limestone Mining,” 127.

22 Watts, “Concrete: the most destructive material on Earth.”

23 Editors of Encyclopaedia Britannica, “Alluvium.”

24 Hogberg, “Environmental Geology of the Twin Cities,” 11.

25 Ibid.

26 PCA, “Aggregates.”

27 Opara, Eziefula, and Eziefula, “Comparison of physical and mechanical properties of river sand concrete,” 127.

28 Ibid.

29 Beiser and EBSCOhost, *The World in a Grain,* 46.

30 Opara, Eziefula, and Eziefula, “Comparison of physical and mechanical properties of river sand concrete,” 127.

31 Padmalal & Maya, “Impacts of River Sand Mining,” 31.

32 Padmalal & Maya, “Impacts of River Sand Mining,” 32.

33 Padmalal & Maya, “Impacts of River Sand Mining,” 36.

34 Padmalal & Maya, “Impacts of River Sand Mining,” 38.

35 Ibid.

36 Ibid.

37 Padmalal & Maya, “Impacts of River Sand Mining,” 40.

38 Padmalal & Maya, “Impacts of River Sand Mining,” 44.

39 Padmalal & Maya, “Impacts of River Sand Mining,” 48.

40 Beiser, “The Deadly Global War for Sand.”

41 Beiser, “The Deadly Global War for Sand.”

42 Carroll, “Engineering the Falls.”

43 Carroll, “Engineering the Falls.”

44 Carroll, “Engineering the Falls.”

45 Carroll, “Engineering the Falls.”

46 Hogberg, “Environmental Geology of the Twin Cities,” 2.

47 Hogberg, “Environmental Geology of the Twin Cities,” 3.

48 Materials Science and Technology Teacher’s Workshop. “Concrete - Scientific Principles.”

49 PCA, “How Concrete is Made.”

50 Materials Science and Technology Teacher’s Workshop. “Concrete - Scientific Principles.”

51 Materials Science and Technology Teacher’s Workshop. “Concrete - Scientific Principles.”

52 Materials Science and Technology Teacher’s Workshop. “Concrete - Scientific Principles.”

53 Watts, “Concrete: the most destructive material on Earth.”

54 Rahman, Rahman, Ashiqur, Haque & Rahman, “Sustainable Water Use in Construction,” 211.

55 Rahman, Rahman, Ashiqur, Haque & Rahman, “Sustainable Water Use in Construction,” 212.

56 Ibid.

57 Ibid.

58 Watts, “Concrete: the most destructive material on Earth.”

59 Rahman, Rahman, Ashiqur, Haque & Rahman, “Sustainable Water Use in Construction,” 211.

60 Population Matters, “Resources and Consumption.”

61 Roberts, “Predicting the future of global water stress.”

62 Fischetti, “How Much Water Do Nations Consume?”

63 Ritchie and Roser, “Water Use and Stress.”

64 Minneapolis.gov. “Primary Zoning Districts.”

65 Penn State College of Engineering, “Batching.”

66 MnDOT, “Certified Ready-Mix Plants.”

67 Frederick, *Guide to Air Quality Permitting*, 3.

68 Frederick, *Guide to Air Quality Permitting*, 2.

69 Penn State College of Engineering, “Batching.”

70 PCA, “Batching, Mixing, Transporting.”

71 PCA, “Batching, Mixing, Transporting.”

72 PCA, “Batching, Mixing, Transporting.”

73 PCA, “Batching, Mixing, Transporting.”

74 Flower and Sanjayan, “Greenhouse Gas Emissions Due to Concrete Manufacture,” 7.

75 PCA, “Ready Mixed Concrete.”

76 PCA, “Batching, Mixing, Transporting.”

77 PCA, “Ready Mixed Concrete.”

78 Flower and Sanjayan, “Greenhouse Gas Emissions Due to Concrete Manufacture,” 1.

79 Flower and Sanjayan, “Greenhouse Gas Emissions Due to Concrete Manufacture,” 1.

80 Frederick, *Guide to Air Quality Permitting*, 4.

81 Ibid.

82 Frederick, *Guide to Air Quality Permitting*, 5.

83 Center for Earth, Energy & Democracy. “Major Pollution in the Neighborhood,” 2.

84 Ibid.

85 Ibid.

86 Center for Earth, Energy & Democracy. “Major Pollution in the Neighborhood,” 2.

87 Watts, “Concrete: the most destructive material on Earth.”

88 Watts, “Concrete: the most destructive material on Earth.”

89 United States Access Board, “ADA Standards,” 5.

90 Forty, *Concrete and Culture,* 14.

91 Hurst, “Concrete: do architects have their heads in the sand?”

92 Union of Concerned Scientists, “Climate Science.”

93 Watts, “Concrete: the most destructive material on Earth.”

94 Watts, “Concrete: the most destructive material on Earth.”

95 Page, “Can the building industry break its addiction to concrete?”

CONCRETE LANDSCAPE SOURCES:

Beiser, Vince, and EBSCOhost. *The World in a Grain : The Story of Sand and How It Transformed Civilization*. New York: Riverhead Books, 2018.

Carroll, Jane Lamm. “Engineering the Falls: The Corps of Engineers’ Role at St. Anthony Falls.” US Army Corps of Engineers St. Paul District. October 27, 2015. https://www.mvp.usace.army.mil/Media/News-Stories/Article/626089/engineering-the-falls-the-corps-of-engineers-role-at-st-anthony-falls/

Center for Earth, Energy & Democracy. “Major Pollution in the Neighborhood.” Accessed: 10/28/2020. http://ceed.org/wp-content/uploads/2016/07/CEED-north-air.pdf

City of Minneapolis. “Primary Zoning Districts - Plate 12.” Minneapolis.gov. Last Amended: November 22, 2019. http://www2.minneapolismn.gov/www/groups/public/@cped/documents/maps/convert_255698.pdf

Editors of Encyclopaedia Britannica.“Alluvium.” britannica.com. July 20, 1998. https://www.britannica.

com/science/alluvium

Flower, David J. M, and Sanjayan, Jay G. “Greenhouse Gas Emissions Due to Concrete Manufacture.” *The International Journal of Life Cycle Assessment* 12, no. 5 (2007): 282-88.

Forty, Adrian. *Concrete and Culture : A Material History*. London: Reaktion, 2012.

Ganapathi H., Phukan M. “Environmental Hazards of Limestone Mining and Adaptive Practices for Environment Management Plan.” *In Environmental Processes and Management,* ed. Singh R., Shukla P., Singh P. Water Science and Technology Library, vol 91. Springer, Cham. (2020), 121-134 https://doi.org/10.1007/978-3-030-38152-3_8

Hogberg, R.K.”Educational Series 5. Environmental Geology of the Twin Cities Metropolitan Area.” *Educational Series 5. Environmental Geology of the Twin Cities Metropolitan Area*, 1971.

Hurst, Will. “Concrete: do architects have their heads in the sand?” *Architect’s Journal.*, January 16, 2019. https://www.architectsjournal.co.uk/news/concrete-do-architects-have-their-heads-in-the-sand

King, Hobart M. “Limestone What Is Limestone and How Is It Used? Geology.com. Accessed: 10/28/2020. https://geology.com/rocks/limestone.shtml

Materials Science and Technology Teacher’s Workshop. “Concrete - Scientific Principles.” University of Illinois Department of Materials Science and Engineering. Accessed: October 29, 2020. http://matse1.matse.illinois.edu/concrete/prin.html

Minnesota. Department of Transportation. “Certified Ready-Mix Plants and Approved Contractor Mix Designs.” 2020. https://rmx.dot.state.mn.us/rm_mix/

Opara, Hyginus E., Uchechi G. Eziefula, and Bennett I. Eziefula. “Comparison of physical and mechanical properties of river sand concrete with quarry dust concrete”, *Selected Scientific Papers - Journal of Civil Engineering* 13, s1 (2018): 127-134, doi: https://doi.org/10.1515/sspjce-2018-0012

Padmalal D., Maya K. “Impacts of River Sand Mining. In: Sand Mining.” Environmental Science and Engineering. Springer, Dordrecht.(2014): 31-56 https://doi-org.ezp2.lib.umn.edu/10.1007/978-94-017-9144-1_4

Page, Thomas. “Can the building industry break its addiction to concrete?” *CNN,* Updated: May 4, 2018. https://www.cnn.com/style/article/concrete-alternatives-future-building/index.html

Penn State College of Engineering. “Batching.” Accessed: 10/28/2020. https://www.engr.psu.edu/ce/courses/ce584/concrete/library/construction/mixingtransport/Batching.htm

Portland Cement Association. “Aggregates.” Cement.org. Accessed:10/28/2020. https://www.cement.org/cement-concrete-applications/concrete-materials/aggregates
Portland Cement Association. “How Concrete is Made.” Cement.org. Accessed:10/28/2020. https://www.cement.org/cement-concrete-applications/how-concrete-is-mades

Portland Cement Association. “Chapter 10 - Batching, Mixing, Transporting, and Handling Concrete.” in *Design and Control of Concrete Mixtures.*12th ed. Skokie, Ill.: Portland Cement Association, 1979, 167-189

Portland Cement Association. “Ready Mixed Concrete.” Cement.org. Accessed:10/28/2020. https://www.cement.org/cement-concrete-applications/products/ready-mixed-concrete

Rahman, Muhammad Muhitur, Rahman, M Ashiqur, Haque, Md Mahmudul & Rahman, Ataur. "Chapter 8 - Sustainable Water Use in Construction." *Sustainable Construction Technologies*. Edited by Vivian W.Y. Tam & Khoa N. Le, 211-235. Butterworth-Heinemann, 2019.

"Resources and Consumption." populationmatters.org. Accessed:10/28/2020. https://populationmatters.org/the-facts/resources-consumption

Ritchie, Hannah and Roser, Max."Water Use and Stress." Our World in Data. Last Modified: July 2018. https://ourworldindata.org/water-use-stress#global-freshwater-use

Roberts, Alli Gold. "Predicting the future of global water stress." *MIT News,* January 9, 2014. https://news.mit.edu/2014/predicting-the-future-of-global-water-stress

The Shelly Company. "How is concrete made from limestone?" January 29, 2014. https://www.shellyco.com/2014/01/29/concrete-made-limestone/

Union of Concerned Scientists. "Climate Science." Accessed: 10/28/2020. https://www.ucsusa.org/climate/science

United States Access Board. "ADA Standards - Chapter 3: Floor and Ground Surfaces." Accessed:10/28/2020. https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/guide-to-the-ada-standards/chapter-3-floor-and-ground-surfaces

Watts, Jonathan. "Concrete: the most destructive material on Earth." *The Guardian*, February 25, 2019. https://www.theguardian.com/cities/2019/feb/25/concrete-the-most-destructive-material-on-earth

PART 4: THE UNDERSIDE

Time allows for interaction and transforms the static 'snapshot' of the living world into an ecosystem.
- Alice Foxley

FIGURE 27 : THE UNDERSIDE TITLE PAGE

OBSERVE:

Pedestrians in the Twin Cities traverse rugged terrain. Every spring, after the snow and ice finally melt away, the sidewalk emerges as a cracking, crumbling, bulging topography. (A shared affliction that can also be observed in the pitted roads that run alongside.) While construction crews descend upon the undulating concrete strips, patching what's repairable and removing what's not, opportunistic plants sprout in every crack and crevice and slowly creep onto the paved pathways from all sides. In the places where the sidewalk panels are most lifted, a rogue tree root is often responsible and can be easily tracked from beneath the slab to the base flare of a nearby shade tree (FIGURE 28).

WONDER:

Why are the sidewalks I walk on everyday so lumpy and crumbly? How is the adjacent landscape affecting and being affected by the presence of the sidewalk? What's really going on underneath the slab?

EXPLORE:

Because I'm not able to lift the slab to look underneath, I began my exploration of the underside through observations of the exposed surface, photographing the cracking and lifting panels, speculating on the possible causes of the damage. I followed this with a significant amount of traditional research, creating an annotated bibliography of 10 sources ranging from 2 books about the soil and geology of the Twin Cities, 5 soils science studies, and 3 practical soil articles aimed at practitioners of arboriculture, horticulture and landscape design. All the literature I reviewed was subsequently used to build this section of my thesis, but the foundational documents were: *Soils of the Twin Cities Metropolitan Area and Their Relation to Urban Development,* by Lowell D. Hanson, "Urban Soils Part 1: Understanding Compaction," by James Urban, and the straightforward and comprehensive, *A description of urban soils and their desired characteristics*, written by landscape architect and forester, Phillip J. Craul. Other sources not included in the annotated bibliography have been referenced as needed. Through these sources and the guidance of my soil science professor, Nic Jalenski, I developed an understanding of the characteristics of Twin Cities urban soils that might be contributing to the sidewalk damage and how the sidewalk might be harming the soil in return. I also interviewed Craig Pinkalla, the forestry preservation coordinator for Minneapolis Parks about the complex relationship between urban sidewalks, soil and street trees. I also relied heavily on the research of trailblazing plant scientist, Nina Bassuk, to expand on this subject.

REPORT:

When walking the paved streets of my Minneapolis neighborhood, it's easy to forget that the ground below me is a living entity and a dynamic ecosystem. Sidewalks sit on soil. Like all the urban surfaces we take for granted, sidewalks can feel separate from the earth, but they are always just on top of, not instead of, the ground. Despite their discrete appearance, sidewalks and the urban underground are interrelated and belong to the same ecosystem. Inserting sidewalks into the soil changes the underground ecosystem and the underground ecosystem changes sidewalks. The construction of concrete sidewalks above the soil artificially flattens and compacts the ground, disrupting natural systems at play. But over time the soil's persistent processes of growth and physical and chemical (mass) exchange begin to break down sidewalks and distort their strictly engineered form, ultimately integrating the slab into the underground landscape.

In order to better understand how the slab's complex relationship with the soil results in undulating sidewalks, it's necessary to understand a little about the physical qualities of urban soils, their vital ecological roles, and the impacts of sidewalk construction on soil ecology. Even the most altered urban soil is not inert. Soil is a "dynamic natural body, composed of mineral and organic solids, gases, liquids and living organisms which can serve as a medium for plant growth."[1] In general, soils are composed of four distinct parts. minerals (broken down rock particles) and organic matter (decomposed living things) make up the solid bits and the rest (about 50%) is pore space, filled with water and gas that fluctuate interchangeably.[2] The specific properties and proportions of soil components are the result of their underlying "parent material" as well as their associated climate, biota and topography.[3] Soils are also in constant motion over both long and short timescales, resulting in soil materials that differ across the landscape.[4]

Soil is more than the sum of its dynamic parts. Soil is not merely a material made up of minerals, organic matter, water and air, but an essential part of our global ecosystem. The many functions of soil can be grouped into five vital ecological roles: (1) soil is a medium for plant growth, (2) a habitat for soil organisms, (3) a recycling system (for dead plants and animals), (4) a system for water supply and purification, (5) and an engineering medium for construction, providing a "foundation for virtually every road, airport, and house we build."[5] Given the critical importance of these roles, "to a great degree, the quality of soil determines the capacity of land to support animal life and society."[6] However, in most urban areas, the soil's role as an engineering medium has taken prominence, often at the expense of its other vital functions. Whether we recognize it or not, soil is a habitat unto itself, the foundation of our interconnected global ecosystem, and the source and destination for all life on our planet.

The soil habitat is a dynamic but delicate system, and the brute insertion of urban infrastructure can deeply interfere with the natural cycles of the living ground.[7] The "presence of anthropic materials and other contaminants,"[8] such as a concrete sidewalk slab, is one of the many ways that urban soils are different from their naturally occurring counterparts. Sidewalks and other paved surfaces inflict damage on the adjacent soil environment and threaten organisms that rely on city soil for survival.

The intentional compaction of soil below sidewalks, combined with pressure from foot traffic above and vibrations from vehicular traffic on nearby roadways, leads to soils that are exceptionally dense near sidewalks.[9] In preparation for sidewalk construction, a vibrating roller machine is often used to compress the foundation soil while applying a compacting force.[10] This technique is used to collapse soil pore space and help mineral particles fit more tightly together. This process can even break the tight bonds that exist between clay soil particles, helping to increase compaction at deeper levels below sidewalks than would normally occur from compaction force without vibration.[11] This compacted soil creates an inhospitable environment for plant growth (FIGURE 29). At bulk densities greater than 1.70 mg/m3, "soil structure is destroyed, and the majority of large interconnected pores (macropores) are crushed."[12] Without open pore space, soil becomes restrictive to mechanical root growth and gas and water exchange. This is an all to common occurrence near urban sidewalks. A study of soils adjacent to the Washington DC pedestrian mall, for example, found soil densities ranging from "1.54 to 1.90 g/cm3 with most centering on 1.82 g/cm3."[13] This level of compaction is detrimental to plants whose roots are unable to push through the dense soil or extract essential water, oxygen, and nutrients from the collapsed pore space. Arguably, urban street trees suffer most, living only an average of 20-30 years in roadside environments.[14] "Simply put, when soils are inadequate, plant growth suffers and trees die prematurely."[15]

In addition to severely compacting the soil under the slab, sidewalk construction can also cause differences between the compacted soil and the less altered neighboring soils. This change in texture between the soils or soil layers (horizons) creates an abrupt boundary, or *lithologic discontinuity* within the soil profile.[16] A lithological discontinuity is formed when two soils of dramatically different particle size or mineralogy share a boundary, whether stacked or side-by-side. While these discontinuities in texture also occur naturally, in urban environments they tend to be more abundant and extreme due to the frequency of "soil excavation, cut and fill, regrading, and soil compaction."[17] Lithologic discontinuities create a barrier to water and gas exchange between soil layers which in turn causes problems for streetside plants because one soil layer may be hospitable to plant growth, while the adjacent layer is not. Additionally, "roots...may have difficulty crossing layers where there is any dramatic difference in porosity."[18] Over time, mineral particles can build up along the boundary between layers, further limiting exchange between soils.[19] The "spatial variability may be just as complex as vertical variability" because the soil under the sidewalk has undergone greater disturbance than the soils that run alongside.[20] In this way deep compaction and discontinuities caused by sidewalk construction can also create a horizontal barrier, preventing water and oxygen from moving laterally to and from nearby soil.

In addition to increasing soil compaction and discontinuities, sidewalks also seal off soil from water and gas exchange with the atmosphere, creating an obstacle for nutrient cycling under the slab. This paved, impervious barrier can significantly impact the important and often overlooked role that soils play as a carbon sink for atmospheric carbon dioxide.[21] Globally, "more carbon resides in soil than in the atmosphere and all plant life combined; there are 2,500 billion tons of carbon in soil, compared with only 800 billion tons in the atmosphere and 560 billion tons in plant and animal life."[22] While urban regions are by far the major source of atmospheric CO2 emissions (producing 78% globally), cities also have the potential to store large amounts of soil organic carbon and mitigate increases in atmospheric CO2.[23] However, multiple studies have shown that soil carbon storage is reduced by 68% under roads and sidewalks.[24] While the exact reason for the decrease remains unknown, lowered carbon storage capacity is "likely due to removal of topsoil, compaction, and gaseous and aqueous losses" resulting from the construction of pavement and surface sealing.[25] Currently, impervious surfaces cover over 580,000 square kilometers globally, an area greater than France, and are rapidly expanding.[26] Minneapolis alone has 1,800 miles of sidewalk,[27] (and 32,000 "lane miles" of paved road).[28] This impervious cover significantly reduces the potential for soil carbon sequestration within the city.

Pavement-caused soil problems extend beyond the slab footprint to the soils that run alongside. For example, soils near sidewalks and roads are likely to be contaminated with heavy metals from passing combustion engines. Heavy metals such as cadmium, zinc and lead are detrimental to soil, reducing the "diversity and activity of soil microbes" which "play significant roles in recycling of plant nutrients, maintenance of soil structure, detoxification of noxious chemicals and the control of plant pests."[29] While some heavy metals, such as copper, nickel, and zinc are necessary for plant growth, they can easily become toxic in large doses. Even trace amounts of nonessential metals, such as lead, can be toxic to plants and inhibit some vital plant processes, including photosynthesis, mitosis and water absorption.[30] Metal contaminants also migrate from the roadsides via water, polluting important aquatic resources. In humans, exposure to these metals can cause symptoms ranging from nausea and muscle aches to cancer, kidney failure, brain damage, and death.[31] The concentration of heavy metals tends to increase closer to streets and housesides.[32] Studies in numerous cities have found heavy metal concentrations to be significantly higher near roadsides, typically not extending much past 20m from the road.[33]

Sidewalks complicate this problem, especially in northern climates, where the Sodium chloride (NaCl) that is applied as a deicing salt in the winter raises the pH of the surrounding soil. The more alkaline streetside soils of northern cities like Minneapolis bond with heavy metal cations, a reaction that is positively correlated with increased heavy metal retention.[34] In simple terms, this means that soils that have elevated levels of pH, are likely to also contain a higher quantity of harmful heavy metals. In one way, high pH can actually benefit street trees and pedestrians because "the soil is more likely to immobilize the metals from atmospheric suspension and plant and human uptake."[35] However, the higher concentrations of metals in the soil can pose a threat to people or animals who interact with contaminated soil directly.

Regardless of its effect on heavy metals, deicing salt alone can damage the soil. In addition to raising soil pH, high concentrations of sodium chloride lead to "reduced water permeability, poor aeration, [and] surface crusting" in soils near the sidewalk.[36] In turn, these changes in the soil negatively impact the vegetation growing along the pavement. Soil salinity is a particular threat for the street trees which line the sidewalks in many northern cities. High sodium chloride concentrations have been shown to impact trees through direct ionic toxicity, as well as causing "osmotic effects" which interfere with water and nutrient uptake."[37] While salt can also reach trees by airborne spray from nearby roads, many of the sodium chloride ions are taken up by roots from the soil. After salts enter the tree, they become concentrated in leaf tissue, often leading to "leaf chlorosis and/or necrosis, reduction of photosynthetic rates, and premature leaf senescence".[38] Multiple studies have shown that, for many tree species, "the extent of plant injury and mortality correlates with leaf Na and/or Cl concentration." [39] Although elevated sodium chloride in soil has become recognized as a "major factor in the decline of urban trees" the use of deicing salt has actually increased over the last decade.[40] Deicing salt does not pose the same threat to pedestrians and can even enliven the winter sidewalk-scape with a rainbow watercolor effect (from the dyes added to the deicers). But these inky marks also serve as a reminder of the casual damage we do to the environment in the name of human convenience (FIGURE 30).

Despite the irrefutable damage done to the soil by sidewalks, the living ground is not simply a passive victim of the pavement. The soil does fight back. The dynamic processes that continually recycle and replenish the soil habitat are stubborn and assert their own force back against the concrete slab. I observe evidence of this struggle every day, when I walk the sidewalks of my Twin Cities neighborhood. In order to understand how the soil causes problems for the sidewalk, it's important to understand the particulars of the soil ecosystem under the slab. The soils of my Minneapolis walking area consist primarily of mixed clayey glacial loams (as well as the sandier soils of the Mississippi River terraces). The loams, which comprise more than 75% of the soils in Hennepin County, are largely the product of glacial till deposited during the last ice age by the Des Moines Lobe glacier.[41] These medium to fine textured loams are productive and generally stable, providing fertile land for agriculture and a solid foundation for urban development. However, these "heavy" loams also have a high clay content, especially from a depth between 12-48 inches.[42]

The presence of finely textured clay creates trouble for the sidewalks because fine clays drain slowly.[43] They also possess the unique capacity to contract and expand, "swelling on wetting and shrinking on drying."[44] As a result of this expanding, slow-draining clay, the glacial loams of my walking have a "high water-holding capacity."[45] In warmer months, excessive water in the soil can damage sidewalks from below, causing loose soil particles to float and shift under the sidewalk, resulting in gaps between the flat concrete slab and its aggregate foundation.[46] But the more sinister effects of water come as the temperature drops. As soil temperatures fluctuate above and below freezing, cycles of freezing and thawing in soil water concentrate into layers of ice within the soil profile.[47] As these layers freeze and melt the soil layers shift. For the soil, this "action breaks up large masses and greatly improves granulation."[48] This benefits the soil by reducing compaction over time. But for the sidewalk, it's a different story. Freezing can "heave shallow foundations" causing the slab to lift and settle unevenly against the ground, creating pressure points.[49] Pressure from above combined with the instability below, cracks the concrete, allowing spaces for decomposition to take hold. According to UMN Concrete Superintendent, Catherine Vennewitz, freeze-thaw is the number one cause of sidewalk damage on campus.[50] But on some level, every Minnesotan who has walked on uneven, pitted sidewalks or driven pot-holed roads in the spring, probably already knows this.

Soil dwelling organisms also attack sidewalks from below. Tree roots, in particular, can do tremendous damage. The deep soil compaction that results from traditional sidewalk construction, makes root penetration in the lower soil profile difficult. But tree roots are powerful and opportunistic. Craig Pinkalla, the Forestry Preservation Coordinator with Minneapolis Parks put it this way, "trees are not inherently deep or shallow rooted...they are efficient resource seekers...they will grow where the growing is best."[51] Because the heavily compacted soil under and around sidewalks is depleted of oxygen and nutrients, the best growing for tree roots is often the air gaps between the concrete slab and soil. These freeze-thaw formed pockets are often a street tree's easiest access to oxygen and moisture.[52] This causes big problems for the slab. The strong shallow growing roots easily heave concrete panels, sometimes lifting the slab many inches above the ground, creating "trippers" that can be dangerous to pedestrians and an impediment to sidewalk access.[53]

Diligent maintenance is required to combat the lifting of panels, and cracking that often follows. The City of Minneapolis has a suite of tools to take this on. Sometimes arches are cut out of the slab to make room for roots to expand, sometimes the panels are ramped on either side, creating more space for roots below the slab. Other times, a sidewalk "alignment change" is required to curve both edges of the pavement away from the tree. But often, eventually, replacement of the entire concrete panel is still required (FIGURE 31).[54]

Even the roots of smaller herbaceous plants can do damage by colonizing existing cracks in the concrete. For certain disturbance-adapted colonizer species such as *Eragrostis pectinacea* (Tufted Lovegrass) *Chamaesyce maculata* (Spotted Spurge), sidewalk cracks provide an ideal environment.[55] These rugged species that grow on exposed rock in nature have no trouble germinating in the extreme environment of a sidewalk crack - a phenomenon that can be easily observed when walking any given stretch of Minneapolis sidewalk in the summertime. As these plants mature, their growing root networks continue to break down the stony edges bit by bit, causing the cracks to crumble and expand as dust and organic matter accumulate within them.[56] These larger cracks allow more water to enter and freeze within the slab, further expanding the openings, allowing space for more plants to germinate in spring. As these plants die, organic matter continues to build up as it mixes with accumulated dust and the mineral rubble of the broken down concrete components: limestone, gravel, and sand - creating a welcoming substrate for larger herbs to establish. The weeds and grasses adjacent to the slab also take advantage of the newly laid soil deposits as they begin to slowly creep onto the slab from the sides (FIGURE 32).[57]

Ants, earthworms and other soil biota also contribute to the slab's undoing. These tiny, soil-dwelling ecosystem engineers tenaciously use every crack and crevice to gain entrance to the soil below the slab. As they dig down into the soil profile, ants and earthworms pile displaced soil on the surface, pulling minerals and nutrients up from below through a process known as bioturbation (FIGURE 33). By excavating the soil through burrowing and mounding "soil biota...continuously mix and displace particles, including artifacts."[58] Eventually, this continual movement of soil from underneath an artifact onto its surface, tends to "displace larger objects downward."[59] Over time, even a sidewalk slab will be buried by bioturbation - a recent study of abandoned mining sites in western Illinois, estimated that "the upper 15 cm of soil is displaced at least every 50 – 100 years through earthworm and ant mound formation." [60] So if left alone for a half century or so, the ordinary anthills, which feel so fragile and fleeting scattered across the solid slab surface, will expand into an overlying layer of soil. That soil can then serve as a new base for plants to germinate, grow, and die - providing food for decomposing organisms, producing a rich organic layer above the ever sinking slab. As the new soil layer grows thicker, the slowly deteriorating sidewalk can become a complex and thriving habitat of its own.

Sidewalks can feel permanent but they are far more ephemeral than the ancient soils they sit upon. At best, concrete sidewalks in Minneapolis have a relatively short life-span.

The sidewalk experts I talked to all agreed that the average concrete panel only survives about 20 years (interestingly, they share the same life expectancy as their street tree adversaries). Witnessing the soil's ceaseless attack against human-paved sidewalks can feel like a thrilling victory for nature. However, as concrete breaks down in the soil, it also changes the soil. When concrete weathers, it releases lime (calcium carbonate) into the soil, altering the physical, chemical, and biological balance of this ecosystem.[61] Large chunks of construction materials in urban soils can also exacerbate discontinuities in the soil profile, creating new barriers for root growth and blockages to water and gas cycles.[62] Furthermore, if sidewalks are not properly maintained, and deterioration begins early, more resources are unnecessarily extracted from the earth and more energy is unnecessarily used to process these resources into construction components to replace the damaged sidewalks. Through extraction of resources used for its construction, a sidewalk has deleterious effects beyond the ecosystem it exists in. For this reason, we should be committed to extending the longevity of sidewalks as much as possible. Unfortunately, because conventional sidewalk design does not account for dynamic soil processes, that effort is currently at odds with the underlying soil ecosystem, constantly working to break down the slab and integrate it into the underground landscape.

REFLECT:

So, maybe for the sake of the soil and the environment beyond, we just shouldn't have sidewalks all? (Especially, if all that we're left with are lumpy sidewalks that are destined to fail.) Maybe. There is no doubt impervious surface inflicts serious damage to the soil environment where it is installed as well as to the landscape from where its parts are extracted (See "Part 3: The Concrete Landscape"). Sidewalks are clearly antagonistic to the landscape, but in another way, sidewalks also protect the landscape from us. In cities, there are thousands, sometimes millions of us exerting our significant bipedal force upon the ground. Because "compaction force is a function of both the weight of an object and the surface area over which the weight distributed… pedestrians, with their small footprint-to-mass ratio, can cause more compaction than a track grading machine."[63] Sidewalks actually help to restrict our movement to a narrow surface that distributes our load, protecting the surrounding soil from our potentially harmful paths of individual desire.

Furthermore, while traditional sidewalk construction does require intentional compaction of the soil, compaction is not merely the consequence of making pavement, it is a consequence of movement over the land. Compaction by foot traffic is the reason hiking paths, which we tend to think of as natural spaces, remain clear of plant growth (and the reason we are asked to "stay on the path" at many parks).[64] Compaction is the reason that wagon wheel ruts from the Oregon Trail are still visible after almost two centuries.[65] Soil compaction is natural and on some level, unavoidable, and if there is going to be so many of us moving about in one place, in one way or another, it makes sense to try to limit where we walk. By restricting our movement, sidewalks help to mitigate potential harm to the soil ecosystem. For this reason alone, sidewalks have a purpose, an important role to play in the greater urban environment. So, how do we better protect the soil from the sidewalks themselves? How can we design to reduce the conflict between sidewalks and the soil ecosystem?

First and foremost, we need to care more about our urban soil. Even in the soil sciences, urban soil is not well understood. A prime example of this is the dearth of urban soil surveys - geographical representations which map the "soil properties and features" in a particular area of interest.[66] According to the USDA Natural Resource Conservation Service, very few cities have comprehensive soil maps.[67] "For most urban areas, the current soil information is incomplete, outdated, or nonexistent…"[68] Because our urban soil information is inadequate, when it comes time to design a sidewalk, or anything else in the urban environment, we really don't know much about the underlying substrate. This inevitably leads to deficiencies in design because specific soil properties can affect the sidewalk differently. For example, the presence of expanding-contracting clay might cause the slab to lift and heave whereas a sandier substrate could result in undermining of the slab if the loose minerals erode over time.[69] In order to build longevity into the slab, sidewalks should at least be tailored to the specific soil conditions of a particular site. The MnDot standards (which govern the construction of sidewalks and other infrastructure in my walking area) don't do much to fill this information gap. While tests for soil moisture content and density are required prior to construction,[70] no tests are required to understand attributes of the soil such as soil type and texture, or other characteristics that might be relevant to the long term stability of the sidewalk.[71]

We also need to think about our urban soil differently. Traditionally, when soil *is* considered in sidewalk design and construction, it is primarily in its role as an engineering medium. But this is only one of soil's five ecosystem services. In general the soil's other vital functions (recycling system, habitat, water system, and planting medium) go unacknowledged. For example, there are MnDot specifications for the degree of soil compaction necessary to stably support a concrete slab (100% minimum, if less than 3 feet below grade) but no specs for how to protect soil's ability to recycle nutrients and organic waste[72]. Nor are there specifications for maintaining the integrity of the habitat for soil organisms under and around the slab. Increasingly, the soil's role as a system for water supply and purification is being considered as planners and designers are starting to measure and in some cases working to reduce the amount of water and pollutants that run off paved surfaces into adjacent water bodies.[73] But best practices for reducing impervious surfaces are often left out of design conversations because they are at odds with conventional "sprawl zoning" which requires a minimum of paved surfaces for businesses and residences.[74] This lack of consideration is not only damaging to our soil, it is also a disservice to our sidewalks, which suffer heaving, cracking, and undermining because of our disregard for soil's dynamic nature.

On the other hand, as charismatic street trees have gained popularity and are generally considered part of an urban strategy for mitigating the effects of climate change, more attention is being paid to streetside soil's role as a medium for plant growth.[75] For instance, engineered structural soils, first developed by Cornell forest scientist, Nina Bassuk, have become an increasingly popular alternative to compacting existing soils under sidewalks. These man-made replacement soils consist of a load-bearing "lattice" of angular crushed stone with a heavy clay loam or loam fill, which is specially engineered to mitigate compaction and allow for superior root expansion within the lattice.[76] Because open space (for water and gas exchange) is maintained within the stone lattice, this system can offer greatly increased availability of uncompacted soil for root growth under sidewalks. This is happy news for sidewalks as well. Because of the greater volume of available soil, tree roots can grow deeper in the soil profile, where they are less likely to heave and crack the pavement.[77] Rock based lattice systems like these are increasingly common in Minneapolis and favored by the city's forestry preservation coordinator, because they are effective, easy to source, require no specialized installation, and have high plasticity which makes them "easy to work around any shape."[78] There is even early research that suggests structural soils may act as an effective sink for roadside pollutants.[79]

While structural soils do reduce compaction, promote plant growth, and help to flatten uneven pedestrian pathways, the insertion of engineered soils will still change the soil ecosystem. The ground is continuous, and the introduction of a different substrate will inevitably alter the underground habitat and create discontinuities, potentially affecting the flow of water, oxygen, nutrients, and organisms in soil far beyond the slab. I have found no research about how engineered soils affect the greater soil landscape, but that's not surprising since urban soil is so often ignored, our focus alway trained to our above ground world. Whether we acknowledge it or not, we can't escape the foundational governance of the soil, upon which everything is built. More than anything, the undulating sidewalks of my Minneapolis neighborhood are a consequence of rarely considering the living soil landscape at all. In order to construct stable sidewalks that also protect the urban landscape and support soil's vital ecosystem services, sidewalks must be designed in deference to the needs of the soil. Until sidewalk designers and engineers take the time to better understand how the built environment impacts the urban underside, not only will the soil suffer, but sidewalks will continue to crack, heave, and crumble as they struggle against the processes of the living ground.

ENDNOTES:

1 Brady and Weil, *Elements of the Nature and Properties of Soils*, 587.

2 Brady and Weil, *Elements of the Nature and Properties of Soils*, 13.

3 Brady and Weil, *Elements of the Nature and Properties of Soils*, 31-48.

4 Correspondence with Nic Jelinski, Nov 20, 2020.

5 Brady and Weil, *Elements of the Nature and Properties of Soils*, 2.

6 Brady and Weil, *Elements of the Nature and Properties of Soils*, 1.

7 Brady and Weil, *Elements of the Nature and Properties of Soils*, 5.

8 Craul, “A description of Urban Soils,” 331.

9 Craul, “A description of Urban Soils,” 332.

10 Urban, “Understanding Compaction,” 24.

11 Urban, “Understanding Compaction,” 26.

12 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil*, 6-7.

13 Craul, “A description of Urban Soils,” 332.

14 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil*, 5.

15 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil*, 6.

16 Craul, “A description of Urban Soils,” 331.

17 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil*, 6.

18 Urban, “Understanding Compaction,” 27.

19 Ibid.

20 Craul, “A description of Urban Soils,” 331.

21 Correspondence with Nic Jelinski, Nov 20, 2020.

22 Schwartz, “Soil as Carbon Storehouse.”

23 Lorenz, Klaus, & Rattan, “Biogeochemical C and N Cycles,” 1.

24 Wei, “Density and Stability of Soil Organic Carbon.”

25 Ibid.

26 Ibid.

27 City of Minneapolis. “Walking in Minneapolis.”

28 City of Minneapolis, “How Streets are Plowed.”

29 Singh & Kalamdhad, "Effects of Heavy Metals on Soil."

30 Singh & Kalamdhad, "Effects of Heavy Metals on Soil."

31 Singh & Kalamdhad, "Effects of Heavy Metals on Soil."

32 Craul, "A description of Urban Soils," 334.

33 Wang, Meie, & Haizhen, "Accumulation of Heavy Metals."

34 Wang, Meie, & Haizhen, "Accumulation of Heavy Metals."

35 Correspondence with Nic Jelinski, Nov 20, 2020.

36 Equiza, Calvo-Polanco, Cirelli, Señorans, Wartenbe, Saunders, & Zwiazek, "Long-term impact of road salt."

37 Ibid.

38 Ibid.

39 Ibid.

40 Ibid.

41 Hanson, Springer, Farnham, Robertson & Allred, "Soils of the Twin Cities," 18.

42 Hanson, Springer, Farnham, Robertson & Allred, "Soils of the Twin Cities," 19.

43 Hanson, Springer, Farnham, Robertson & Allred, "Soils of the Twin Cities," 20.

44 Hanson, Springer, Farnham, Robertson & Allred, "Soils of the Twin Cities," 19.

45 Ibid.

46 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

47 Brady and Weil, *Elements of the Nature and Properties of Soils,* 220.

48 Brady and Weil, *Elements of the Nature and Properties of Soils,* 220-221.

49 Brady and Weil, *Elements of the Nature and Properties of Soils,* 221.

50 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

51 Interview with Craig Pinkalla, MPRB Forestry Preservation Coordinator, April 7, 2020.

52 Ibid.

53 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil,* 7-8.

54 Interview with Craig Pinkalla, MPRB Forestry Preservation Coordinator, April 7, 2020.

55 Seiter, "Profiles of Spontaneous Urban Plants."

56 Brady and Weil, *Elements of the Nature and Properties of Soils*, 49.

57 Ibid.

58 Balek, "Buried artifacts in stable upland sites," 41.

59 Ibid.

60 Balek, "Buried artifacts in stable upland sites," 45.

61 Correspondence with Nic Jelinski, Nov 20, 2020.

62 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

63 Urban, "Understanding Compaction," 26.

64 Adams, "Why does it matter if I stay on the trail."

65 Urban, "Understanding Compaction," 28.

66 USDA, "How to Use a Soil Survey."

67 Brady and Weil, *Elements of the Nature and Properties of Soils*, 91.

68 USDA, "Urban Soils."

69 Interview with Catherine Vennewitz, FM Concrete Superintendent, February 14, 2020.

70 MnDot, *Standards and Specifications for Construction,* 91.

71 MnDot, *Standards and Specifications for Construction*, 94.

72 Ibid.

73 EPA, *Managing Wet Weather*, 4.

74 Lakis, "No More Pavement!"

75 Safford, Larry, McPherson, Nowak & Westphal, *Urban Forests.*

76 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil*, 19.

77 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil*, 11.

78 Interview with Craig Pinkalla, MPRB Forestry Preservation Coordinator, April 7, 2020.

79 Bassuk, Denig, Grabosky, Haffner, & Trowbridge, *CU-Structural Soil.*

THE UNDERSIDE SOURCES:

Adams, Mary Beth. "Why does it matter if I stay on the trail while hiking in the woods and parks?" *Science Society of America*, June 15, 2015. https://soilsmatter.wordpress.com/2015/06/15/why-does-it-matter-if-i-stay-on-the-trail-while-hiking-in-the-woods-and-parks/

Balek, C.L., "Buried artifacts in stable upland sites and the role of bioturbation: A review." *Geoarchaeology*, 17 (2002): 41-51. doi:10.1002/gea.10002
City of Minneapolis. "How Streets are Plowed in Minneapolis." Last updated Dec 3, 2018. http://www2.minneapolismn.gov/snow/snow_snow-removal-basics

Bassuk, Nina & Denig, Bryan & Grabosky, Jason & Haffner, Ted & Trowbridge, Peter. *CU-Structural Soil: A Comprehensive Guide*. Urban Horticultural Institute, Cornell University 2015.

Brady, Nyle C., and Weil, Ray R. *Elements of the Nature and Properties of Soils*. 2nd ed. Upper Saddle River, N.J.: Prentice Hall, 2004.

City of Minneapolis. "Walking in Minneapolis." Last updated Aug 17, 2020. http://www2.minneapolismn.gov/pedestrian/index.htm.

Craul, P.. "A description of urban soils and their desired characteristics." *Journal of arboriculture* (1985): 330-339.

Hogberg, R.K. "Educational Series 5. Environmental Geology of the Twin Cities Metropolitan Area." *Educational Series 5. Environmental Geology of the Twin Cities Metropolitan Area*, 1971.

Equiza, M.A., Calvo-Polanco, M., Cirelli, D., Señorans J., Wartenbe M., Saunders, C, Zwiazek, J.J. "Long-term impact of road salt (NaCl) on soil and urban trees in Edmonton, Canada." *Urban Forestry & Urban Greening* 21 (January 2017): 16-28

Hanson, Lowell D, Springer, Clement D, Farnham, Rouse S, Robertson, Alex S, and Allred, Evan R. "Soils of the Twin Cities Metropolitan Area and Their Relation to Urban Development." 1966.

Lakis, Polycarpou, "No More Pavement! The Problem of Impervious Surfaces" *State of the Planet. Earth Institute Columbia University*, July 13, 2010. https://blogs.ei.columbia.edu/2010/07/13/no-more-pavement-the-problem-of-impervious-surfaces/

Lorenz, Klaus, and Rattan Lal. "Biogeochemical C and N Cycles in Urban Soils." *Environment International*, vol. 35, no. 1 (2009): 1–8.

Minnesota. Department of Transportation. *Standards and Specifications for Construction 2018 Edition*, 2018.

Safford, H.; Larry, E.; McPherson, E.G.; Nowak, D.J.; Westphal, L.M. *Urban Forests and Climate Change*. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center, August 2013. www.fs.usda.gov/ccrc/topics/urban-forests/

Seiter, David. "Profiles of Spontaneous Urban Plants." *Urban Omnibus*, December, 2011. https://urbanomnibus.net/2011/12/profiles-of-spontaneous-urban-plants/

Singh, Dr. Jiwan & Kalamdhad, Ajay. "Effects of Heavy Metals on Soil, Plants, Human Health and Aquatic Life." *International Journal of Research in Chemistry and Environment* 1, no. 2 (October, 2011): 15-21

Schwartz, Judith D. "Soil as Carbon Storehouse: New Weapon in Climate Fight?" *Yale Environment 360*, March 4, 2014.

Taylor, A.R., Lenoir, L., Vegerfors, B. *et al.* "Ant and Earthworm Bioturbation in Cold-Temperate Ecosystems." *Ecosystems* 22 (2019): 981–994. https://doi.org/10.1007/s10021-018-0317-2

United States. Environmental Protection Agency. *Managing Wet Weather with Green Infrastructure Action Strategy 2008*. National Service Center for Environmental Publications, 2008.

Urban, James. "Urban Soils - Part 1: Understanding Compaction: Excerpt from Up By Roots" *International Society of Arboriculture Magazine* (Apr. 2008): 25-28.

USDA Natural Resource Conservation Service. "How to Use a Soil Survey." Accessed October 22, 2020. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053375

USDA Natural Resource Conservation Service. "Urban Soils." Accessed October 22, 2020. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/urban/

Wang, Meie, and Haizhen Zhang. "Accumulation of Heavy Metals in Roadside Soil in Urban Area and the Related Impacting Factors." *International journal of environmental research and public health* 15, no. 6 (May 2018): 1064

Wei, Zongqiang, et al. "Density and Stability of Soil Organic Carbon beneath Impervious Surfaces in Urban Areas." *PLoS ONE*, vol. 9, no. 10 (October 9, 2014): E109380.

FIGURE 28 : HEAVING AND CRACKING PANELS

FIGURE 29 : COMPACTED AGGREGATE, COMPACTED SOIL, TRENCH ROLLER (COMPACTOR)

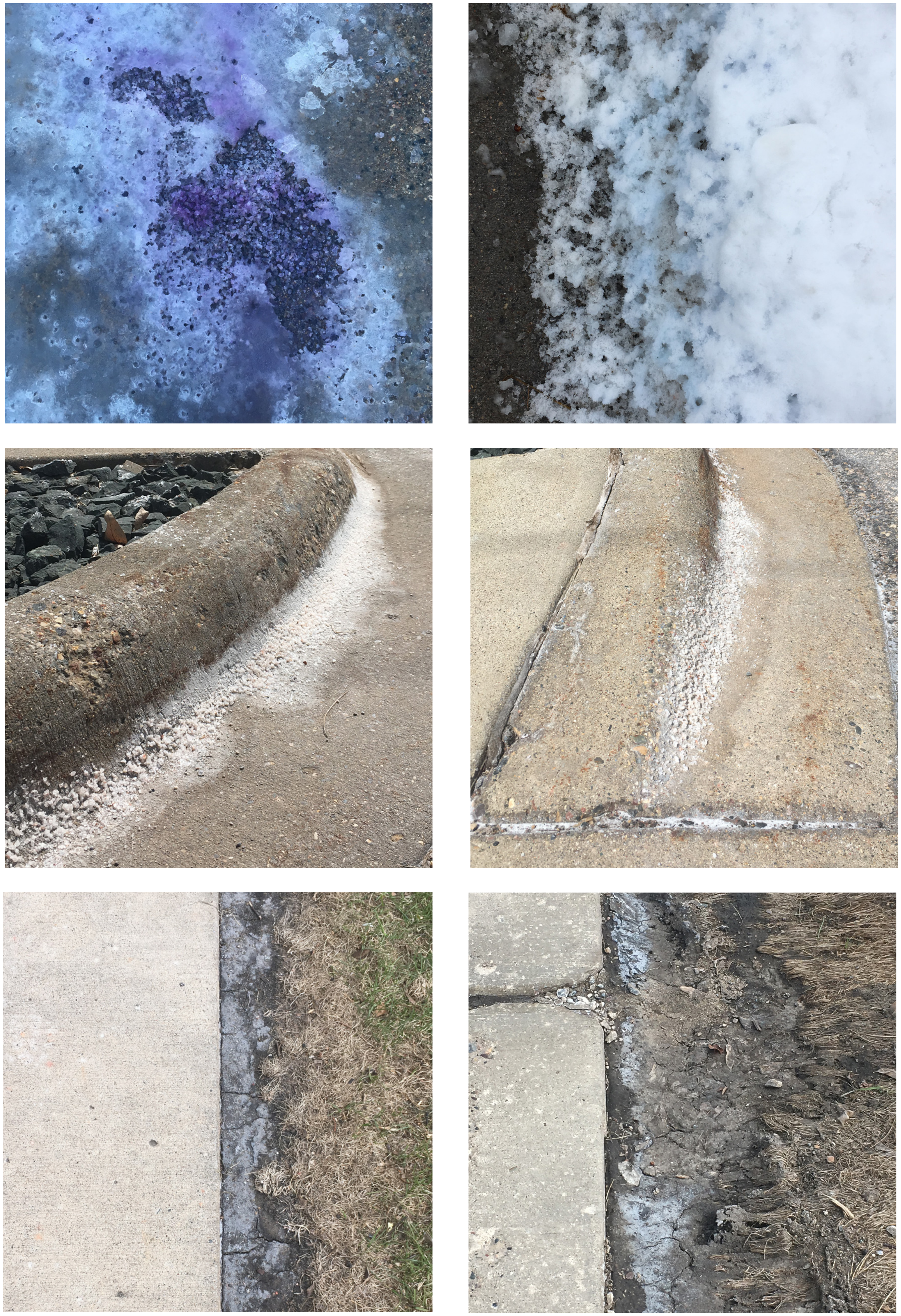


FIGURE 30 : DEICING SALT

FIGURE 31 : TREE ARCH, ASPHALT RAMP, REPLACEMENT PANEL

FIGURE 32 : SIDEWALK PLANTS

FIGURE 33 : ANT BIOTURBATION

FIGURE 34 : FUTURE WALKS TITLE PAGE

For the past year, I've been investigating the urban sidewalks of Minneapolis neighborhood. I've allowed traces and occurrences I've observed on the sidewalk surface to spark my curiosity about sidewalks and guide my examinations of the concrete slab - what it's made of and how it's made. I've conducted this sidewalk research through multifarious methods, curious to see what kind of picture would emerge if I explored the sidewalk through different modes of art, design, and academic inquiry. These methods led me to explore some of the under-considered and largely invisible systems that overlap with sidewalks. My research has focused on sidewalk construction as well as the effects of sidewalks and their material components on local and global landscape systems. This work has helped me understand how these larger systems intersect each other in the physical slab.

Overall, the thesis had two goals: (1) To use traditional and nontraditional research methods to build a more holistic perspective of urban sidewalks and a deeper understanding of the landscape systems with which they interact. (2) To prioritize research over construction in the landscape design process.

SUMMARY OF FINDINGS:

The body of this thesis consists of four sections. Each section examines the urban sidewalk through the lens of a different system with which the sidewalk network overlaps. Each of these investigations taught me something unique about urban sidewalks and sidewalk design. Taken together, these sections tell a complex story of a common urban artifact. The first section, "Leaf Impressions," was based around a printmaking project where I created relief prints of leaf impressions I found stamped into the sidewalk surface. This print project inspired me to investigate how the impressions came to be in the concrete in the first place. I came away from this research with an understanding of the physical/chemical process of concrete curing and an educated hypothesis for how and when leaf impressions are made. More importantly though, I learned about the value of talking to experts and the great potential for an artistic endeavor to direct and instigate research. "The Slab," the second section of the thesis, contemplates the construction of a new sidewalk on the UMN campus. While watching the pouring of a new concrete sidewalk, I became aware of the bespoke nature of sidewalks and surprising flexibility of the materials, process, and practitioners involved with concrete construction. I found this discovery to be incredibly liberating for imagining what future sidewalks might become. The third section, “The Concrete Landscape” investigates the landscapes from which the concrete ingredients are extracted and the environmental impacts of these landscapes of extraction. This research confirmed my suspicion that concrete is an environmentally harmful material. Through research of the individual concrete components and visits to these intact material landscapes, I was able to more fully understand the scope and gravity of the ecological damage of concrete production. I also came to see clearly the misplaced allegiance to the material in the fields of design and construction. The final section, “The Underside”*,* explores the dynamic landscape of urban soil that sits below the slab. From this section I learned that the living soil landscape is rarely considered as anything other than a construction foundation. The negative consequences of this simplistic perspective can be easily observed in the soil, as well as in the general disrepair of Minneapolis’s short-lived sidewalk slabs.

KEY FINDING:

The combined result of this research contradicts the story of the ubiquitous concrete sidewalk as an inevitable and unchangeable feature of urban infrastructure. However permanent our sidewalks might seem, they are temporary and fragile when confronted with the dynamic systems of the natural landscape that surrounds them. At the same time**, sidewalks themselves are more custom made and inherently flexible in their design and construction** than their fixed reputation would suggest. In actuality, sidewalks are an imperfect but provisional feature of the urban landscape, perfectly positioned for reconsideration and redesign.

SUGGESTIONS FOR FUTURE WALKS AND FUTURE RESEARCH:

The understanding I gained after a year of sidewalk research, has led me to some specific proposals for how urban sidewalk design could be improved and suggestions for further sidewalk research: (1) explore alternative materials and (2) consider the soil.

To begin with, designers should ambitiously explore alternative sidewalk materials with the goal of replacing concrete sidewalks. To the average American city dweller, sidewalks may seem synonymous with concrete. However, concrete sidewalks are a relatively new phenomenon, while pedestrian walking paths are as old as civilization itself. (The earliest records are from around 2000 BC, in the Karum of Kultepe, an ancient merchant site in Anatolia.)[1] Throughout their long history in the West, urban sidewalks have taken on many forms, and have been constructed from a variety of materials including the tall and slender stone sidewalks of Pompeii and the grand cobblestone boulevard promenades of many European cities.[23] It's worth noting that the sidewalks of Pompeii are still standing after more than 2000 years and cobblestone sidewalks can survive for centuries, well outlasting the 20-30 year life-span of an average Minneapolis concrete walk. In American cities, urban sidewalks were often constructed of wood planks, flagstones, or brick before concrete became the material of sidewalk modernity.[4] In Minneapolis, sidewalks made from quarried stone blocks of sandstone, commonly called "Belgian Blocks" were popular during the second half of the 19th century.[5] So, even in the United States, sidewalks made out of a material other than concrete are not without precedent.

Although concrete is a recommended sidewalk material by ADA guidelines, this is not necessarily because concrete is a superior sidewalk material. The interest in improving pedestrian access for persons with disabilities occurred during an age when the dominant material of sidewalks in the US was already concrete, so the material has been engineered to respond to that demand. Therefore, the marriage between concrete and accessibility is more a matter of two independent historical paths intersecting rather than the material being uniquely suited for this purpose. In fact, the long civil rights movement for wheelchair access, that culminated with the passing of the Americans with Disabilities Act, was initially set off by disabled student activists at Berkeley who used sledgehammers to smash wheelchair ramps into concrete campus walks that were not inherently accessible.[6] Over time, concrete sidewalks reformed in response to these new demands, but that should not mislead us into thinking it is the only sidewalk material with the ability to accommodate our accessibility requirements.

While wood sidewalks in the urban environments have fallen out of fashion, wooden pedestrian walks that are ADA accessible are still used in the United States, although we tend to distinguish them as boardwalks. Oceanside boardwalks, for example, must be solidly constructed to hold up to sun, wind, water inundation, winter weather, high pedestrian traffic, and even heavy vehicular loads.[7] In fact, the tropical ipe wood used on the old Rockaway Beach boardwalk in Queens, NY is so durable, that after Hurricane Sandy, when the boardwalk structure was replaced by a concrete seawall, wooden slats were salvaged and reused to make benches and other features for the new concrete walk.[8]

However, wooden sidewalks would not necessarily be a superior option. In northern climates like the Twin Cities, any alternative sidewalk material would have to be engineered to provide good traction and withstand cycles of freeze-thaw. And in order to be a true improvement over concrete, another material option would have to be less environmentally damaging and more sustainable (unfortunately, the harvesting of tropical hardwoods like ipe, which are more dense and durable than North American Hardwoods, also cause their own serious environmental damage).[9] The material would also need to be simple to source and allow for sidewalks that are easy to manufacture. Given this, it's not hard to understand why, despite the issues that come with concrete, construction industries have been resistant to change. But as designers, we should be more innovative. After all, the charge of design has always been to get prosaic materials to do imaginative things that we want them to do. For this reason, experimenting with alternative paving materials that cause less damage to the local and global ecosystems should be enthusiastically embraced by landscape designers.

While we are reconsidering the material from which sidewalks are made, we must also begin to consider the soil, the medium upon which they are constructed. Urban soil is precious. It is a carbon sink, a filter of pollutants and a complex habitat. But the way we currently construct sidewalks does not account for these important services or the dynamic needs of the soil ecosystem. Therefore, it is time to start asking how we can better serve our soil through sidewalk design, construction, and maintenance. If the sidewalks were made with a permeable material, would that limit soil sealing and allow for improved carbon cycling? If the slab was elevated, would it alleviate compaction and benefit soil biota? (It might at least help reduce sidewalk damage from freeze-thaw.) Can we change the amount or application of deicing salt? Or, better yet, can we design a sidewalk surface that does not require a deicing agent? Without further research, I don't know for sure that any of these scenarios would improve the soil near sidewalks. I only know with certainty that not asking these questions will continue to make the urban soil worse.

While structural soils are designed to benefit trees more than the soil ecosystem, they still offer a useful example for how a substrate can be engineered to be structurally sound while also beneficial to a feature of the living landscape. This way of thinking offers a template for designers interested in addressing tensions between the natural landscape and human artifacts but we need to expand our priorities to also include concern for urban soil, and value it in the same way we have come to value street trees. Of course, the well being of the two are inherently linked. The current lack of understanding and respect for the soil also has negative impacts on the longevity of sidewalks (and anything else we build or grow upon the ground). For that reason, soil research and increased consideration of the living soil landscape should become a fundamental concern for the landscape design profession.

METHODS AND METHODOLOGY:

Stated simply, research methods are "specific tools and procedures used to collect and analyze data" and methodology is the "overarching strategy and rationale for research."[10] During this study, I experimented with ways that research methods used in the landscape design studio process (site visits, observational drawings, diagramming, and photo documentation) could also be tools for gaining a deeper understanding of how a designed object is operating in the landscape and how that object interacts with other landscape systems. As I tested out various design studio methods in this process, an overarching design research methodology began to emerge.

This methodology is qualitative and utilizes a pragmatic (mixed methods) approach to data collection.[11] It is also largely phenomenological, in that it is “descriptive” and “object-centered”, utilizing intuition-driven “preliminary exploration” that “complements the traditional methods of research” that follow.[12] This pragmatic approach to research includes trace observations, one-to-one interviews, review of literature/existing data, as well as an assortment of exploratory practices from the disciplines of art and design. These multimodal methods are employed in order to understand complex and overlapping human, geological, and biological systems from a variety of perspectives and scales.[13] My diverse methods also borrow from conceptual art practices as well as existing science, social science, and design methodologies.

I have utilized numerous perspectives from human participants to shape my understanding of interconnected sidewalk systems. However, my interest is not primarily human-centered and I have attempted to give equal voice and weight to the non-human systems I encountered through these explorations - to consider these systems as real beyond my own experience of them.[14] In this way my approach partially aligns with object-oriented ontology, a school of thought that rejects the privileging of human existence over the existence of nonhuman objects. But my approach departs dramatically from object-oriented theory in that it does not view objects (whether human or non-human) as discrete, stable entities but rather as unique contributors in fluid relation with one another through a multitude of obvious and hidden pathways.[15]

Overall, my methodological approach is exclusively qualitative, in that it involves “collection and analysis of non-numerical data.”[16] However, I’ve extended these methods to phenomena that are often relegated to quantitative study, such as biological processes and engineering and construction practices. I analyzed these under-considered systems through qualitative methods with the goal of making them more relatable to design practitioners and to illustrate the ways in which these systems are connected to and impacted by the objects we design.

METHODS:

The five step methods structure that makes up my methodology is defined in detail in the introduction and followed through each subsequent section of this thesis. In order the method steps are:

(1) Observe - to notice
(2) Wonder - to question
(3) Explore - to research
(4) Report - to share (the research)
(5) Reflect - to analyze, synthesize, and tie-back the research to the realm of design

Research methods are a customary part of the thesis process for good reason. Methods provide "specific procedures for collecting and analyzing data."[17] They also bring order to what tends to be a long and complicated research and writing process. My own methods served exactly this purpose. They provided a template for organizing my thoughts and data. They enabled me to efficiently systematize the explorations within each thesis section while also creating a sense of continuity across the thesis sections. This structure kept me on track and moving forward in this process; it kept me from getting lost within the grand scale of the document.

The methods had another profound effect on the thesis that I did not expect. It turned out that making decisions about the structure beforehand, enabled me to stay present within each step of the process. For example, I was able to approach my observations, questions, and research more openly and with less judgment because I knew that critical analysis would come later in the process. I believe this enabled me to see things I would normally have overlooked if I was distracted by building a particular argument for or against a condition from the beginning.

MAKING METHODS:
The five-step thesis structure I created functions similarly to scientific methods and method structures used to guide social science research or studio design projects. Even so, I chose to create my own methods rather than follow a preexisting set of rules. The reason I made my own methods was less because of a deep interest in methodological

design, and more because I had a particular goal for this project and I did not know of an existing methods structure that would help me achieve that goal.

While all method structures have the same general purpose - to guide the course of research - not all methods map the same territory. If you use a set of instructions meant to lead to a specific destination, they won't provide a very good guide to get someplace else. For example, all the design methodologies that I am familiar with do include an observation and research phase but they are generally weighted towards problem solving and/or the creation of a physical end product. For example, in Byran Lawson's influential book, *How Designers Think*, the author-architect lays out a loose, five phase design model, with steps that include: "formulating," "moving," "representing," "evaluating," and "reflecting."[18] The first phase, "formulating," does include recommendations for "understanding and exploring" problems. However, formal research is limited to this step of the model.[19] Steps two through five are focused instead on generating, representing, presenting and reflecting on solutions (although Lawson readily acknowledges the nonlinear nature of the design process).[20] On the other hand, the author makes his skepticism toward traditional research in the design process clear, stating, "problems of science...do not fit the description of design problems" because "design is essentially prescriptive whereas science is predominantly descriptive."[21] While there may not be anything inherently wrong with this type of model, my intent for this thesis was to remain almost exclusively within the domain of research, so a guide like the one presented in *How Designers Think* would not have served my goal.

Additionally, while the design case studies and precedents that informed my thesis, like *Distance and Engagement* and *Learning from Las Vegas*, certainly have research methodologies, they are not explicitly called-out as such in the text. So deriving methods from these sources was more of a process of extrapolation and adding or editing out steps that did not serve my goal.

Ultimately, it was my familiarity with conceptual art rule-making practices, like those of Sol LeWitt's *Wall Drawings,* that gave me the confidence to design thesis methods specific to my desired outcome. Conceptual Art rule-sets generally serve the same purpose as any other methods but offer a more flexible template because the steps are not preordained. The guidelines in conceptual art are specific to individual works, tailored to a unique outcome for a particular project. This freedom to design my own rules was instrumental to the creation of my methods and the resulting thesis.

LESSONS LEARNED:

The methods for this thesis were created at the beginning of the process, in conjunction with the explorations in the "Leaf Impressions" section of the thesis. These methods were effective in so far as they guided my process and helped me achieve my end goal - to observe phenomena, understand the phenomena and associated systems through research, and then analyze and synthesize the research to show the phenomena's relevance to the discourse of landscape design. But the resulting methodology for design research is more than the methods created at the beginning of the process. The methodology that I will take away from this thesis, and that I offer to the reader, also includes lessons that I learned while conducting this research. These lessons have led me to the conclusion that the typical design research practice could be expanded to become a more meaningful part of the design process in the following ways: (1) consider the interconnected systems, (2) develop a collaborative process and (3) cultivate an experimental design research practice.

First and foremost, when designing anything in the landscape, it's critical to consider the other systems that intersect with the proposed intervention. With sidewalks, I specifically looked at the underlying soil system, landscapes of extraction, and sidewalk engineering and construction systems. While all of these are important to understanding sidewalks, they are also only a small fraction of the systems that sidewalks engage, just a couple of stories about things that usually go unconsidered. Additionally, sidewalks are a complex social space - a gathering space for many, an economic space for some, a living space for others. Sidewalks are also a space for protest, harassment, and violence. Sidewalks are an essential element of an interconnected urban transportation system. In addition to a dynamic soil environment, the sidewalk underside is also home to an elaborate system of utilities and public infrastructure. And there are other systems that engage with sidewalks, these are just some systems that overlapped with my own sidewalk research. Any sidewalk design has the potential to affect all the systems and processes mentioned above and then some.

Sidewalks are a relatively simple piece of built infrastructure, but their relationship with other systems makes them much greater than the sum of their parts. This is the case with anything built upon the landscape. In order to design to accommodate all these connected systems, we must first take the time to understand them on their own, in tandem, and over time. This is no small task for a designer. It's time consuming and asking questions about the interconnected systems of the landscape will inevitably complicate the work of landscape design. But allocating more time for this type research, will lead to a greater understanding of the existing landscape and ultimately to design interventions that are responsive to that landscape. These interventions can also be more long-lasting if they acknowledge instead of deny the other dynamic landscape systems that affect their shared environment.

While this type of research resists a simplistic reduction of the landscape, it can also reveal connections between seemingly unrelated things, which can, in turn, lead to the discovery of mutually beneficial outcomes. For instance, many of the experts I talked to expressed concern about the use of deicing salt on sidewalks. My soil science professor was concerned about the implications of unnaturally alkaline urban soil, the forester I talked to was concerned about the high concentration of streetside salt in soil when trees emerge from winter dormancy, and the engineer was concerned with salt's corrosive effect on a newly poured sidewalk surface. Interestingly, both the engineer and forester, suggested that the removal of salt from the sidewalks before the spring thaw would reduce its deleterious impact. These overlapping interests suggest a change in maintenance practices that might be worthy of special consideration because it would have benefits across systems.

Thinking about the landscape as a collection of intersecting systems is challenging, especially because you have to try to think about things that usually go unconsidered. Keeping an open mind is easier said than done. Even as I explicitly tried to conduct objective research into sidewalks, I was still surprised when I started to see sidewalks as an adaptable piece of infrastructure, not predetermined in form or material. It turned out, my preconception of the inevitable nature of sidewalks was an assumption I was also carrying around without even realizing it. So how do you know if you're seeing all the systems? How can you tell if you're asking the right questions? How can you see if your own limited perspective is clouding your perception? One of the most important things I learned while conducting this research is the unique and necessary role that collaboration can play in answering these questions. Talking to other people - designers, engineers, biologists, ecologists, practitioners, users - about a design problem will help illuminate blind spots in the research and expose missed connections. It will force a designer step outside of their own brain and away from their own biases. While this thesis does not account for every interconnected aspect of the sidewalk network, it does present a perspective shaped by multiple conversations with a planner, engineer, soil scientist, forester, pedestrians and an entire sidewalk construction crew. Not to mention the guidance and feedback I received from my friends, family, colleagues and thesis committee. The result is a far richer understanding than I could have arrived at through individual research alone. Additionally, through collaboration, the burden of holding a complex conception of the landscape is shared with many. It's not essential that each landscape designer knows everything about every associated system, as long as they know how to work with other people who do. For these reasons, building, valuing, and utilizing networks of collaborators will make designers and their designs better.

In addition to building a collaborative research process, it is important to cultivate an experimental design research practice. While traditional academic research (finding information in books, journals, articles, websites, etc.) is valuable and has been vital in the construction of this thesis, other modes of research such as interviews, site visits, and photo documentation can present unexpected avenues of inquiry. These other modes can also be an efficient way to clarify what is most relevant or urgent, or where there might be an unexpected intersection across systems. I found this to be particularly true of interviews I conducted for this thesis.

Art and design practices enliven research and supply new insights. Beginning this thesis process with a printmaking project resulted in a very specific trajectory of inquiry that I would not have pursued if I had simply started with the intent of studying sidewalks. The printmaking project directed me toward questions about the material processes and construction of sidewalks. At the same time, making these relief prints with hands and knees pressed against the rough pavement, provided space for a tactile and tender relationship to emerge. Simply put, because I made these prints first, I felt more connected to the sidewalks I was studying.

WHY METHODOLOGY MATTERS:

The culmination of this work is not a design product in the traditional sense. Typically, a design process ends with a design proposal, a recommendation for an intervention to be built upon the landscape. However, in this thesis, the product is the research process itself. My reason for forgoing a proposal for a built design is simple. It is my belief that landscape designers tend to focus too much effort on the end product with too little consideration for systems and relationships at play within the landscape. At best, this lack of understanding results in landscape interventions that are beautiful but unresponsive to their surroundings. At their worst, the proposed designs are harmful to the landscapes they seek to highlight and celebrate.

This is more than a theoretical concern. Recently, Landscape Architect, Pamela Conrad, developed a program, called *Pathfinder*, which enables landscape designers to calculate the carbon impact of their projects. The results were startling. Even projects specifically designed to sequester carbon over time ended up having massive carbon footprints, taking anywhere between 30-300 years to offset the carbon costs of construction.[22] Conrad explains the surprising results this way, "a landscape looks green, so we assume that it's good and that we do good things...but it has a unique carbon impact that is hidden to the eye—it's only when we measure that we can fully understand this complex formula."[23] The Pathfinder tool supports what I've learned through my own research: the parts of a design that designers do not consider can have massive consequences, so designers must start by building a better understanding. Practically, this means utilizing studio design methodologies that embrace research of complex ecological systems and deep engagement with the existing landscape.

In general, the landscape designers I know care deeply about the natural environment and genuinely want to interact with the landscape in ways that are beneficial to the land. At the same time, many of my colleagues either feel frustrated by their lack of access to scientific data and/or struggle to understand scientific research and tie it back to their design practice. Bryan Lawson articulates this problem eloquently in *How Designers Think*:

> Recently there has rightly been more emphasis placed on the ecological implications of design decisions. Most of the energy consumed in the developed countries is connected with the manufacturing and use of products. A very high proportion indeed is connected with the construction industry. Similarly, levels of pollution and atmospheric emissions are heavily influenced by the decisions of [designers]. All this leads us to want more information on the true impact of design decisions, not just at the stage of constructing but in terms of the full life cycle...Most designers are probably very conscious of the need to improve our world in this way, but find it extremely difficult to incorporate findings and recommendations into their design process. The findings and data are seldom clearly expressed in a form which a designer can make sense of.[24]

Unfortunately, popular design methodologies often don't allot enough time and space for designers to acquire a deep understanding of landscape systems. There can be intense pressure to move on to generating design solutions without gaining a deep understanding first. And, as Lawson suggests, even when ample time for research is provided, synthesizing technical and scientific data can still be a challenge because it is not necessarily something that designers are trained to do. This is particularly unfortunate because researchers in the natural sciences continue to develop data *for* practitioner use, data that designers should be able to synthesize and implement in their designs. After all, even if we accept that the "problems of science" are outside the jurisdiction of design, the subjects of environmental science (horticulture, ecology, botany, geology, forestry, etc.) still constitute the body of the landscape, the medium with which landscape designers work. In order to facilitate scientific understanding, methods of research and analysis that help translate scientific data into the language of design need to be created in order to make that data accessible to designers. To that end, I offer this methodology as one template for understanding complex landscape systems and integrating that knowledge into the design process.

Like current sidewalk design and construction practices, many of our design methodologies are also relics from another era when, as a society, we were less aware of how our actions might cause long term damage to our planet. But as we speed ever deeper into full environmental catastrophe, we can no longer turn a blind eye to the consequences of our interventions. Nor can we allow ourselves to hold a dangerously simplistic understanding of the landscapes in which we intervene. New construction is not always necessary and can ultimately be harmful to the landscape if it does not account for the systems and processes already at play. As we move forward in this uncertain period of social upheaval and environmental crisis, the landscape design profession must be much more critical of what and how we build. If we are to be ambassadors of the landscape to the public, we must first take the time to expand our own understanding of the complex urban environment. We should rethink our infatuation with the new and reconnect with the existing world around us - taking the time to observe and explore the unconsidered landscapes of the everyday.

ENDNOTES:

1 Loukaitou-Sideris and Ehrenfeucht, *Sidewalks:Conflict and Negotiation ,* 15.

2 Weiss, "Determining Function of Pompeian Sidewalk," 364.

3 Loukaitou-Sideris and Ehrenfeucht, *Sidewalks:Conflict and Negotiation ,* 17.

4 Williams, "Historic Pavement."

5 Williams, “Historic Pavement.”

6 Hall, “Curb Cuts.”

7 Berger, “A Fight Over Keeping Boards.”

8 Kensinger, “Rockaway Boardwalk Re-emerges.”

9 Berger, “A Fight Over Keeping Boards.”

10 Scribbr. “What’s the difference between method and methodology?”

11 Alzheimer Europe. “Qualitative research.”

12 Moustakas, “Human Science Perspectives and Models,” 10.

13 Alzheimer Europe. “Qualitative research.”

14 Lemke, “Materialism Without Matter,” 1.

15 Lemke, “Materialism Without Matter,” 1.

16 Scribbr, “An introduction to qualitative research.”

17 Scribbr. “An introduction to research methods.”

18 Lawson, *How Designers Think*, 291.

19 Lawson, *How Designers Think*, 292.

20 Lawson, *How Designers Think*, 297.

21 Lawson, *How Designers Think*, 125.

22 Lee, “The Plus Side.”

23 Lee, “The Plus Side.”

24 Lawson, *How Designers Think*, 81.

CONCLUSION SOURCES:

Alzheimer Europe. “Qualitative research.” The four main approaches. August 21, 2009. https://www.alzheimer-europe.org/Research/Understanding-dementia-research/Types-of-research/The-four-main-approaches

Berger, Joseph. “A Fight Over Keeping Boards in the Boardwalk.” *The New York Times*, July 1, 2011. https://www.nytimes.com/2011/07/02/nyregion/fighting-over-rain-forest-ipe-in-coney-island-boardwalk.html

Hall, Delaney. “Episode 308 - Curb Cuts.” *99% Invisible (Episode Transcript)*, May 22, 2018. https://99percentinvisible.org/episode/curb-cuts/transcript

Kensinger, Nathan. “Rockaway Boardwalk Re-emerges With a New Identity.” *Curbed NY*, Aug 13, 2015. https://ny.curbed.com/2015/8/13/9931108/rockaway-boardwalk-re-emerges-with-a-new-identity

Lee, Lydia. “The Plus Side.” *Landscape Architecture Magazine*, October, 2020. https://landscapearchitecturemagazine.org/october-2020/

Lawson, Bryan. *How Designers Think*. London : Westfield, N.J.: Architectural Press ; Eastview Editions, 1980.

Lemke, Thomas.“Materialism Without Matter: The Recurrence of Subjectivism in Object-Oriented Ontology.” *Distinktion: Journal of Social Theory*, 18 (2017): 133-152. 10.1080/1600910X.2017.1373686.

Loukaitou-Sideris, Anastasia and Ehrenfeucht, Renia. *Sidewalks : Conflict and Negotiation over Public Space*. Urban and Industrial Environments. Cambridge, Mass.: MIT Press, 2009.

Moustakas, Clark. “Human Science Perspectives and Models.” In *Phenomenological research methods*, 1-24. Thousand Oaks, CA: SAGE Publications, Inc., 1994. http://dx.doi.org/10.4135/9781412995658.

Scribbr. “An introduction to research methods.” Accessed Dec 12, 2020. https://www.scribbr.com/category/methodology/

Scribbr. “What’s the difference between method and methodology?” Accessed Dec 15, 2020. https://www.scribbr.com/frequently-asked-questions/method-vs-methodology/

Scribbr. “An introduction to qualitative research.” Accessed Dec 15, 2020. https://www.scribbr.com/methodology/qualitative-research/

Taylor, A.R., Lenoir, L., Vegerfors, B. *et al.* “Ant and Earthworm Bioturbation in Cold-Temperate Ecosystems.” *Ecosystems* 22 (2019): 981–994. https://doi.org/10.1007/s10021-018-0317-2

Weiss, Claire. “Determining Function of Pompeian Sidewalk Features through GIS Analysis.” *Making History Interactive: Proceedings of the 37th CAA*, (March 22-26, 2009): 363-372

Williams, Robin B. “Historic Pavement.” Copyright 2016. http://www.historicpavement.com/

BIBLIOGRAPHY

Adams, Mary Beth. "Why does it matter if I stay on the trail while hiking in the woods and parks?" *Science Society of America*, June 15, 2015. https://soilsmatter.wordpress.com/2015/06/15/why-does-it-matter-if-i-stay-on-the-trail-while-hiking-in-the-woods-and-parks/

Alzheimer Europe. "Qualitative research." The four main approaches. August 21, 2009. https://www.alzheimer-europe.org/Research/Understanding-dementia-research/Types-of-research/The-four-main-approaches

American Forests. "The Best Urban Forests." February 5, 2013. https://www.americanforests.org/blog/the-best-urban-forest

Artnet. "Sol LeWitt." Accessed Dec 12, 2020. http://www.artnet.com/artists/sol-lewitt/

Axelson, Peter, Julie B. Kirschbaum, and United States. Federal Highway Administration. *Designing Sidewalks and Trails for Access*. 1999.

Balek, C.L., "Buried artifacts in stable upland sites and the role of bioturbation: A review." *Geoarchaeology*, 17 (2002): 41-51. doi:10.1002/gea.10002

Bassuk, Nina & Denig, Bryan & Grabosky, Jason & Haffner, Ted & Trowbridge, Peter. *CU-Structural Soil: A Comprehensive Guide*. Urban Horticultural Institute, Cornell University 2015.

Beiser, Vince, and EBSCOhost. *The World in a Grain : The Story of Sand and How It Transformed Civilization*. New York: Riverhead Books, 2018.

Berg, Amber, and Gregory L. Newmark. "Incorporating Equity into Pedestrian Master Plans." Transportation Research Record 2674, no. 10 (October 2020): 764–80. https://doi.org/10.1177/0361198120936256.

Berger, Joseph. "A Fight Over Keeping Boards in the Boardwalk." *The New York Times*, July 1, 2011. https://www.nytimes.com/2011/07/02/nyregion/fighting-over-rain-forest-ipe-in-coney-island-boardwalk.html

Brady, Nyle C., and Weil, Ray R. *Elements of the Nature and Properties of Soils*. 2nd ed. Upper Saddle River, N.J.: Prentice Hall, 2004.

Carroll, Jane Lamm. "Engineering the Falls: The Corps of Engineers' Role at

St. Anthony Falls." US Army Corps of Engineers St. Paul District. October 27, 2015. https://www.mvp.usace.army.mil/Media/News-Stories/Article/626089/engineering-the-falls-the-corps-of-engineers-role-at-st-anthony-falls/

Center for Earth, Energy & Democracy. "Major Pollution in the Neighborhood." Accessed: 10/28/2020. http://ceed.org/wp-content/uploads/2016/07/CEED-north-air.pdf

City of Minneapolis. "How Streets are Plowed in Minneapolis." Last updated Dec 3, 2018. http://www2.minneapolismn.gov/snow/snow_snow-removal-basics

City of Minneapolis. "Minneapolis and the Urban Tree Canopy." Last updated Oct 26, 2017.
http://www2.minneapolismn.gov/sustainability/trees/canopy-map

City of Minneapolis. "Primary Zoning Districts - Plate 12." Minneapolis.gov. Last Amended: November 22, 2019. http://www2.minneapolismn.gov/www/groups/public/@cped/documents/maps/convert_255698.pdf

City of Minneapolis. "Walking in Minneapolis." Last updated Aug 17, 2020. http://www2.minneapolismn.gov/pedestrian/index.htm.

Concrete Network. "Concrete Bull Floats and Darbies." Updated: June 16, 2020. https://www.concretenetwork.com/concrete/concrete_tools/bull_floats_and_darbies.htm

Craul, P.. "A description of urban soils and their desired characteristics." *Journal of arboriculture* (1985): 330-339.

Editors of Encyclopaedia Britannica."Alluvium." britannica.com. July 20, 1998. https://www.britannica.com/science/alluvium

Equiza, M.A., Calvo-Polanco, M., Cirelli, D., Señorans J., Wartenbe M., Saunders, C, Zwiazek, J.J. "Long-term impact of road salt (NaCl) on soil and urban trees in Edmonton, Canada."
Urban Forestry & Urban Greening 21 (January 2017): 16-28

Flower, D.J.M. and Sanjayan, J.G. "Chapter 1 - Greenhouse Gas Emissions Due to Concrete Manufacture." in *Handbook of Low Carbon Concrete*, ed. Oxford: Elsevier Science & Technology, 2017, 1-16. https://doi.org/10.1016/B978-0-12-804524-4.00001-4

Forty, Adrian. *Concrete and Culture : A Material History*. London: Reaktion, 2012.

Foxley, Alice., and Vogt Landschaftsarchitekten. *Distance & Engagement : Walking, Thinking and Making Landscape*. Baden, Switzerland: Lars Müller Publishers, 2010.

Gagosian. “Ed Ruscha.” Accessed Dec 12, 2020. https://gagosian.com/artists/ed-ruscha/

Ganapathi H., Phukan M. “Environmental Hazards of Limestone Mining and Adaptive Practices for Environment Management Plan.” *In Environmental Processes and Management,* ed. Singh R., Shukla P., Singh P. Water Science and Technology Library, vol 91. Springer, Cham. (2020), 121-134 https://doi.org/10.1007/978-3-030-38152-3_8

Garfield, Leanna. “This ingenious illustration reveals how much space we give to cars.” *Business Insider,* Apr 28, 2017. https://www.businessinsider.com/car-illustration-karl-jilg-2017-4

Goguen, C. “Concrete Bleeding.” *National Precast Concrete Association*, September 17, 2014. https://precast.org/2014/09/concrete-bleeding/

Hall, Delaney. “Episode 308 - Curb Cuts.” *99% Invisible (Episode Transcript)*, May 22, 2018. https://99percentinvisible.org/episode/curb-cuts/transcript

Hanson, Lowell D, Springer, Clement D, Farnham, Rouse S, Robertson, Alex S, and Allred, Evan R. “Soils of the Twin Cities Metropolitan Area and Their Relation to Urban Development.” 1966.

Harrouk, Christele. “New York Map Highlights Sidewalks with Social Distancing Possibilities.” *ArchDaily*, Aug 27, 2020. https://www.archdaily.com/938303/new-york-map-highlights-sidewalks-with-social-distancing-possibilities

Hogberg, R.K. “Educational Series 5. Environmental Geology of the Twin Cities Metropolitan Area.” *Educational Series 5. Environmental Geology of the Twin Cities Metropolitan Area*, 1971.

Hurst, Will. “Concrete: do architects have their heads in the sand?” *Architect’s Journal.*, January 16, 2019. https://www.architectsjournal.co.uk/news/concrete-do-architects-have-their-heads-in-the-sand

Imbrie-Moore, Will. “Reclaiming the Built Environment.” *Harvard Political Review*, Jun 30, 2020. https://harvardpolitics.com/reclaiming-the-built-environment/
Internet Encyclopedia of Philosophy. “Phenomenology.” Accessed Dec 12, 2020. https://iep.utm.edu/phenom/

King, Hobart M. “Limestone What Is Limestone and How Is It Used? Geology.com. Accessed: 10/28/2020. https://geology.com/rocks/limestone.shtml

Kensinger, Nathan. “Rockaway Boardwalk Re-emerges With a New Identity.” *Curbed NY*, Aug 13, 2015. https://ny.curbed.com/2015/8/13/9931108/rockaway-boardwalk-re-emerges-with-a-new-identity

Lakis, Polycarpou, “No More Pavement! The Problem of Impervious Surfaces” *State of the Planet. Earth Institute Columbia University*, July 13, 2010. https://blogs.ei.columbia.edu/2010/07/13/no-more-pavement-the-problem-of-impervious-surface

Lawson, Bryan. *How Designers Think*. London : Westfield, N.J.: Architectural Press ; Eastview Editions, 1980.

Lee, Lydia. “The Plus Side.” *Landscape Architecture Magazine*, October, 2020. https://landscapearchitecturemagazine.org/october-2020/

Lee, Richard J, Sener, Ipek N, and Jones, S. Nathan. “Understanding the Role of Equity in Active Transportation Planning in the United States.” Transport Reviews 37, no. 2 (2017): 211-26.

Lemke, Thomas.“Materialism Without Matter: The Recurrence of Subjectivism in Object-Oriented Ontology.” *Distinktion: Journal of Social Theory*, 18 (2017): 133-152. 10.1080/1600910X.2017.1373686.

LeWitt, Sol. “Paragraphs on Conceptual Art.” *Artforum*. (Summer, 1967): 79-83. https://www.artforum.com/print/196706/paragraphs-on-conceptual-art-36719

Lindsey, Greg, Tao, Tao, Wang, Jueyu, and Cao, Jason. “Pedestrian and Bicycle Crash Risk and Equity: Implications for Street Improvement Projects.” Pedestrian and Bicycle Crash Risk and Equity: Implications for Street Improvement Projects, 2019.

Loukaitou-Sideris, Anastasia and Ehrenfeucht, Renia. *Sidewalks : Conflict and Negotiation over Public Space*. Urban and Industrial Environments. Cambridge, Mass.: MIT Press, 2009.

Lorenz, Klaus, and Rattan Lal. “Biogeochemical C and N Cycles in Urban Soils.” *Environment International*, vol. 35, no. 1 (2009): 1–8.

Materials Science and Technology Teacher’s Workshop. “Concrete - Scientific Principles.” University of Illinois Department of Materials Science and Engineering. Accessed: October 29, 2020. http://matse1.matse.illinois.edu/concrete/prin.html

Minnesota. Department of Transportation. “Certified Ready-Mix Plants and Approved Contractor Mix Designs.” 2020. https://rmx.dot.state.mn.us/rm_mix/

Minnesota. Department of Transportation. *Standards and Specifications for Construction 2018 Edition*, 2018.

Minnesota. Department of Transportation. *Standard Specifications for Construction :*

Special Provisions for the Construction of Concrete Sidewalks, Curb, Curb and Gutter, Alleys and Drive Approaches, 2007.

http://www2.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_278509.pdf

Moustakas, Clark. "Human Science Perspectives and Models." In *Phenomenological research methods*, 1-24. Thousand Oaks, CA: SAGE Publications, Inc., 1994. http://dx.doi.org/10.4135/9781412995658.

Moustakas, Clark. "Transcendental Phenomenology: Conceptual Framework." In *Phenomenological research methods*, 25-42. Thousand Oaks, CA: SAGE Publications, Inc., 1994. http://dx.doi.org.ezp2.lib.umn.edu/10.4135/9781412995658.

Natarajan, Mangai, Schmuhl, Margaret, Sudula, Susruta, and Mandala, Marissa. "Sexual Victimization of College Students in Public Transport Environments: A Whole Journey Approach." Crime Prevention and Community Safety 19, no. 3-4 (2017): 168-82.

Opara, Hyginus E., Uchechi G. Eziefula, and Bennett I. Eziefula. "Comparison of physical and mechanical properties of river sand concrete with quarry dust concrete", *Selected Scientific Papers - Journal of Civil Engineering* 13, s1 (2018): 127-134, doi: https://doi.org/10.1515/sspjce-2018-0012

Padmalal D., Maya K. "Impacts of River Sand Mining. In: Sand Mining." Environmental Science and Engineering. Springer, Dordrecht.(2014): 31-56 https://doi-org.ezp2.lib.umn.edu/10.1007/978-94-017-9144-1_4

Page, Thomas. "Can the building industry break its addiction to concrete?" *CNN,* Updated: May 4, 2018. https://www.cnn.com/style/article/concrete-alternatives-future-building/index.html

Pavement Interactive. "A Solid Base Is Rock Steady." Accessed: November 11, 2020. https://pavementinteractive.org/a-solid-base-is-rock-steady/

Penn State college of Engineering "Batching." Accessed: 10/28/2020. https://www.engr.psu.edu/ce/courses/ce584/concrete/library/construction/mixingtransport/Batching.htm

Popular Mechanics. "How It Works: Concrete." October 1, 2009. https://www.popularmechanics.com/home/how-to/a3214/1275111/

Portland Cement Association. "Aggregates." Cement.org. Accessed:10/28/2020. https://www.cement.org/cement-concrete-applications/concrete-materials/aggregates

Portland Cement Association. "Chapter 10 - Batching, Mixing, Transporting, and

Handling Concrete.” in *Design and Control of Concrete Mixtures.*12th ed. Skokie, Ill.: Portland Cement Association, 1979, 167-189

Portland Cement Association. “How Concrete is Made.” Cement.org. Accessed:10/28/2020. https://www.cement.org/cement-concrete-applications/how-concrete-is-mades

Portland Cement Association. “Ready Mixed Concrete.” Cement.org. Accessed:10/28/2020. https://www.cement.org/cement-concrete-applications/products/ready-mixed-concrete

Safford, H.; Larry, E.; McPherson, E.G.; Nowak, D.J.; Westphal, L.M. *Urban Forests and Climate Change*. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center, August 2013. www.fs.usda.gov/ccrc/topics/urban-forests/

Our Streets Minneapolis. “Making Winters Walkable.” Accessed Dec 12, 2020. https://www.ourstreetsmpls.org/making_winters_walkable

Rahman, Muhammad Muhitur, Rahman, M Ashiqur, Haque, Md Mahmudul & Rahman, Ataur.
“Chapter 8 - Sustainable Water Use in Construction.” *Sustainable Construction Technologies*. Edited by Vivian W.Y. Tam & Khoa N. Le, 211-235. Butterworth-Heinemann, 2019.

“Resources and Consumption.” population matters.org. Accessed:10/28/2020. https://populationmatters.org/the-facts/resources-consumption

Roberts, Alli Gold. “Predicting the future of global water stress.“ *MIT News,* January 9, 2014. https://news.mit.edu/2014/predicting-the-future-of-global-water-stress

Ritchie, Hannah and Roser, Max.“Water Use and Stress.” Our World in Data. Last Modified: July 2018. https://ourworldindata.org/water-use-stress#global-freshwater-use

Seiter, David. “Profiles of Spontaneous Urban Plants.” *Urban Omnibus*, December, 2011. https://urbanomnibus.net/2011/12/profiles-of-spontaneous-urban-plants/

Singh, Dr. Jiwan & Kalamdhad, Ajay. “Effects of Heavy Metals on Soil, Plants, Human Health and Aquatic Life.” *International Journal of Research in Chemistry and Environment* 1, no. 2 (October, 2011): 15-21

Schwartz, Judith D. “Soil as Carbon Storehouse: New Weapon in Climate Fight?” *Yale Environment 360*, March 4, 2014.

Scribbr. “An introduction to research methods.” Accessed Dec 12, 2020.

https://www.scribbr.com/category/methodology/

Taylor, A.R., Lenoir, L., Vegerfors, B. *et al.* “Ant and Earthworm Bioturbation in Cold-Temperate Ecosystems.” *Ecosystems* 22 (2019): 981–994. https://doi.org/10.1007/s10021-018-0317-2

Tate. “Edward Ruscha ‘Twentysix Gasoline Stations’ 1963.” Maria White, May 2013. https://www.tate.org.uk/about-us/projects/transforming-artist-books/summaries/edward-ruscha-twentysix-gasoline-stations-1963

Thomas, Destiny. “Safe Streets’ Are Not Safe for Black Lives.” *Bloomberg CityLab*. June 8, 2020. https://www.bloomberg.com/news/articles/2020-06-08/-safe-streets-are-not-safe-for-black-lives

The Shelly Company. “How is concrete made from limestone?” January 29, 2014. https://www.shellyco.com/2014/01/29/concrete-made-limestone/

Sheree R., Curry. “George Floyd’s Minneapolis: Multicultural facade hid decades of simmering racial inequality.” *USA TODAY,* June 11, 2020. https://www.usatoday.com/in-depth/money/2020/06/11/george-floyd-minneapolis-simmering-racial-unrest/3146692001/

Spewak, Danny. “MPD to do more safety walks in Marcy-Holmes.” *Kare11*, September 21, 2020. https://www.kare11.com/article/news/crime/mpd-to-do-more-safety-walks-in-marcy-holmes/89-9b856e7e-61b2-4c97-8b36-e69649f0b83a

Union of Concerned Scientists. “Climate Science.” Accessed: 10/28/2020. https://www.ucsusa.org/climate/science

United States Access Board. “ADA Standards - Chapter 3: Floor and Ground Surfaces.” Accessed:10/28/2020. https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/guide-to-the-ada-standards/chapter-3-floor-and-ground-surfaces

United States. Environmental Protection Agency. *Managing Wet Weather with Green Infrastructure Action Strategy 2008*. National Service Center for Environmental Publications, 2008.

United States Geological Survey : Water Science School. “Adhesion and Cohesion of Water.” Accessed November 10, 20202. https://www.usgs.gov/special-topic/water-science-school/science/adhesion-and-cohesion-water?qt-science_center_objects=0#qt-science_center_objects

Venturi, Scott Brown, Izenour, and Izenour, Steven. *Learning from Las Vegas : The*

Forgotten Symbolism of Architectural Form. Cambridge, Mass.: MIT Press, 1977.

Urban, James. “Urban Soils - Part 1: Understanding Compaction: Excerpt from Up By Roots” *International Society of Arboriculture Magazine* (Apr. 2008): 25-28.

USDA Natural Resource Conservation Service. “How to Use a Soil Survey.” Accessed October 22, 2020. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053375

USDA Natural Resource Conservation Service. “Urban Soils.” Accessed October 22, 2020. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/urban/

Venturi, Scott Brown, Izenour, and Izenour, Steven. *Learning from Las Vegas : The Forgotten Symbolism of Architectural Form*. Cambridge, Mass.: MIT Press, 1977.

Wang, Meie, and Haizhen Zhang. “Accumulation of Heavy Metals in Roadside Soil in Urban Area and the Related Impacting Factors.” *International journal of environmental research and public health* 15, no. 6 (May 2018): 1064

Watts, Jonathan. “Concrete: the most destructive material on Earth.” *The Guardian*, February 25, 2019.https://www.theguardian.com/cities/2019/feb/25/concrete-the-most-destructive-material-on-earth

Wei, Zongqiang, et al. “Density and Stability of Soil Organic Carbon beneath Impervious Surfaces in Urban Areas.” *PLoS ONE*, vol. 9, no. 10 (October 9, 2014): E109380.

Weiss, Claire. “Determining Function of Pompeian Sidewalk Features through GIS Analysis.” *Making History Interactive: Proceedings of the 37th CAA*, (March 22-26, 2009): 363-372

Williams, Robin B. “Historic Pavement.” Copyright 2016. http://www.historicpavement.com/

Zeisel, John. “Observing Physical Traces.” In *Inquiry by Design : Tools for Environment-behavior Research*, 159-90. The Brooks/Cole Basic Concepts in Environment and Behavior Series. Monterey, Calif.: Brooks/Cole Pub., 1981.

WALKING THROUGH THE PANDEMIC
(A POSTSCRIPT)

When the Coronavirus arrived in Minneapolis in March, I had already spent months observing and documenting the sidewalks of my neighborhood for my thesis. But as the city went into lockdown, the purpose of these daily walks changed. Separated from family, friends, and grad school colleagues, I began to walk as a way to process my loneliness and escape the confines of my apartment as much as to conduct thesis research. At the same time, in the upside-down early days of the pandemic, my neighborhood was turned unfamiliar - quiet and overgrown, slightly disordered. I was not alone in finding comfort, escape, and eerie stimulation in daily walks as friends in other places were rediscovering their own familiar landscapes made strange by the pandemic. As a way to remain grounded and connected from an unsteady distance, I asked others to share their own walking observations.

Walking Through the Pandemic is a small collection of observations of the ordinary world during an extraordinary time. It is my attempt to archive an unusual moment of seeing. Using a six-step list of rules as a guide, I asked people to explore the landscapes of their daily walks while following simple instructions for documenting their observations. I tried to make the rules as open to interpretation as possible, in the hope that people wouldn't fixate on a "right way," but engage in whatever way felt most natural. Three of the rules guided walking and recording and the other three provided a guide for reflecting after the walk.

I compiled the resulting photos and words into a participatory record. Presented here are submissions 1-20, received between April 6th, 2020 and June 10th, 2020. They are presented in chronological order. This is not a random sampling. To some degree, I know each one of these participants. I did try to include a diverse range of people, places and perspectives, hoping it would result in greater variation within the responses. However, what surprised me most as I received the results of these excursions, is how tenaciously certain themes reappeared. Overall, there is a sense of reconsidering the world, as formerly unseen boundaries come into sharp focus, then instantly blur. As if, without the certainty of civilization, the unambiguous lines between life/death, trash/treasure, public/private, people/nature began to seem ridiculous and surprisingly penetrable.

At the same time, these submissions stubbornly resist an easy synthesis; they defy a clean conclusion. At best these documents sit restlessly side-by-side like incomplete fragments from a torn tapestry. I desperately want to bring them together, or to present these walks as clues to a changing landscape in a transformational moment. Maybe with more submissions or more time, a grand narrative would appear - one epic communal walk. But I can't tell that story today. If it is there, it's still obscured by the uncertain fog of the ongoing pandemic. So instead, I offer these to you as I actually see them, as ragged pieces of a shredded timeline, a collection of voices and visions to carry with you on your own journey further into the deep unknown. Maybe you will see patterns I don't. Maybe they will help you feel a little less alone on your walk.

Part 1: The Walk:

1. Walk to a place you walk to often.

2. Use your camera to document an occurrence, trace, or artifact that you discover on your walk.

3. Repeat instruction 2, 2 more times (1 of the 3 photos must include the sidewalk.).

Part 2: After the Walk:

1. Title your walk.

2. Title your 3 photographs.

3. Write about your walk In less than 100 words. Describe a connection between your photos without referring directly to your photos.

Play

1. impossible hopscotch

2. ghost concerts

3. 2 hills are better than 1

I walked to the park where we used to smoke weed in high school. I see ghosts from those years when I walk there - good ghosts. There are new ghosts now, young ghosts, I guess you might call them humans. They worry-play.

-Washington DC

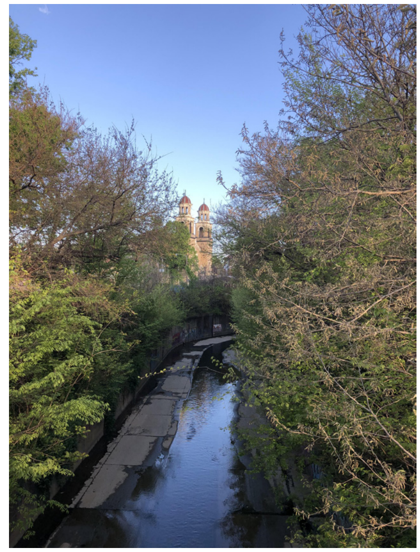
FIGURE 35 : PANDEMIC WALK 1

Walk For Coffee

1. Old Church

2. That's a Fire Station?

3. Shit.



I walked to get coffee this morning and recently have been noticing the old in the neighborhood and thinking about how many buildings, bridges, structures are over 100 years old around here. At the same time there's still lots of change and new construction.

-Louisville, KY

FIGURE 36 : PANDEMIC WALK 2

Boom Island Route

1. Almost

2. Magica (Joy)

3. Should I be concerned about this?

The world is made up of idiosyncratic creations that almost made sense. That was before and now they all feel like remnants. Even when there's no one out, people still want to share what they've been making. Squirrels keep dying and Boomers will never think you've done enough.

-Minneapolis, MN

FIGURE 37 : PANDEMIC WALK 3

Beach Stroll

1. Welcome to Kings Beach

2. Kings Beach speed bump

3. All sidewalks lead to the beach

Sidewalks in Kings Beach are a scarce commodity. The only sidewalk goes through the main drag to accommodate the tourists with their beach toys, strollers, skateboards and bicycles. The sidewalk ends at the beach, shops and restaurants. In the residential areas folks walk on the shoulder of the road.

-Kings Beach, CA

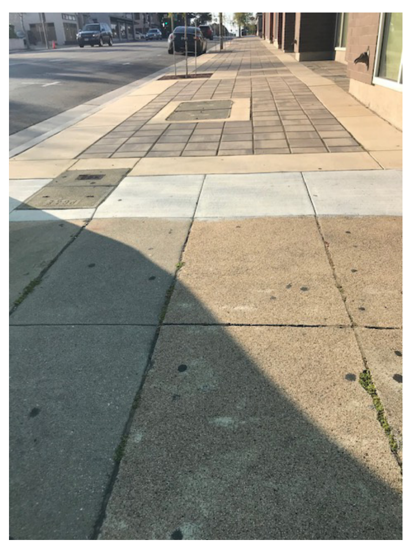
FIGURE 38 : PANDEMIC WALK 4

George and Sam stroll Mark II

1.Easter Sardines

2.Scofflaws

3.Public and private sectors



Nicest day we've had since the start of lockdown, so more people than there'd been. I think folks can be forgiven for pushing the boundaries a little. When the sidewalks are empty, you can see a lot of boundaries that you would miss otherwise.

-Monterey, CA

FIGURE 39 : PANDEMIC WALK 5

To Pringle Park

1. Sidewalk to downtown

2. Street light from the past

3. The way forward

I've taken this walk many times over the past 16 months, yet it's much different now. There are no direct paths from point A to point L. There are still the same markers, the same signs, the same garbage to walk around tossed by the same idiots who have not magically grown brains or feelings in the past two months. Like any self-respecting re-route, we have no idea of the distance the new way will take us, what we'll see along the way or if our destination will be as promised, or less, or more.

-Goshen, IN

FIGURE 40 : PANDEMIC WALK 6

Walk to the park

1. Hope

2. Caution: playground

3. Butts

A walk to the park is always an adventure. There are sidewalks all the way there. Sometimes I spot Mother Nature's contribution, sometimes I see the contributions that are man-made. Sometimes those contributions are unwelcome. Nonetheless, they are all part of what we are. The contributions that I see can demonstrate our selfish disregard for one another, The contributions that I see can demonstrate that we are not really in control. They can also demonstrate that in spite of it all, nature is there, and offering hope for something better. I need that hope.

-Goshen, IN

FIGURE 41 : PANDEMIC WALK 7

Walk to the Water

1. The Statue of Liberty

2. Nature Takeover

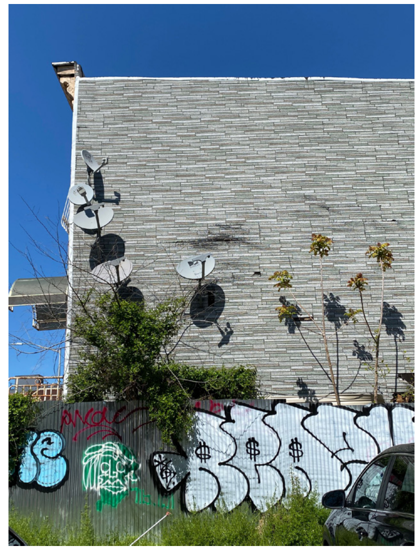
3. Spring Time Happy Time

Everyday day my partner and I walk anywhere between 3 to 6 miles. No matter what we always walk to the water. From where we live we can see the Statue of Liberty, lower Manhattan, and the Verrazano Bridge. It's the kind of break we need - sweeping views. We have been walking since the lockdown began in March which was the end of winter/early spring. As the seasons changed we noticed how nature is bursting through the side walks. Typically the grass is mowed, the sidewalks are weedless, and there is usually trash everywhere. These days it's all weeds, tall grasses, some gloves and mask trash, flowers, and birds. It's truly resplendent. Life on lockdown has been hard but the walks and the little small changes in the land that we see are what keeps us going.

-Brooklyn, NY
(Bay Ridge)

FIGURE 42 : PANDEMIC WALK 8

Afternoon walk to the liquor store



1. Patterns

2. Oasis

3. Stained glass

Today is April 28, 2020. It is a rare sunny day and I savored the opportunity by taking an afternoon walk to my local liquor store in between Zoom meetings. Every little bit of green that I see during my walk feels like a welcome escape from the constant steel and concrete.
I often admire the repeated patterns in the walls and fences surrounding and separating each house in my neighborhood, creating separate domestic islands. A private oasis. I'm often surprised by how resourceful Bushwick residents are with the little outdoor space that they have, and a lot of activities spill out onto the sidewalk. There's a lot of trash. Sometimes, the trash looks like treasure. Broken bottles can look like stained glass. It's hard to tell what has been intentionally discarded, placed, or composed, and what has just been left behind.

-Bushwick, NY

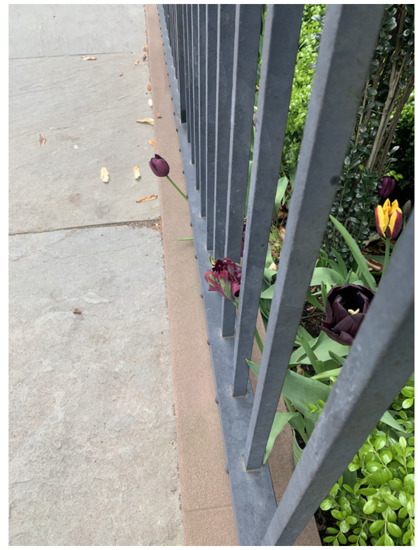
FIGURE 43 : PANDEMIC WALK 9

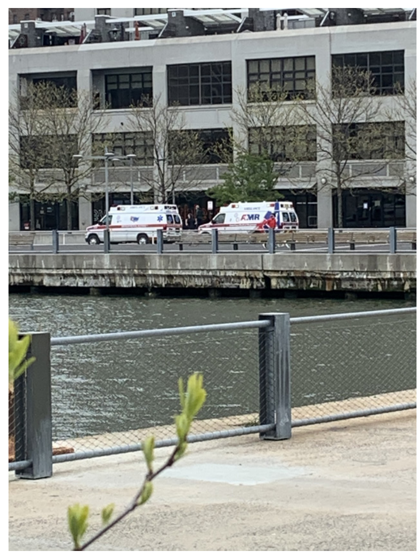
Nature vs. nurture

1. Life goes on

2. It’s the end of the world as we know it

3. But Ruby feels fine





I take a walk with my dog every day during this pandemic and watch the world keep turning amidst the disaster. Circumstances are pulling the reigns on humans and one can observe nature flourishing while humans are being confined. Flowers and trees are blooming. Animals are happier and braver. We can hear the birds singing in the city. Less planes, no boats, less cars, less humans. Humans are being forced to become more aware of their surroundings. Looking outside of their own small world and respecting space. We have lost our control.

-Brooklyn, NY

FIGURE 44 : PANDEMIC WALK 10

WALKABOUT : LISTEN TO THE EARTH

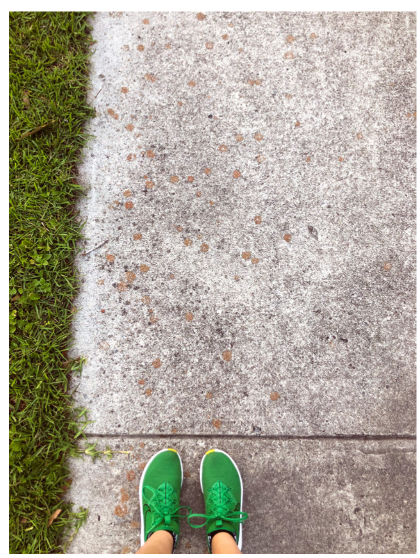
1. WISP

2. ETCHING

3. JOHN DEER RED CLAY

My eyes continue to be drawn upward to the cutaways in the sky. Trees, oak, pine, and magnolia. Clouds, cirrus and cumulus, speckled with a yellow, single propeller mosquito sprayer. Spanish moss, draped on branches, webbed in leaves, and nested on rooftops.

The textures created from the marriage of domestication and the natural sphere. My eye line is fixed, and my mind begins to travel to the root of it all: a forest, a cul de sac; a dirt path, an asphalt lane; a wild mustang, a metal mustang. Each step is a ripple through a wrinkle in time.



-Savannah, GA
(Wilmington Island)

FIGURE 45 : PANDEMIC WALK 11

Untitled Walk

1. thank you cat

2. topical garbage

3. happy heart

Walking my dogs through my neighborhood is a daily occurrence. We walk different routes down the same blocks. I daydream, enjoy the weather, disagree with my dogs on which way to go but each time I notice something new. A new planter, a tree was cut down, new yard signs, a garage burned to ashes if I was new to the route these would go unnoticed but this is my neighborhood and I am nosy and curious. Who lives there? Who left this out? Who would be so disgusting? What will I see tomorrow?

-St Paul, MN
(Midway)

FIGURE 46 : PANDEMIC WALK 12

Altered reality/Open skies/ Relaxation

1. Mind the barricades.

2. Empty atmosphere.

3. Lovely bench.

A walk around the lakes this summer is different from past years. The parkways have limited access to increase social distancing for people. I especially notice the clear 1950's blue skies with few jets and little air pollution. The birdsong is also clearer in a less noisy environment. Clean air, clear skies and overall quiet leads to a meditative relaxation that can't be beat.

-Minneapolis, MN

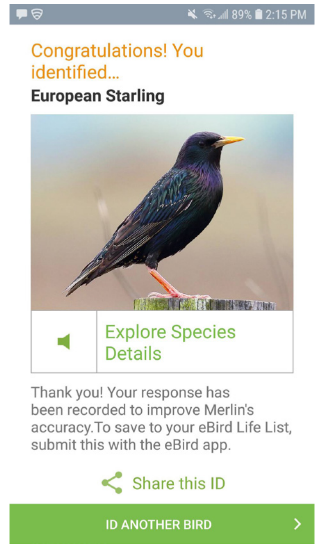
FIGURE 47 : PANDEMIC WALK 13

Following Spring to the Greenway and Back

1. Screenshot from Merlin Bird ID App

2. A Native Bee Friend

3. Reading Parable of the Sower in Vera's Garden



Yesterday I was relieved to get outside and enjoy the spring! I brought my cheapo binoculars along and was glad of it because early on the walk someone stopped to ask what birds I was looking for—conversation with a stranger is a real luxury these days. I turned at the corners with the most flowers, and always stopped to smell them. I finally ID'ed a bird I keep seeing: European starling. I ended up at the Midtown Greenway and sat on a garden bench to read my book. When my coffee caught up with me, I wandered on home.

-Minneapolis, MN

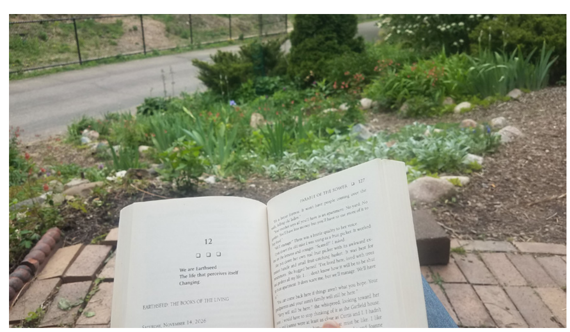


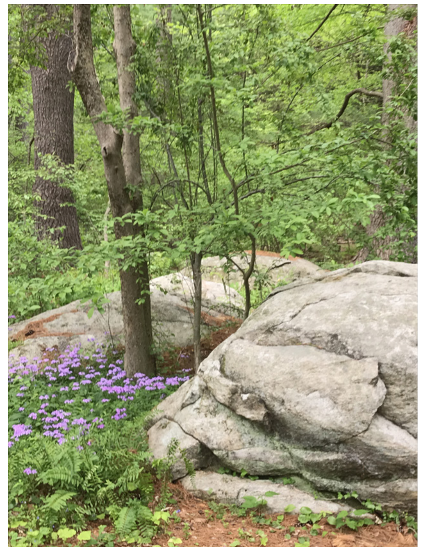
FIGURE 48 : PANDEMIC WALK 14

Family Memories.

1. The Family Rock

2. Trillium

3. Giant Sequoia



I have been thinking about family connections during the pandemic as I walk through the woods. Particularly the times I experienced the grandeur and beauty of nature with my family as a daughter, granddaughter, sibling, wife, mother, mother-in-law and grandmother. My memories include camping and backpacking in the Sierras, identifying and pressing plants, marveling at natural formations, weathering a few storms and documenting our times together through photography.

Nature has always had a special way of bringing my family together, observing and sharing its beauty, diversity and mutability. Somehow it strengthens us, tightens our bonds and enables us to put our daily lives in perspective.

-Ringwood, NJ
(Skylands Botanical Garden)

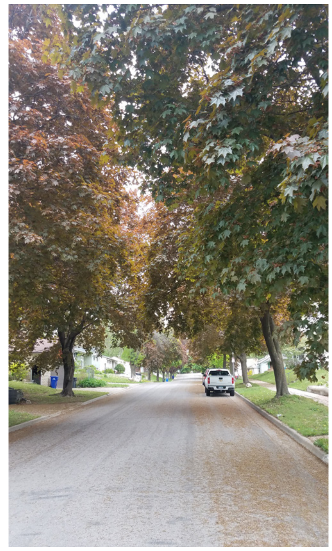
FIGURE 49 : PANDEMIC WALK 15

Como Stroll with Carlton

1. The First Obstacle

2. The Second Obstacle

3. The Third Obstacle



We are often at odds with our environment. Culturally, it seems we depend on conflict for meaning, defining ourselves and finding purpose. Maybe it helps us craft a familiar narrative. Maybe once upon a time struggle was essential, inevitable, maybe it still is. Here are three obstacles, or challenges I encountered on my walk - were they overcome? temporary? do we learn from these struggles? do we grow?

-Saint Paul, MN

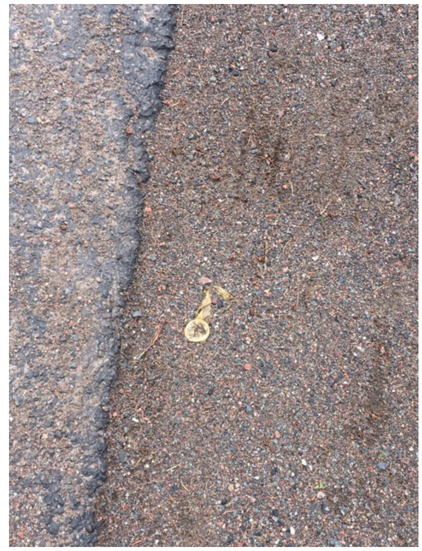
FIGURE 50 : PANDEMIC WALK 16

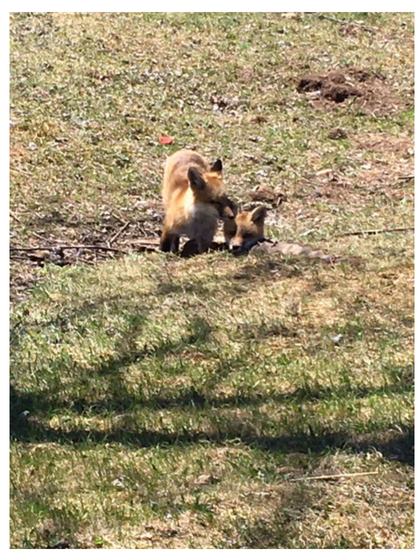
The Lunch Hour Walk and Life Cycle

1. Condom on the sidewalk

2. A little calm

3. Babies





During my lunchtime after sitting conducting virtual visits with patients all morning, I try to get out and take a quick walk. The closest place to walk is around the cemetery which is across the road from the clinic. It feels nice to get out of the clinic and take my mask off to breathe in some fresh air. I have never paid much attention to this quick walk until taking these pictures. I began to notice many things that I never have really paid attention to before.

-Duluth, MN
(Hermantown)

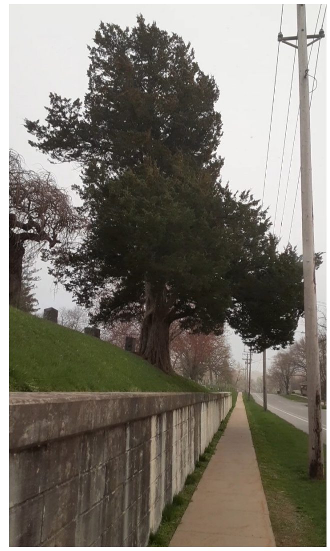
FIGURE 51 : PANDEMIC WALK 17

Trees through the graveyard

1. Evergreen on a Windy Day

2. Gravestones

3. A Beautiful Tree



I have a favorite tree that moves in a nice way in Summer wind. We look at each other as I go to the graveyard. The gravestones remind me of a chessboard, with their shadows laid out on a grid. There are many dead here from the 1918 flu. I think the trees here are trying to talk to me.

-Iowa City, IA

FIGURE 52 : PANDEMIC WALK 18

George's Morning

1. Community News

2. The Loudest Plywood

3. Untitled Photo

Our cities walls have never spoken so loud. They scream. Their cries are heard across oceans. They ricochet between urban fabric, from new york to berlin.

The morning is sweet. The mourning is bitter.

-Minneapolis, MN
(Cedar - Riverside)

FIGURE 53 : PANDEMIC WALK 19

Deep Pine

1. Pattern Recognition

2. Shifting Priorities

3. Touch

we build for stability, safety
the patterns are already laid out
for us, the inherent structure
we are all running functions
within the same system

my ancestral blood begs me to
just please exist outside
the sun brings relief from the
long winter
the wind on my skin brings relief
from the sun

there is nothing better than the
cool running stream
just a hand
then two feet
what is the point of anything else

-Iowa City, IA

FIGURE 54 : PANDEMIC WALK 20