Movement Legacy: A Bioethical and Epigenetically Grounded Architectural Framework for Healthy Lifestyle Change

by

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New research in neuroscience, environmental psychology, and medicine have revealed factors in the built environment that improve health, however, these are not yet widely understood or adopted by the design community. A novel approach that better leverages the scientific literature to inform design is required. Recent discoveries in epigenetics reveal the immense impact our environment has on intergenerational human health through the process of epigenomic editing and the resultant genetic expression. This thesis argues that design and health are inextricably linked to bioethical questions that require deeper exploration and ought to compel designers to reframe their role and responsibility in community health. A new theoretical framework is developed that aligns design elements at multiple scales with evidence-based principles, which elicit positive health outcomes through increased physical activity prevalence. Informed by the framework, a network of design interventions for Sudbury, Ontario, demonstrates how the built environment can foster healthy lifestyle change.

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Table of Contents

Abstract and Keywords iv
Acknowledgements vi
List of Figures x
Preface xiv

Introduction A Call for Health Sustainability 1

Chapter 1 The Invisible Epidemic and Exercise 8
1.1 The Non-Communicable Disease Epidemic 10
1.2 The Pivotal Modifiable Risk Factor: Physical Activity 15

Chapter 2 Intergenerational Health: Agency & Responsibility 18
2.1 Epigenetics 21
2.2 Bioethics 26

Chapter 3 Movement Legacy Framework 30
3.1 Safety 36
3.2 Choice 38
3.3 Joy 40
3.4 Nature 42
3.5 Movement 43
3.6 Measurability 45
3.7 Future Intentions 49
3.8 Precedent Study 50

Chapter 4 Sudbury: Obesity Capital of Canada 54
4.1 An Industrial Urban Fabric 56
4.2 Critique of City Planning Documents 58

Chapter 5 Projects 62
5.1 Mapping and Site Selection 66
5.2 Grow ‘n Go (Frood Road Site) 70
5.3 Sudbury Nexus (Elgin Street Site) 82
5.4 Loving The Lake Centre (Ramsey Lake Site) 94

Conclusion An Upgradeable Future 106

Bibliography 110

List of Figures

Figure 01 Total deaths from NCDs, both sexes, all ages, globally between 1990-2019. Source: Institute for Health Metrics and Evaluation. "GBD Compare." Accessed May 6, 2023. http://vizhub.healthdata.org/gbd-compare. 11

Figure 02 Deaths per 100,000 from NCDs, both sexes, all ages, globally between 1990-2019. Source: Institute for Health Metrics and Evaluation. "GBD Compare." Accessed May 6, 2023. http://vizhub.healthdata.org/gbd-compare. 11

Figure 03 Total deaths from NCDs, both sexes, all ages, in Canada between 1990-2019. Source: Institute for Health Metrics and Evaluation. "GBD Compare." Accessed May 6, 2023. http://vizhub.healthdata.org/gbd-compare. 12

Figure 04 Deaths per 100,000 from NCDs, both sexes, all ages, in Canada between 1990-2019. Source: Institute for Health Metrics and Evaluation. "GBD Compare." Accessed May 6, 2023. http://vizhub.healthdata.org/gbd-compare. 12

Figure 05 The Seventeen Sustainable Development Goals developed by the United Nations. Source: United Nations Department of Economic and Social Affairs. "THE 17 GOALS | Sustainable Development." Accessed March 7, 2023. https://sdgs.un.org/goals. 13

Figure 06 The Blue Zones shown on a world map. Source: Center for Integrative Healing & Wellness. "Blue Zones - Learning from the Longevity Hot Spots," September 30, 2021. https://www.drfabio.com/healthblog/blue-zones-learning-from-the-longevity-hot-spots. 22

Figure 07 The Blue Zone Power 9 Behaviours. Source: Rotary Club of Hilo Bay. "Blue Zones: Live Longer Better." Accessed May 6, 2023. http://HILOBAYROTARY.COM/Stories/blue-zones-live-longer-better. 23

Figure 08 Epigenetic modifications, illustrated. Source: Genomics Research from Technology Networks. "Above the Genome: How Epigenetics Influences Cancer and Obesity." Accessed December 6, 2022. http://www.technologynetworks.com/genomics/articles/above-the-genome-how-epigenetics-influences-cancer-and-obesity-310015. 24

Figure 09 The ten existing health frameworks/publications that were critically analyzed as part of the thesis methodology for the purpose of creating a new framework. Source: HOK. "The Architecture of Well-Being." Accessed October 23, 2022. https://www.hok.com/ideas/research/the-architecture-of-well-being/.; Malkin, Jain. A Visual Reference for Evidence-Based Design. Concord, CA: Center for Health Design, 2008.; DIALOG. "Community Wellbeing Framework." Accessed October 20, 2022. https://dialogdesign.ca/community-wellbeing-framework/.; World Health Organization. Regional Office for Europe. *Towards More Physical Activity in Cities: Transforming Public Spaces to Promote Physical Activity – a Key Contributor to Achieving the Sustainable Development Goals in Europe.* World Health Organization. Regional Office for Europe, 2018. https://apps.who.int/iris/handle/10665/345147.; Global Wellness Institute. "Wellness Architecture & Design Initiative Resources." Accessed October 17, 2022. https://globalwellnessinstitute.org/initiatives/wellness-architecture-design-initiative/wellness-architecture-resources/.; Antonovsky, Aaron. "The Behavioral Sciences and Academic Family Medicine: An Alternative View." Family Systems Medicine 10, no. 3 (1992): 283–91. https://doi.org/10.1037/h0089058.; Cushing, Debra Flanders, and Evonne Miller. Creating Great Places: Evidence-Based Urban Design for Health and Wellbeing. 1st ed. Milton: Routledge, 2019. https://doi.org/10.4324/9780429289637.; WELL. "WELL Standard." WELL Standard. Accessed September 26, 2022. https://v2.wellcertified.com/en/wellv2/overview.; Allen, Joseph G. 9 Foundations of a Healthy Building. Harvard T.H. Chan School of Public Health, 2017. https://9foundations.forhealth.org/.; The Center for Health Design. "Topics," Accessed November 9, 2022. https://www.healthdesign.org/topics. 33

Figure 10 Overview of the Movement Legacy Framework, by author. 34

Figure 11 Safety pillar of the Movement Legacy Framework, by author. Source: K&E Flatwork LLC. "What Makes a Sidewalk Unsafe?" August 18, 2019. https://www.keflatwork.com/blog/spotting-and-solving-sidewalk-deficiencies/. 37

Figure 12 Choice pillar of the Movement Legacy Framework, by author. Source: Freepik. "Beautiful Autumn View of Sokolniki Park in Moscow. Bifurcation of the Road." Accessed May 6, 2023. https://www.freepik.com/premium-photo/beautiful-autumn-view-sokolniki-park-moscow-bifurcation-road_15946010.htm. 39

Figure 13 Joy pillar of the Movement Legacy Framework, by author. Source: Moore, Susan. "Trencadis Serpentine Mosaic Tile Bench at Gaudi's Park Guell Barcelona." Solo Trips And Tips, May 28, 2014. https://solotripsandtips.com/trencadis-serpentine-mosaic-tile-bench-at-gauds-park-guell/. 40

Figure 14 Nature pillar of the Movement Legacy Framework, by author. Source: Sanghvi, Aayushi. "What Architects Must Know about Landscape Urbanism." Rethinking The Future, November 15, 2020. https://www.re-thinkingthefuture.com/2020/11/15/a2064-what-architects-must-know-about-landscape-urbanism/. 41

Figure 15 Movement pillar of the Movement Legacy Framework, by author. Source: "Schwartz Besnosoff Architects Designs Technion Entrance Gate as a Bridge," *Dezeen.* October 6, 2020. https://www.dezeen.com/2020/10/06/technion-entrance-gate-israel-institute-technology-schwartz-besnosoff-architects/. 43

Figure 16 Measurability pillar of the Movement Legacy Framework, by author. Source: Cycling Embassy of Denmark. "An Extra Bonus - Street Furnuture for Cyclists," April 10, 2019. https://cyclingsolutions.info/street-furniture-for-cyclists/. 45

Figure 17 Feedback loop relationship. Source: Quan, Xiaobo, Lyn Geboy, and Rachael Ginsberg. Building the Evidence Base: Understanding Research in Healthcare Design. 3rd edition. Concord, CA: The Center for Health Design, 2018. 47

Figure 18 Example of a research tool. Source: McLaughlin, Tom, and Vic Gephart. Integrating Evidence-Based Design: Practicing the Healthcare Design Process. 2nd edition. Concord, CA: The Center for Health Design, 2009. 48

Figure 19 Future intentions for the Movement Legacy Framework, post-thesis submission. The Thesis will be packaged in two formats for easier dissemination, by author. 49

Figure 20 Case study 1: Bicycle Snake, a project in Copenhagen by Dissing + Witling which revitalized a desolate wharf area by implementing a cycling path that curves between buildings and over the water. Source: Dissing + Weitling. "Bicycle Snake." Accessed April 3, 2023. https://dissingweitling.com/en/project/bicycle-snake. 51

Figure 21 Case study 1: Bicycle Snake images are shown with the Movement Legacy Framework principles overlaid. Source: Dissing + Weitling. "Bicycle Snake." Accessed April 3, 2023. https://dissingweitling.com/en/project/bicycle-snake. 51

Figure 22 Case study 2: Basket Bar, a project in the Netherlands by NL Architects combines a restaurant, seating area, bike path, and rooftop basketball court. Source: NL Architects. "Basket Bar." Accessed May 6, 2023. http://www.nlarchitects.nl/slideshow/92/. 52

Figure 23 Case study 2: Basket Bar images are shown with the Movement Legacy Framework principles overlaid. Source: NL Architects. "Basket Bar." Accessed May 6, 2023. http://www.nlarchitects.nl/slideshow/92/. 52

Figure 24 Case study 3: Loyly sauna, a project in Helsinki, Finland, by Avanto Architects. Source: "Löyly / Avanto Architects," *ArchDaily*. June 30, 2016. https://www.archdaily.com/790432/loyly-avanto-architects. 53

Figure 25 Case study 3: Loyly sauna images are shown with the Movement Legacy Framework principles overlaid. Source: "Löyly / Avanto Architects," *ArchDaily.* June 30, 2016. https://www.archdaily.com/790432/loyly-avanto-architects. 53

Figure 26 Sudbury mapping series shows the unique distribution of roads, railways, towns, and mine sites, highlighting how their position is largely dictated by the geological formations of the area, lakes, and ore deposits,by author. 57

Figure 27 Map: Sudbury the regional capital, compared to Ottawa and Toronto in terms of population and area, by author. 58

Figure 28 Map: Sudbury downtown, highlighting the urban fabric that has formed as a result of industrial and geological factors, by author. 59

Figure 29 Census data comparing Sudbury to National averages, with three categories highlighted.
Source: Government of Canada, Statistics Canada. "Census Profile, 2016 Census - Greater Sudbury [Census Metropolitan Area], Ontario and Canada [Country]," February 8, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.PR=01&B1=All&TABID=1&type=0. 60

Figure 30 Jan Gehl and World Health Organization report on physical activity.
Source: World Health Organization. Regional Office for Europe. *Towards More Physical Activity in Cities: Transforming Public Spaces to Promote Physical Activity – a Key Contributor to Achieving the Sustainable Development Goals in Europe.* World Health Organization. Regional Office for Europe, 2017. https://apps.who.int/iris/handle/10665/345147. 61

Figure 31 Four municipal documents from the Greater City of Sudbury:
Source: City of Greater Sudbury. *A New Vision for Downtown Sudbury: Guiding Principles, Strategies, Projects, and Programs.* December 14, 2005. https://www.greatersudbury.ca/linkservid/40919E1B-A4A9-F817-143C9C71D16AC491/showMeta/0/.; City of Greater Sudbury. *Parks, Open Space & Leisure: Master Plan Review.* June 2014. https://www.greatersudbury.ca/linkservid/71BB45BE-F9B0-D8D3-7E87CEDBDA48FC79/showMeta/0/.; City of Greater Sudbury. *Population Health: A Call to Action 2018-2028.* 2018. https://www.greatersudbury.ca/city-hall/reports-studies-policies-and-plans/report-pdfs/population-health-call-to-action/.; City of Greater Sudbury. *Population Health, Community Safety & Well-Being: A Made in Greater Sudbury Solution.* June 1, 2021. https://www.greatersudbury.ca/city-hall/reports-studies-policies-and-plans/report-pdfs/population-health-june-2021/. 61

Figure 32 Axonometric map series 1 of 7: highlighting the downtown core area of Sudbury, by author. 65

Figure 33 Axonometric map series 2 of 7: highlighting the barriers to movement created by the railways, by author. 65

Figure 34 Axonometric map series 3 of 7: showing the few connection points across the railway, by author. 66

Figure 35 Axonometric map series 4 of 7: existing multi-use trails are shown, by author. 67

Figure 36 Axonometric map series 5 of 7: existing and proposed bike lanes are shown, by author. 68

Figure 37 Axonometric map series 6 of 7: fragmented active transportation network shown, by author. 68

Figure 38 Axonometric map series 7 of 7: proposed primary sites are shown along with linear parks/active transportation interventions dashed in blue, by author. 69

Figure 39 Collage showing the existing pedestrian tunnel photo, map, and design intervention, by author. 71

Figure 40 Site photo 1 of Frood Road, by author. 71

Figure 41 Site photo 2 of Frood Road, by author. 71

Figure 42 Aerial map delineating the proposed site for Frood Road project, by author. 71

Figure 43 Panoramic site photo with Movement Legacy Framework principles overlaid, by author. 73

Figure 44 Axonometric drawing of Grow 'n Go design proposal, by author. 74

Figure 45 Plan, Grow 'n Go design proposal, by author. 76

Figure 46 Render 1: from south edge of playground, looking north at Grow 'n Go site, by author. 78

Figure 47 Render 2: from west area of site in the community garden area, looking east at Grow 'n Go site, by author. 80

Figure 48 Collage showing photo of the area in front of McEwen School of Architecture, map, and design proposal for new crosswalk and urban interventions, by author. 83

Figure 49 Site photo 1 at Sudbury Nexus site, by author. 83

Figure 50 Aerial map, delineating the proposed site for the Elgin Street project, by author. 83

Figure 51 Panoramic site photo 1 with Movement Legacy Framework principles overlaid, author. 85

Figure 52 Panoramic site photo 2 with Movement Legacy Framework principles overlaid, by author. 85

Figure 53 Axonometric drawing of Sudbury Nexus design proposal, author. 86

Figure 54 Plan drawing of Sudbury Nexus design proposal, by author. 88

Figure 55 Render 3: near northwest corner of the site, looking east-southeast towards community stage and sloped linear park, by author. 90

Figure 56 Render 4: near southeast corner of the Sudbury Nexus site, looking east-northeast towards Corten-wrapped train bridge, by author. 92

Figure 57 Collage showing photo of the area in front of the pedestrian bridge at Edmund Street, aerial map, and design proposal for new parkettes, by author. 95

Figure 58 Site photo 1 at Loving The Lake Centre site, by author. 95

Figure 59 Site photo 2 at Loving The Lake Centre site, by author. 95

Figure 60 Site photo 3 at Loving The Lake Centre site, by author. 97

Figure 61 Aerial map, delineating the proposed site for the Loving The Lake Centre project, by author. 97

Figure 62 Panoramic site photo with Movement Legacy Framework principles overlaid, by author. 97

Figure 63 Axonometric drawing of the Loving The Lake Centre design proposal, by author. 98

Figure 64 Plan, Loving The Lake Centre design proposal, by author. 100

Figure 65 Render 5: view from the sauna rooftop looking in the direction of the restaurant, by author. 102

Figure 66 Render 6: view from the sauna docks near the southwest corner of the site, by author. 104

Figure 67 Typical lifespan of three generations compared to lifespan of the species, a typical building, and the planet, by author. 109

Preface

At the age of 19, I had the immense privilege of traveling to Germany and the Netherlands over the Christmas holidays. As a member of the Queen's University Men's Volleyball team, we were slated to play a series of exhibition games against professional clubs, partake in several joint training sessions, and compete in a tournament against pro clubs, which we ended up winning in front of about a thousand Dutch supporters. When we weren't playing, we spent time in Assen, Wuppertal, Amsterdam, and Berlin enjoying tremendous cultural experiences that ultimately changed the way I look at cities. In our time in Assen, our team was divided up into pairs, and matched with a billet family. My teammate Anthony and I spent three days living with a Dutch family of five, with three children around our age. They lived in a small townhouse in a suburb outside the city core, but rarely used their car.

On a night off from training, they offered to take us to a local club for some drinks and live music. Excited to do something other than train, Anthony and I accepted the invitation, not knowing it was in fact a bicycle marathon disguised as a night off. After about 25 minutes of cycling on dedicated bike paths through fields, over canals, and through even more fields, we arrived at the club. In the small parking lot, interestingly, were no cars, but at least a hundred and fifty bicycles. Had everybody recently lost their licenses? Were all their cars at the mechanic's? I was shocked to learn that in fact no, the

attitude of locals was simply that cycling was better for a variety of reasons, and after only one night, I believed them.

Three years later I graduated with my Kinesiology degree in hand and entered the workforce, determined to help people live healthier lives. I became licensed as a Kinesiologist with the College of Kinesiologists of Ontario, and worked for several years for a consulting firm which offered a variety of services geared to helping people return to work after injury or illness. Conducting ergonomic assessments and functional movement screens was engaging, and I enjoyed helping people progress through their recovery, but I knew what I was doing was reactive, not proactive. Treatment and return to work planning is important, and a critical aspect of returning to good health, but who was looking after people's health in a proactive way? What factors were contributing to good health for some, and poor health for others? Why were some people willing to exercise by walking, running, cycling in their neighbourhood, while others were not? The night in the northern Netherlands came swirling back as a reminder of the tremendous power of lifestyle to dictate one's short and long-term health.

Introduction

A Call for Health Sustainability

Introduction: A Call for Health Sustainability

Diseases that reach epidemic levels are commonly believed to include only those which are contagious and can thus be transmitted rapidly throughout a population, but this is not always the case. Chronic diseases, also known as noncommunicable diseases (NCDs), are those which are not spread through infection or through other people, but instead are caused by a combination of genetic, physiological, environmental, and behavioural factors.[1] The most common NCDs are cardiovascular diseases, cancers, chronic respiratory diseases, mental health conditions, and diabetes. In total, NCDs account for nearly three quarters of deaths, globally.[2] NCD prevalence rates are strongly correlated with a remarkably short list of risk behaviours including tobacco use, poor nutrition, excessive alcohol use, and physical inactivity.[3] The Public Health Agency of Canada and the World Health Organization have named chronic diseases collectively as the greatest epidemic in the world.[4]

1 Centers for Disease Control and Prevention, "Principles of Epidemiology | Lesson 1 - Section 11," December 20, 2021, https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html.

2 International Federation of Red Cross, "Non-Communicable Diseases | IFRC," accessed March 9, 2023, https://www.ifrc.org/our-work/health-and-care/community-health/non-communicable-diseases.

3 World Health Organization, "Non Communicable Diseases," accessed December 6, 2022, https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.

4 Government of Canada Public Health Agency, "Working Together Globally: Canada's World Health Organization (WHO) Collaborating Centre on Chronic Noncommunicable Disease Policy," Last updated March 7,

The annual impact of Non-Communicable Diseases:

74% ***of all deaths, globally,***

90% ***of all deaths in Canada***

41 ***million deaths, globally***

In recent years, the ways in which our environment - both built and natural - affects our health is becoming better understood. The fields of neuroscience, evolutionary biology, environmental psychology, epidemiology, and medicine are identifying ways in which the built environment can support improved health outcomes, but they are not yet widely understood or adopted by the design community. Proximity to nature, quality of views, ease of wayfinding, perceived safety, sense of control, and opportunity for socialization are a few of the factors that have been identified for their importance in determining health outcomes.[5] The mechanisms by which health outcomes are affected vary from factor to factor. These include stress hormone responses, pleasure neurotransmitter responses, behavioural nudges, and a variety of other psychological and physiological processes initiated by our sensory perception of - and engagement with - our environment.[6]

When we consider the capacity for our environment to facilitate or undermine human wellness alongside the correlation of NCD prevalence and unhealthy behaviours, the importance of treating design as a tool for creating health-supporting environments is clear. A vast body of medical research confirms that behaviours such as smoking cessation, healthy eating, and physical activity lead to better health outcomes, so the elements in our environments providing prompts for healthier lifestyle choices must be better understood. In this thesis, a novel design framework is developed that better leverages the scientific literature and translates it into specific architectural, urban, and landscape design principles that have been proven to improve user health. Differentiating my proposed "Movement Legacy Framework" (MLF) from other health and wellness frameworks is its specificity. Its primary goal is to improve prevalence of one specific behaviour correlated with significantly decreased incidence of non-communicable diseases (NCDs) in all ages, ethnicities, and abilities: physical

2023, https://www.canada.ca/en/public-health/corporate/mandate/about-agency/working-together-globally-canada-world-health-organization-collaborating-centre-chronic-noncommunicable-disease-policy.html.; WHO, "Non Communicable Diseases."

5 Ruca Maass, et al., "The Application of Salutogenesis in Cities and Towns," in *The Handbook of Salutogenesis*, eds. Maurice B. Mittelmark, et al. (Cham: Springer, 2017), 173-176.; Jain Malkin, *A Visual Reference for Evidence-Based Design* (Concord, CA: Center for Health Design, 2008), 7-9.; Ann Sussman, *Cognitive Architecture: Designing for How We Respond to the Built Environment* (New York: Routledge, 2015), 4-5.

6 Sussman, *Cognitive Architecture*.; Jenny Roe, *Restorative Cities: Urban Design for Mental Health and Well-being.* (London: Bloomsbury Visual Arts, 2021), 11.

activity.[7] Rates of physical inactivity have reached record highs, paradoxically at a time when the research and resources supporting the effectiveness of physical activity in reducing NCDs is also at an all-time high. Important to note, exercise is a subcategory of physical activity that is planned, structured, repetitive, and purposefully focused on improvement or maintenance of physical fitness, while physical activity includes all bodily movement produced by skeletal muscles that require energy expenditure.[8] Examples of physical activity include walking, dancing, paddling, gardening, cleaning, bicycling, swimming, and even taking the stairs instead of the elevator, all of which are associated with a reduced incidence of NCDs.

By investigating the relevant fields of neuroscience, environmental psychology, physiology, exercise science, urbanism, and medicine, I expanded my familiarity with the scientific and medical terminology surrounding the relationship between environment and health. Through this rigorous review of the existing literature, those principles dictating the relationship between the built environment and measurable, positive health outcomes were compiled and organized into the six guiding pillars of the MLF: Safety, Choice, Joy, Nature, Movement, and Measurability. This exercise in ascertaining foundational knowledge also provided me with a more critical eye with which to examine ten existing health and wellness frameworks. Taking stock of perceived strengths and weaknesses of these frameworks further laid the groundwork for a uniquely specific design framework targeting healthy lifestyle change. Next, precedents were analyzed through the lens of the MLF to better understand how the six pillars might best translate into specific elements of our built environment, and ultimately how users engage with them. Using an iterative approach, the precedent research produced an inventory of specific, measurable design elements for each of the six pillars, and should continue to develop as more research and precedents emerge.

Recent discoveries in epigenetics reveal the immense impact that the environment plays in our health, which ought to compel designers to reframe their role to prioritize their responsibility for the sustainability of individual and community health. Elements in our environment and lifestyle factors are shown to have both immediate and long-term impacts on our health via epigenetic modifications.[9] Edits to the host of molecules known as the epigenome cause changes in the way our body "reads" our DNA, which leads to changes in our phenotype expression, or more simply, changes to our physiology. Epigenetic edits associated with improved lifestyle are associated with predictably lower risk of diseases such

7 Elizabeth Anderson and J. Larry Durstine, "Physical Activity, Exercise, and Chronic Diseases: A Brief Review," *Sports Medicine and Health Science* 1, no. 1 (Dec 2019): 10.; World Health Organization, "Physical Activity," accessed October 24, 2022, https://www.who.int/news-room/fact-sheets/detail/physical-activity.; Centers for Disease Control and Prevention, "Chronic Disease Fact Sheet: Physical Inactivity," accessed February 21, 2023, https://www.cdc.gov/chronicdisease/resources/publications/factsheets/physical-activity.htm.

8 C. J. Caspersen, et al., "Physical Activity, Exercise, and Physical Fitness: Definitions and Distinctions for Health-Related Research," *Public Health Reports* 100, no. 2 (1985): 126.

9 Jorge Alejandro Alegría-Torres, et al., "Epigenetics and Lifestyle," *Epigenomics* 3, no. 3 (June 2011): 271.

as ischemic heart disease, stroke, diabetes, cancer, and all-cause mortality.[10] What's more, new research shows the epigenome is inherited by subsequent generations, meaning the decisions we make for our own health not only affect us, but provide the baseline for how our children's bodies will operate.[11] Not only does this provide clarity about the immense agency we have over our health, but it shows how design and health are inextricably linked to bioethical questions about architects' and urban designers' intentions and responsibilities for intergenerational population health. As medical researchers have argued, if the built environment is analogous to medical intervention, then design should be treated with the same scrutiny as all other medications and treatments.[12]

When urban and architectural design facilitates movement, communities are more likely to choose active transportation methods over driving, thereby reducing dependency on fossil fuels while nurturing physical health. Improvements to mood, cognitive function, relationships, sex life, and professional life follow, bringing positive changes to community mental health, economic strength, and environmental sustainability.[13] Designing for the holistic health of our communities will require a retooling of both government policy and design theory. Architects and designers must recognize their ethical responsibility for health in the greater sustainability equation and take action to contribute to a viable future for population and planetary longevity.

Sudbury provides an ideal test case for the new Movement Legacy Framework because of its fragmented active transportation network, physical and psychological barriers to movement, higher than average obesity rates, lower than average physical activity rates, and the prioritization of car-culture. An analysis of city planning documents alongside interviews, mapping exercises, and years of lived experience helped to identify the parts of the city that feature the greatest barriers to movement. Three barrier-ridden and severely under-programmed sites were selected, each with a nearby complementary satellite site, for a total of six sites. For each of these, a unique design intervention was proposed. When combined, the six sites form a network of new buildings, trails, active transportation lanes, and linear parks, establishing a movement corridor throughout the downtown area that serves to catalyze physical activity through a variety of accessible, yet unexpected urban and architectural interventions. As Jan Gehl remarks, by prioritizing the needs of the pedestrian and the cyclist you hit five birds with one stone – you get a lively city, an attractive city, a safe city, a sustainable city, and you get a city that's good for your health. [14]

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10 Andrea Baccarelli et al., "Ischemic Heart Disease and Stroke in Relation to Blood DNA Methylation," *Epidemiology 21, no. 6 (Nov 2010): 822.; Alegría-Torres, et al., "Epigenetics and Lifestyle," 268. ; Henriette Kirchner et al., "Epigenetic Flexibility in Metabolic Regulation: Disease Cause and Prevention?," Trends in Cell Biology 23, no. 5 (May 1, 2013): 209.*

11 Andrew P. Feinberg, "Phenotypic Plasticity and the Epigenetics of Human Disease," *Nature* 447, no. 7143 (May 24, 2007): 440.

12 Diana C. Anderson et al., "The Bioethics of Built Space: Health Care Architecture as a Medical Intervention," *Hastings Center Report 52, no. 2 (2022): 38-39.*

13 Anderson and Durstine, "Physical Activity, Exercise, and Chronic Diseases," 5-6.

14 Jan Gehl, *Urban Visionary*, 2020, https://soundcloud.com/environmentshow/jan-gehl.

Environmental and cultural sustainability have become increasingly accepted and firmly held priorities within the architecture and urban planning communities. Knowledge of ecological systems and cultural sovereignty principles has sufficiently permeated the design community and reached a critical mass whereby most design teams can effectively discuss these dimensions of sustainability with a range of consultants, clients, and municipalities alike. This evolution of the collective discourse has enabled greater multidisciplinary collaboration and helped inform design strategies that successfully address issues at a variety of scales. However, notwithstanding the critical nature of environment and cultural considerations, these still represent an incomplete picture of sustainability. This thesis argues a third priority must be included to complete the sustainability equation, namely, health sustainability.

Chapter 1

The Invisible Epidemic and Exercise

Chapter 1 The Invisible Epidemic and Exercise

This chapter discusses the phenomenon of non-communicable diseases, which has reached epidemic proportions, globally. The necessity of the design community to address this epidemic is foregrounded, and put in the context of a more comprehensive definition of sustainability. The immensely positive role that physical exercise can play in mitigating the breadth and severity of NCDs is highlighted.

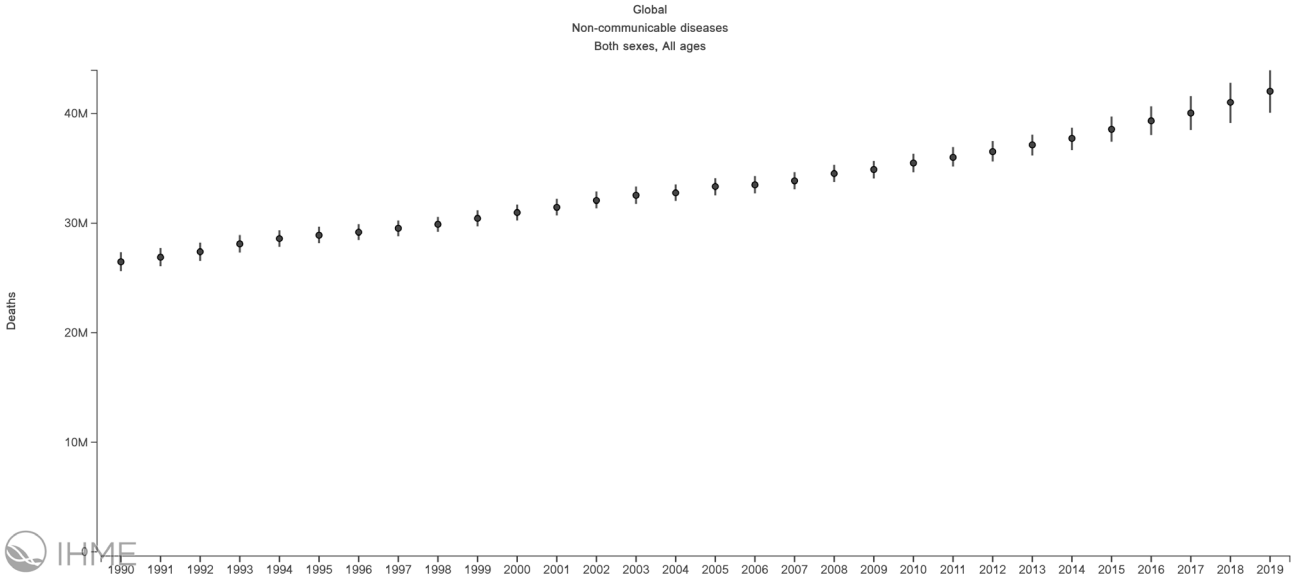
***01 | opposite top,** Total deaths from NCDs, both sexes, all ages, globally between 1990-2019*

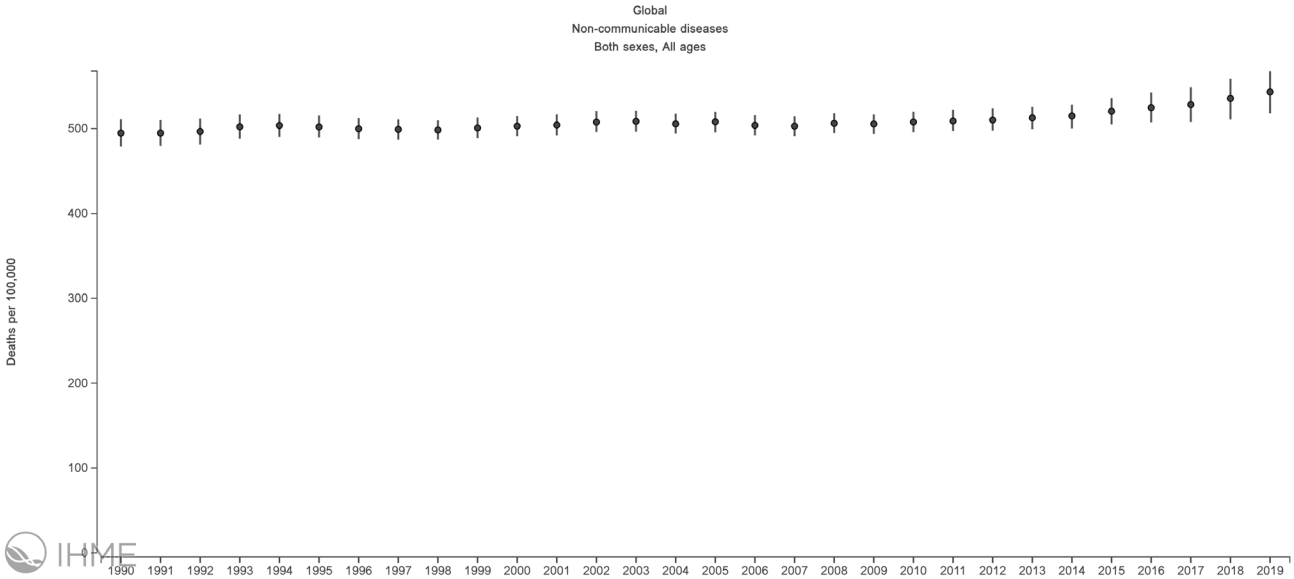
***02 | opposite bottom,** Deaths per 100,000 from NCDs, both sexes, all ages, globally between 1990-2019*

1.1 The Non-Communicable Disease Epidemic

The Center for Disease Control defines an epidemic as an unexpected increase in the number of disease cases in a specific geographic area. However, contrary to popular belief, a disease does not have to be contagious to become widespread and subsequently be classified as an epidemic.[15] Chronic diseases, also known as noncommunicable diseases (NCDs), are not transmissible. These diseases are instead caused by a variety – and often a combination - of genetic, physiological,

15 Centers for Disease Control and Prevention, "Principles of Epidemiology | Lesson 1 - Section 11," December 20, 2021, https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html.


Global
Non-communicable diseases
Both sexes, All ages
Deaths
40M
30M
20M
10M
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
IHME


Global
Non-communicable diseases
Both sexes, All ages
Deaths per 100,000
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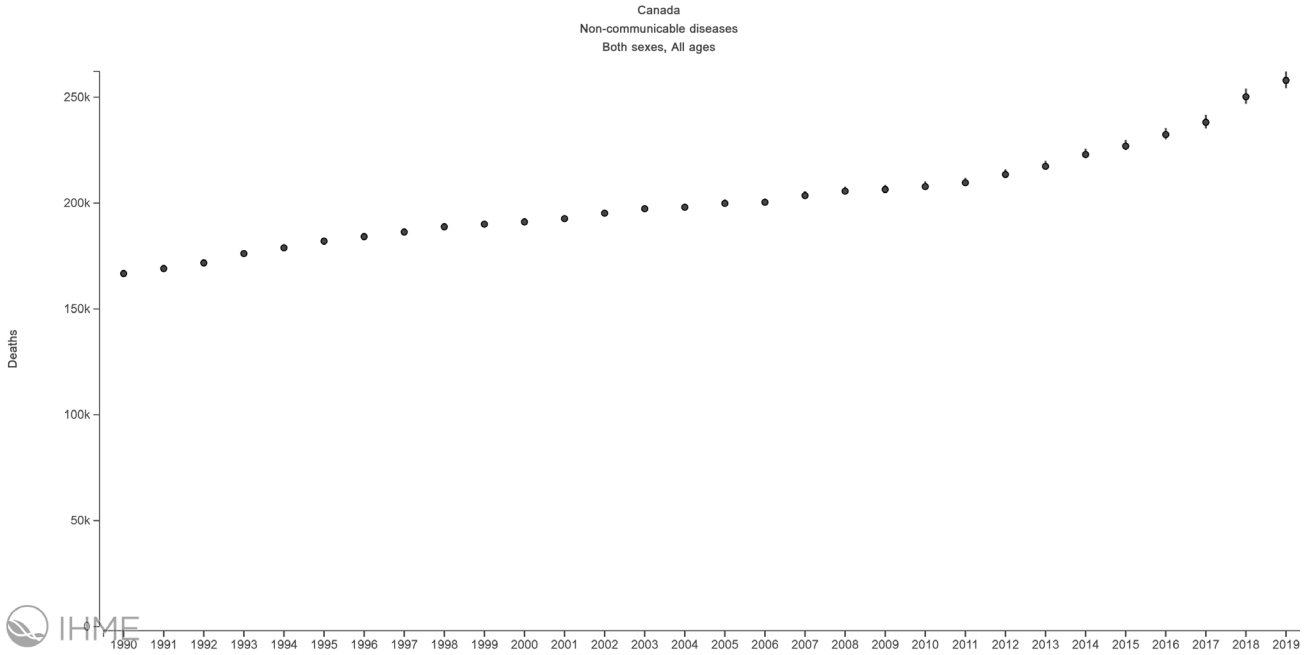
Canada
Non-communicable diseases
Both sexes, All ages
Deaths
250k
200k
150k
100k
50k
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
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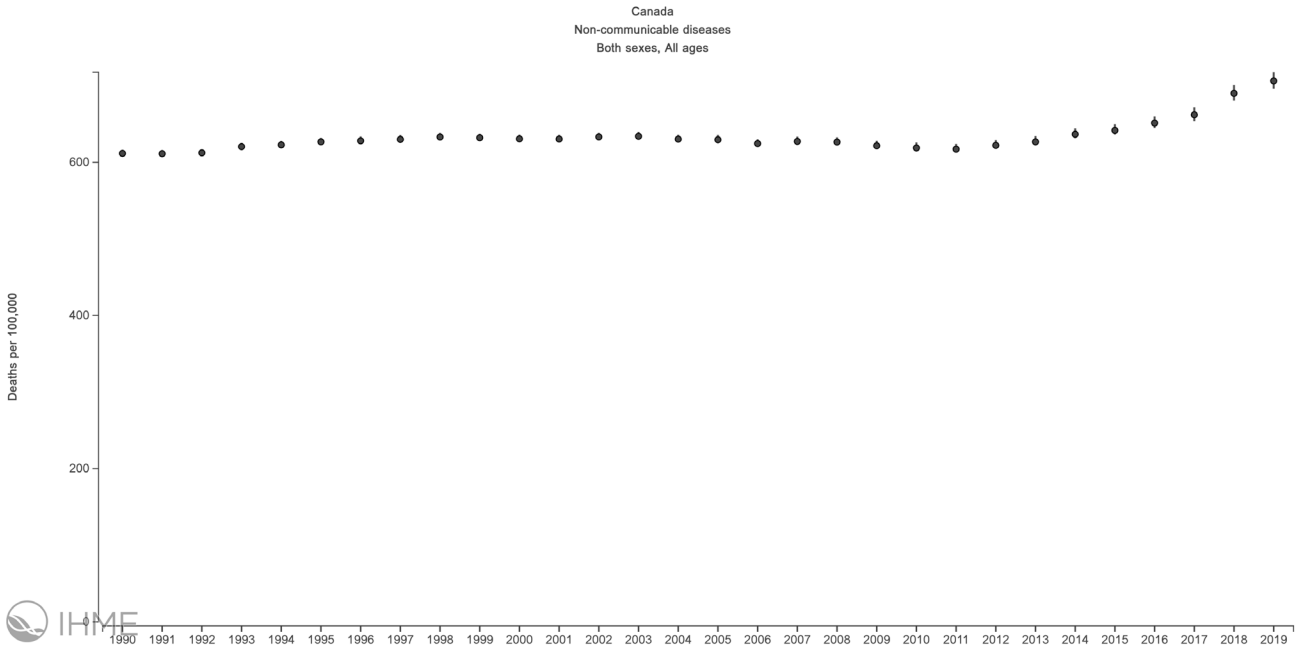
Canada
Non-communicable diseases
Both sexes, All ages
Deaths per 100,000
600
400
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1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
IHME

environmental, and behavioural factors.[16] The most common NCDs include arthritis, diabetes, chronic respiratory disease, cancer, cardiovascular disease, and mental health conditions such as depression. According to the Public Health Agency of Canada and the World Health Organization (WHO), chronic diseases are collectively the greatest epidemic in the world, accounting for the highest number of preventable deaths in the world each year. This represents 74% of all deaths worldwide, totaling 41 million deaths per year.[17] In Canada, the percentage of total preventable deaths is even higher, at 90%.[18] This epidemic results in the largest avoidable burden on the public healthcare system of any disease category, not to mention the largest avoidable cause of ill-health and diminished quality of life.

03 | opposite top, *Total deaths from NCDs, both sexes, all ages, in Canada between 1990-2019*

04 | opposite bottom, *Deaths per 100,000 from NCDs, both sexes, all ages, in Canada between 1990-2019*

05 | above, *The Seventeen Sustainable Development Goals developed by the United Nations*

16 Centers for Disease Control and Prevention, "Principles of Epidemiology | Lesson 1 - Section 11."

17 Government of Canada Public Health Agency, "Working Together Globally: Canada's World Health Organization (WHO) Collaborating Centre on Chronic Noncommunicable Disease Policy," last updated March 23, 2022 https://www.canada.ca/en/public-health/corporate/mandate/about-agency/working-together-globally-canada-world-health-organization-collaborating-centre-chronic-noncommunicable-disease-policy.html.; World Health Organization, "Non Communicable Diseases," accessed December 6, 2022, https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.

18 World Health Organization, "NCD Country Profile: Canada," accessed May 6, 2023, https://ncdportal.org/CountryProfile/GHE110/CAN.

In 2007, the Public Health Agency of Canada's World Health Organization Collaborating Centre put forth a report on the NCD epidemic and provided a comprehensive health policy planning document informed by global best practices for use domestically and around the globe. Compiling research and resources, the report helps policy planners better understand and identify contributing factors, create scaled response plans, mobilize resources, adjust existing policies, and implement a variety of other tools to lower NCD incidence.[19] The WHO continues to play an important leadership role in the coordination and promotion of a unified global effort against NCDs. In fact, in 2019, the World Health Assembly extended the WHO Global action plan for the prevention and control of NCDs 2013–2020 to 2030 and called for the development of an Implementation Roadmap 2023 to 2030 to accelerate progress on preventing and controlling the NCD epidemic. In parallel, the United Nations has also laid out 17 Sustainable Development Goals – a blueprint for peace and prosperity for people and the planet – which were adopted by all UN Member States in 2015. The associated 2030 Agenda for Sustainable Development identifies NCDs as a major challenge for sustainable development. As part of the agenda – and in acknowledgement of the severity of the epidemic - heads of state and government around the world have committed to develop ambitious national responses by 2030 to reduce early mortality from NCDs through prevention and treatment by one third, as outlined in the Sustainable Development Goal target 3.4.[20]

The four behaviours most closely associated with NCD prevalence, namely, diet, physical activity levels, smoking, and alcohol consumption, are behaviours known as modifiable risk factors because of our inherent choice to engage in them or not. Sharing the same risk factors as the rest of the world, Canadians are increasingly exposed to, or are selecting, a high fat and high sugar processed diet, a sedentary lifestyle, and consumption of tobacco and alcohol products, all of which are associated with a significant increased risk of NCDs.[21] The Transtheoretical Model for Behaviour Change (TTM) provides an actionable framework and step by step approach to change, and is widely held as the dominant model for behaviour change related to health.[22] According to the TTM, before we can successfully change our behaviours, we must first move through "precontemplation" (i.e., being unaware our behaviour is problematic, and being unwilling to change), "contemplation" (i.e., considering the pros and cons of making a change), and "preparation" (i.e., convinced of the benefits of change and intending to take action in the immediate future).[23] As a research and interventional tool, the TTM has experienced popularity in the context of physical activity due to the increasing

19 Government of Canada Public Health Agency, "Working Together Globally."

20 United Nations Department of Economic and Social Affairs, "THE 17 GOALS | Sustainable Development," accessed March 7, 2023, https://sdgs.un.org/goals.; United Nations Development Programme, "Sustainable Development Goals," accessed March 7, 2023, https://www.undp.org/sustainable-development-goals.

21 WHO, "Non Communicable Diseases."

22 Christopher J. Armitage, "Is There Utility in the Transtheoretical Model?," *British Journal of Health Psychology 14, no. 2 (2009): 196.*

23 James O. Prochaska and Carlo C. Diclemente, "The Transtheoretical Approach," in *Handbook of Psychotherapy Integration, eds. John C. Norcross and Marvin R. Goldfried (Oxford: Oxford University Press, 2005), 170.*

problems associated with poor diets and sedentary living such as obesity and cardiovascular disease.[24]

The decisions we make in our work, home, and personal routines make up our aggregate lifestyles. Although external factors can be difficult to overcome (e.g., economic stress, job market, social drinking, mental distractions/lost time, lure of television and other sedentary activities, etc.), working towards selecting healthier lifestyle activities can occur gradually. As our world becomes more technologically connected, it seems our lives have become increasingly complex rather than simplified, contrary to what many technologies promised would happen. In the name of efficiency, the accelerated speed of communications and our constant connectivity to media has generated expectations for instant responses that have only served to make us busier and feel more stressed as these additional forces compete for our limited time and attention. Even after we are convinced of the merits of eating a healthy diet, smoking cessation, exercising, and socializing, it can be challenging to make these activities part of our regular routines. It requires conviction and creativity to carve out time in our schedules to prioritize our health, but this is necessary to counter early death from NCDs.

As designers, we must be aware of the stages of behaviour change if we hope to design in innovative ways. Like all professionals in every field, we don't know what we don't know, and tackling an epidemic should not be done alone. Health behaviour change is only possible after we establish self-awareness about our own limited knowledge and make the effort to learn about the foundational concepts so that we may accurately weigh the pros and cons of change. In the context of designing, we must work towards understanding the scientific literature before we can be convinced of change. Once convinced, we should seek collaborators and build our collective understanding throughout our careers. Only then will the sincere enthusiasm and the full gamut of the greater creative community be fully mobilized to design for health sustainability.

1.2 The Pivotal Modifiable Risk Factor: Physical Activity

The volume of innovations in modern medicine - and frequency at which they occur – is a phenomenon paralleled in few other sectors, and it is constantly accelerating.[25] The ever-growing body of scientific research continually expands our understanding of the human body, and has led to discoveries of new medications, imaging technologies, and treatment techniques which better enable us to treat injury, infection, and disease.[26] The greatest medical findings, arguably,

24 Leslie Spencer et al., "Applying the Transtheoretical Model to Exercise: A Systematic and Comprehensive Review of the Literature," *Health Promotion Practice* 7, no. 4 (2006): 428-31.

25 Sharyl J. Nass et al., *Beyond the HIPAA Privacy Rule: Enhancing Privacy, Improving Health Through Research* (Washington, DC: National Academies Press, 2009), 35, https://www.ncbi.nlm.nih.gov/books/NBK9571/.; Harvard Medical School, "Timeline of Discovery," accessed September 25, 2022, https://hms.harvard.edu/about-hms/history-hms/timeline-discovery.

26 Nass et al., *Beyond the HIPAA Privacy Rule,* 42.

Benefits of regular physical activity:

25-30% ***reduced risk of early death***

Prevalence of physical inactivity:

54% ***of adult Canadians***

are those which have correctly identified the body's own built-in mechanisms for prevention of illness, the efficacy of which are proven to increase with associated healthy behavior and lifestyle change.[27] Importantly, the key across these medical findings is that they help us better understand, and thus, set up the condition that eliminate or at least significantly reduce the potential for future health problems. Diet, exercise, sleep, stress, and socialization are factors under our control and when healthy behavioural options are selected, are proven to be associated with positive outcomes for health and longevity, or inversely, and as it is reported in medical journals: lowered disease prevalence and all-cause mortality rate.[28]

Summarizing several key medical findings in the last decade on the positive health impact of exercise, Katz and Pate take the position that exercise should be recognized for its significant role as medicine. All demographics, all ages, with or without chronic diseases who engage in physical activity have a lower risk for cardiovascular disease, diabetes, certain types of cancer, depression, cognitive impairment, and functional decline. They argue that prescribing exercise may be just as important as prescribing medication (and maybe even more so), and that physicians should have more training, tools, and support to prescribe exercise as effectively as they do other medications.[29]

Although smoking, alcohol consumption, poor sleep, and high stress are strongly associated with ill-health, this thesis takes the position that physical activity is the most critical of all modifiable risk factors, especially as architects should be concerned. The direct influence the built environment has on human movement patterns coupled with the centrality of physical activity in improving overall health through a host of peripheral benefits make it vital in the health sustainability equation. Most physiological systems in the body benefit positively from physical activity whereby it significantly supports both primary disease prevention and

27 Igor Vojnovic et al., "The Renewed Interest in Urban Form and Public Health: Promoting Increased Physical Activity in Michigan," *Cities* 23, no. 1 (Feb 2006): 17.; Patricia P. Katz and Russell Pate, "Exercise as Medicine," *Annals of Internal Medicine* 165, no. 12 (December 20, 2016): 880–81.

28 Katz and Pate, "Exercise as Medicine," 880.

29 Katz and Pate, "Exercise as Medicine," 881.

treatment of existing disease.[30] Physical activities are widely accessible regardless of socioeconomic status, race, religion, or age. Further, the range of different physical activities proven to be associated with improved health is seemingly endless when one considers the health benefits of activities such as dancing, playing, and gardening. The breadth of available activities provides tremendous adaptability and customization for individuals across cultures, age groups, and abilities, making it the most important behaviour for designers to target for improved health outcomes.

30 Elizabeth Anderson and J. Larry Durstine, "Physical Activity, Exercise, and Chronic Diseases: A Brief Review," *Sports Medicine and Health Science* 1, no. 1 (Dec 2019): 9.; Darren E. R. Warburton, Crystal Whitney Nicol, and Shannon S. D. Bredin, "Health Benefits of Physical Activity: The Evidence," *CMAJ : Canadian Medical Association Journal* 174, no. 6 (March 3, 2006): 802-8.

Chapter 2

Intergenerational Health: Agency and Responsibility

Chapter 2 Intergenerational Health: Agency and Responsibility

Environmental and cultural sustainability are becoming more widely studied and appreciated in the design world in recent years. Becoming stronger stewards for our ecosystems and cultural sovereignty is an important responsibility of all global citizens. As important factors for overall sustainability of our planet, these should persist as a driving force in designs for the built environment, but mortality rate and disease prevalence of the user should be equally prioritized. Adding a health lens to architects' and urban designers' approaches will require the inclusion of scientific and medical literature on a massive scale into design curricula, professional reports, lectures, and frameworks before this research can be rendered accessible and actionable. This chapter will introduce one such scientific field of study warranting designers' attention due to its potential for massive population health change: epigenetics. Epigenetics is the study of the host of molecules responsible for how our genetic material is "read" by our cells. Harnessing the fundamentals in this remarkable area of research should excite not only designers, but all individuals interested in personal and intergenerational health. Grasping the central principles will empower designers to forge the concept of "health sustainability" into their designs with as much dynamism as they do environmental and cultural sustainability.

2.1 Epigenetics

This thesis intends to add support to, and build on, functional medicine principles, which are generally proactive and preventative in nature. Where conventional medicine describes the 'what' (i.e., what disease is present, what pathway is dysfunctional, and what drug to take), functional medicine is commonly more concerned with 'why' (i.e., the behaviours, factors, and events that account for the root causes of disease). To better understand the host of factors influencing health from a functional perspective, the concept of the exposome was developed by researchers. The exposome is a foundational concept in our understanding of epigenetics and the mechanisms by which it can affect our health. Each of us has an entirely unique exposome, which captures a tremendous amount of data across time. Consisting of three overlapping domains, namely, the general external, the specific external, and the internal environments, the exposome captures a wide range of health factors including one's broader socioeconomic environment, lifestyles, occupations, and pollutant exposures from the time of an individual's conception to the end of their life. Put simply, the exposome is the cumulative exposures of an individual in a lifetime and how those exposures relate to health.[31]

Understanding how exposures from our environment, diet, lifestyle, etc. interacting with our own unique characteristics such as genetics, physiology, and epigenetics might impact our health is how the exposome is communicated.[32] It is widely accepted - after thousands of genome-wide association studies have been conducted - that a relatively small proportion of chronic disease can be explained by genetic factors alone, which further highlights the importance of our unique exposomes.[33] While genetics play a role in our health, disease risks, and potential for longevity, recent research shows that genetics play a much smaller role than our environment, between 10-25%, with the exposome (our environment, lifestyle, diet, etc.) determining the remaining 75-90%.[34]

Not surprisingly, the people living in the areas of the world with the longest life expectancy - in places dubbed the Blue Zones by researcher Dan Buettner, where people consistently live to be 100 years of age - share several common lifestyle characteristics. Further supporting the findings that health is only moderately determined by genetics, these five communities are strewn across the globe and

31 Kyoung-Nam Kim and Yun-Chul Hong, "The Exposome and the Future of Epidemiology: A Vision and Prospect," *Environmental Health and Toxicology* 32 (May 3, 2017): e2017009.

32 Centers for Disease Control and Prevention, "Exposome and Exposomics," August 19, 2022, https://www.cdc.gov/niosh/topics/exposome/default.html.

33 Christine Q. Chang et al., "A Systematic Review of Cancer GWAS and Candidate Gene Meta-Analyses Reveals Limited Overlap but Similar Effect Sizes," *European Journal of Human Genetics: EJHG* 22, no. 3 (2014): 407-8.

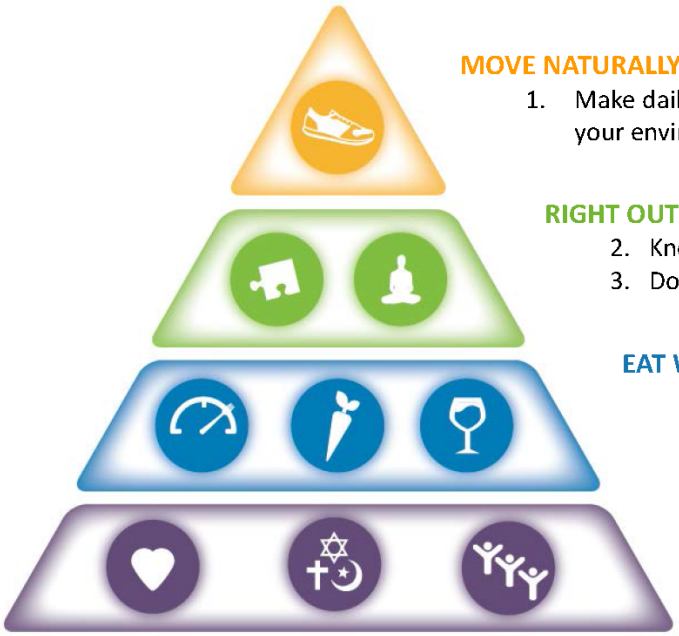
34 Giuseppe Passarino, Francesco De Rango, and Alberto Montesanto, "Human Longevity: Genetics or Lifestyle? It Takes Two to Tango," *Immunity & Ageing* 13 (April 5, 2016): 6.; Graham Ruby et al., "Estimates of the Heritability of Human Longevity Are Substantially Inflated Due to Assortative Mating," *Genetics* 210, no. 3 (November 1, 2018): 1122–24.; A. M. Herskind et al., "The Heritability of Human Longevity: A Population-Based Study of 2872 Danish Twin Pairs Born 1870-1900," *Human Genetics* 97, no. 3 (March 1996): 323.

share very little with each other, genetically speaking. The Blue Zones are located in California, USA; Nicoya, Costa Rica; Sardinia, Italy; Ikaria, Greece; and Okinawa, Japan. What the research uncovered was striking similarities in their routines, rituals, and habits: those elements that make up our aggregate lifestyle. Referred to as the Power 9, this list of lifestyle factors is shared by all five communities, but each address them in a unique and deeply socioculturally-specific manner. For instance, in Okinawa, Japan, they take a few moments each day to remember their ancestors, while in Ikaria, Greece, they take a nap, and those in Sardinia, Italy, partake of happy hour. Though different, all are observed routines designed to help reduce stress, one of the nine factors common across all five populations. At the top of the Power 9 list of most important factors for health and longevity is movement.[35] As explained by Buettner, "The world's longest-lived people do not pump iron, run marathons, or join gyms. Instead, they live in environments that constantly nudge them into moving without thinking about it. They grow gardens and do not have mechanical conveniences for house and yard work."[36] These observations underscore that having an environment that makes the healthy choice the easy choice, or better yet, unavoidable, is a common factor in all Blue Zones. That is good news for all of us because it means if we select for – and design for - these behaviours we could replicate the results found in these anomalous populations, at a larger scale. It also means that we have tremendous agency over our individual and community health and longevity.

35 Dan Buettner and Sam Skemp, "Blue Zones," *American Journal of Lifestyle Medicine* 10, no. 5 (July 7, 2016): 318.

36 Buettner and Skemp, "Blue Zones."

Blue Zones Power 9®



MOVE NATURALLY

1. Make daily physical activity an unavoidable part of your environment

RIGHT OUTLOOK

2. Know your purpose
3. Downshift: work less, slow down, take vacations

EAT WISELY

4. Eat until 80% full
5. More veggies, less meat & processed food
6. Drink a glass of red wine each day

BELONG

7. Create a healthy social network
8. Connect/reconnect with religion
9. Prioritize family

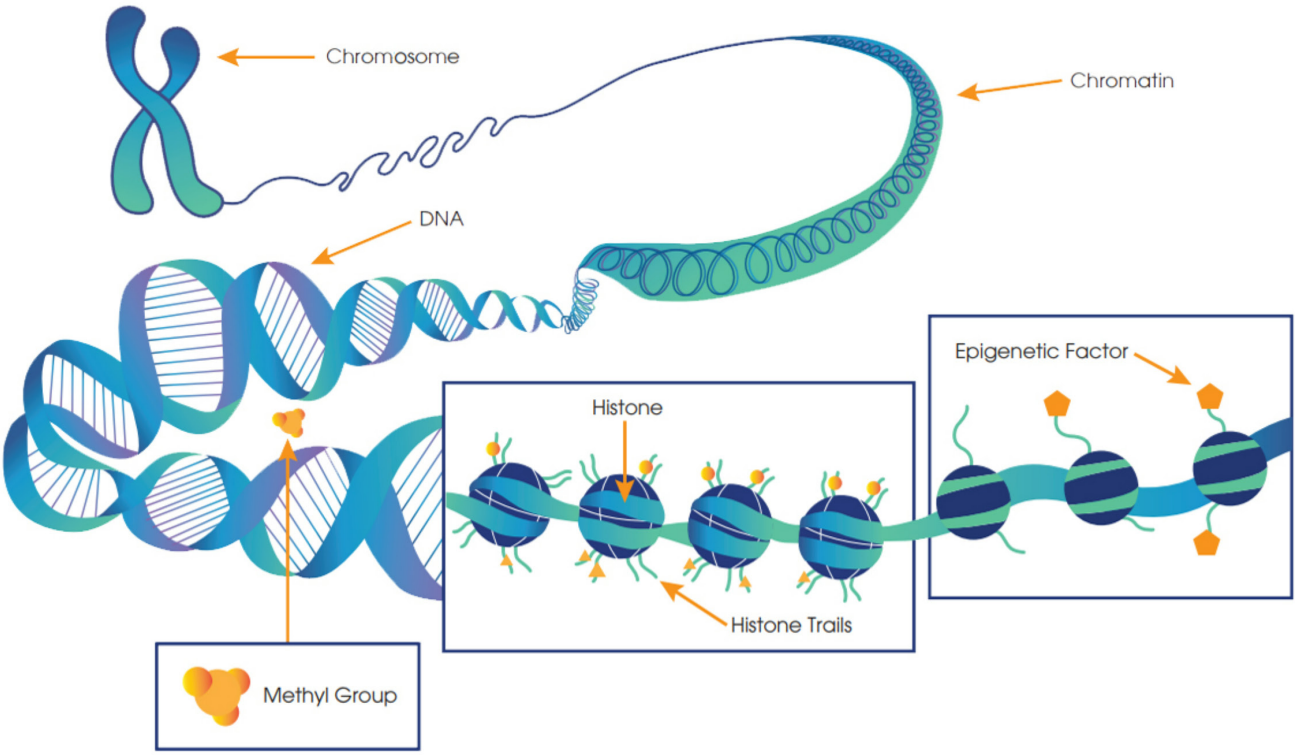
Epigenetics is the study of how our behaviors and environment can cause changes to the way our genes function. Different from genetic changes, epigenetic changes occur in what's known as the epigenome (Latin for "above the" genome), the host of molecules responsible for effectively turning on and turning off gene segments on our DNA. These edits to the epigenome – or epigenetic modifications – are flexible genomic parameters that both alter gene function and provide a mechanism for stable propagation of gene activity states from one generation of cells to the next. In other words, epigenetic mechanisms are the tools by which our cells adapt to exogenous influence (e.g., smoking, exercise, pollutants, etc.), and can pass the playbook of adaptations onto subsequently formed cells.[37]

Changes in gene expression can present in a variety of ways, often invisible to the eye. Expression often relates to cell function and operates on a molecular scale but can be visible sometimes as observable traits. These traits, or phenotypes, can include things such as hair colour and eye colour, but also less obvious traits like whether a new cell will become a heart cell, nerve cell, or skin cell, or whether

06 | opposite, *The Blue Zones: Five unique communities where people have exceptionally long life expectancy*

07 | above, *The Blue Zone Power 9 Behaviours: those behaviours shared across all five Blue Zone communities, highlighting physical activity as the most important shared behaviour responsible for longevity*

37 Jorge Alejandro Alegría-Torres, et al., "Epigenetics and Lifestyle," *Epigenomics* 3, no. 3 (June 2011): 6.; Centers for Disease Control and Prevention, "What Is Epigenetics?," August 15, 2022, https://www.cdc.gov/genomics/disease/epigenetics.htm.



08 | Epigenetic modifications shown in yellow, and DNA in blue-green. Illustrated conceptualy are a methyl group binding to a gene (DNA-methylation), and a histone modification affecting the tightness of gene-wrapping.

the specific gene associated with strengthened immunity to tuberculosis is turned on or off. All our cells have identical DNA but look and act differently based on the epigenome's decisions about which genes (DNA segments) to turn on and which to turn off. [38] If DNA (our genome) is the cookbook, the epigenome is the reader, deciphering the recipes and ultimately deciding what the meal will be comprised of.

Epigenetic mechanisms operate in three ways: DNA methylation, Histone modification, and use of Non-coding RNA. DNA methylation works by adding a chemical group to DNA, blocking proteins from binding to and reading the gene, effectively serving as an on/off switch for specific genes. Histone modification operates a little bit differently. DNA wraps around proteins called histones, and when histones are tightly packed together, proteins that read the genes in that section of DNA cannot bind to it because it is too tightly wrapped. Though different from methylation in its mechanism, this process still functions to make genes either readable or not. Lastly is Non-coding RNA, which helps control gene expression by attaching itself to Coding RNA, breaking it down so it cannot be used to make required proteins for gene expression. Like the other two mechanisms, Non-coding RNA effectively turns genes on or off.[39]

38 Centers for Disease Control and Prevention, "What Is Epigenetics?,"; Alegría-Torres, et al., "Epigenetics and Lifestyle," 1.

39 Centers for Disease Control and Prevention, "What Is Epigenetics?"; David Shenk, "Epigenetics: David Shenk at TEDxLakeGeneva," YouTube video, 2014, https://www.youtube.com/watch?v=7hWUhEA6hxk.;

Epigenetic changes, referred to as markers, respond to factors in our environment and behaviours and will persist for some time, but are reversible. For instance, smoking cigarettes will cause less DNA methylation at the AHRR gene, a gene segment believed to possess several tumour suppressor genes, thus weakening the body's own ability to prevent cancers.[40] Findings from another study suggest that smoking-associated DNA methylation can be reversed following cessation (quitting), and that the length of time in which the epigenetic markers are established and then recovered to baseline is dose dependent (i.e., reflects the amount and duration of cigarettes smoked).[41] In other words, the research shows we have the capability to customize our epigenome with behavioural modifications, for better or worse, and can reverse those changes over time.

Thought for a long time to exist only within individuals and die with them, new research now shows that our epigenome is passed to our children along with our genome. Not only do we provide the complete genetic blueprint for our children, but we also provide the epigenetic playbook for how their bodies will "read" their DNA. With intergenerational epigenomic inheritance in mind, the case of the pregnant woman who smokes offers a striking example of how her behaviour will induce epigenetic changes in three generations at once: in herself, in her unborn daughter, and in her daughter's reproductive cells, increasing the likelihood of several diseases throughout their lives including diabetes and cancer.[42]

Numerous studies have examined the epigenetic changes associated with physical activity levels, the specific genes that are affected, and which diseases those are linked to. In a longitudinal analysis of 712 elderly individuals over 75 months, researchers compared rates of ischemic heart disease and stroke, as well as all-cause mortality with DNA methylation levels, and found those who exercised regularly had higher DNA methylation in the LINE-1 gene area. Participants with lower LINE-1 methylation (i.e. those who did not exercise regularly) were at a higher risk for ischemic heart disease, stroke, and total mortality.[43] These same findings were supported by another research team that compiled findings from 124 sources. They also showed that low methylation in LINE-1 elements was associated with inflammatory responses and chromosomal instability.[44] Another research team reviewed 100 studies and established strong relationships between epigenetic markers and several adult diseases, and found that DNA methylation associated with exercise can help determine intergenerational risks for numerous common adult diseases including cancer.[45]

Henriette Kirchner et al., "Epigenetic Flexibility in Metabolic Regulation: Disease Cause and Prevention?," *Trends in Cell Biology* 23, no. 5 (May 1, 2013): 209.

40 Xiaoyan Zhu et al., "Genome-Wide Analysis of DNA Methylation and Cigarette Smoking in a Chinese Population," *Environmental Health Perspectives* 124, no. 7 (July 2016): 972-73.

41 Daniel L. McCartney et al., "Epigenetic Signatures of Starting and Stopping Smoking," *EBioMedicine* 37 (November 2018): 219–20.

42 Jonathan Shaw, "Is Epigenetics Inherited?," *Harvard Magazine* (May-June 2017).

43 Andrea Baccarelli et al., "Ischemic Heart Disease and Stroke in Relation to Blood DNA Methylation," *Epidemiology* 21, no. 6 (Nov 2010): 823.

44 Alegría-Torres, et al., "Epigenetics and Lifestyle," 2.

45 Andrew P. Feinberg, "Phenotypic Plasticity and the Epigenetics of Human Disease," *Nature* 447, no. 7143

Our built environments and the nudges they can provide for better lifestyle choices can positively impact our health in the short term via weight loss, improved mood, and improved cognitive function, but also in the medium and long term, through epigenetic mechanisms which change the expression of our DNA towards phenotypes that are more resilient to disease. Not only can we improve our own health in this way, but also the health of our children, and their children, through inheritance of our unique epigenome, or epigenetic markers. Architects and designers simply must better understand and respect their place in this equation if we are to affect massive change in the chronic disease epidemic.

2.2 Bioethics

In the early 2000s, doctors, epidemiologists, and other public health researchers at the World Health Organization (WHO) began developing a framework to understand the factors outside our control which were believed to have profound impacts on health outcomes. Over the last twenty years of research and development, these factors have come to include: income and social protection; education; unemployment/job insecurity; working life conditions; food insecurity; housing/ basic amenities and the environment; early childhood development; social inclusion/non-discrimination; structural conflict; and access to affordable health services of decent quality. These Social Determinants of Health, as developed by the WHO, have offered a valuable framework to better understand the economic, social, and political conditions that influence individual and group differences in health status/outcomes.[46] Although many of the social determinants of health are beyond the control of the individual, a growing body of research suggests many are impacted by - and fall within the reach of - the built environment.[47] It is the position of this thesis that designers ought to understand three factors from the Social Determinants of Health framework, namely, “Housing, basic amenities, and the environment”, “Social inclusion/non-discrimination”, and “Working life conditions” as factors that are impacted by the design of the built environment. Arguably, even “Education” and “Early Childhood Development” are impacted in positive ways when schools, playgrounds, neighbourhoods, daycares, and sports facilities are designed sensitively for this younger demographic. If small teams of collaborators (i.e., architects, builders, developers, and clients) are responsible for designing the built environment, then these factors are not out of the control of the individual. On small scale projects when an architect operates alone in the design phase, they have a tremendous amount of influence on these factors - and therefore the health outcomes - for those who will occupy these spaces.[48]

(May 24, 2007): 437.

46 World Health Organization, “Social Determinants of Health,” accessed September 25, 2022, https://www.who.int/health-topics/social-determinants-of-health.

47 Ann Sussman, *Cognitive Architecture: Designing for How We Respond to the Built Environment* (New York: Routledge, 2015), 88.; Davis Harte and Laura Regrut, “Programming Interior Environments, Human Experience, Health and Wellbeing,” in *Programming for Health and Wellbeing in Architecture*, ed. Keely Menezes (Routledge, 2021), 10-12.

48 Igor Vojnovic et al., “The Renewed Interest in Urban Form and Public Health: Promoting Increased Physical

We once believed the brain established its neural networks in childhood and young adulthood with little development later in life. Eloquently put by architect and multidisciplinary researcher Vernon Woodworth, "We now know that complex systems of neural pathways work constantly to process environmental and physiological information according to both learned and inherited cognitive patterns (epigenetics). We have also established that the experience of the subjective states (emotions, esteem, wellbeing) depends upon environmental triggering of built-in affective potentials within the central nervous system. Establishing the neurological basis for this phenomenon opens the door to a world where emotional engagement, productivity, and happiness are more frequently facilitated by positive environmental contexts. Learning, working, healing, and communing all have been shown to be facilitated by the environments in which they take place."[49] He remarks that in the face of these findings we can no longer justify the construction of buildings that lack appropriate neurological significance.

In one paper containing two case studies - one aimed at manipulating the behaviour of persons with neurocognitive impairment, and the other concerned with design science in the service of improved outcomes - Dr. Diana Anderson and her collaborators draw on research in medicine, neuroscience, and psychology to discuss, analyse, and make recommendations about future directions of environmental psychology and bioethics. The argument put forth is that the built environment in health care ought to be considered analogous to a medical intervention, and therefore, should be subject to the same level of ethical scrutiny. Noted is how the profession of architecture lacks the necessary research machinery to conduct long-term, project-spanning research enterprises. Recommendations for a way forward are made, including a call for more research funding to better understand the area of evidence-based design through a multidisciplinary approach.[50]

Having been met with resistance to many of his architectural and urban planning ideas, Jan Gehl has been met with resistance to his design and planning suggestions often. He notes that the cost of most urban and architectural interventions pale in comparison to the immense cost of infrastructure needed for cars. He notes that it typically always costs us more in the long run by not intervening to help people live healthier lives.[51] Research has shown there is tremendous cost saving potential from prioritizing physical activity in the built environment. In 2009, a community research project called The Vitality Project, the American Association of Retired Persons (AARP), Blue Zones, and the United Health Foundation teamed

Activity in Michigan," *Cities* 23, no. 1 (Feb 1, 2006): 10.; World Health Organization, Regional Office for Europe, *Towards More Physical Activity in Cities: Transforming Public Spaces to Promote Physical Activity – a Key Contributor to Achieving the Sustainable Development Goals in Europe,* 2017, https://apps.who.int/iris/handle/10665/345147.

49 Vernon Woodworth, "Introduction," in *Programming for Health and Wellbeing in Architecture*, ed. Keely Menezes, Pamela Oliveira-Smith, and Vernon Woodworth (Routledge, 2011), 2-3.

50 Diana C. Anderson et al., "The Bioethics of Built Space: Health Care Architecture as a Medical Intervention," *Hastings Center Report* 52, no. 2 (2022): 38-39.

51 Jan Gehl, *Urban Visionary*, 2020, https://soundcloud.com/environmentshow/jan-gehl.

up to create America's healthiest hometown by adding ten thousand years of healthy life to its residents, cumulatively. To do this, the goal was to add two years to the life expectancy of five thousand participants. The community of Albert Lea, Minnesota, a prototypical American small town, was selected for the study. Vitality Project experts worked with town leaders to transform the way residents would eat, work, exercise, and play. Residents completed surveys to establish a baseline of data, and using an online interactive tool called the Vitality Compass, measured their individual projected life expectancy based on their baseline lifestyle behaviours. New initiatives implemented in the project included educational programming, the creation of new community gardens, changing restaurant and school cafeteria menus to include healthier options, creating "walking school buses", and building new walking trails in key areas of the city.[52] Ten months later, at the conclusion of the pilot study, participants lost an average of 2.6 pounds each, reported eating more vegetables, walking more, and having fewer days with symptoms of depression. Using the Vitality Compass again, the study saw an average increase of 3.1 years of life expectancy per person. Comparing health insurance claims from 2007, 2008, and 2009, the claims in the first half of 2009 were reduced by 49% from the previous year, with mental health claims dropping 85%.[53]

Municipalities, especially in countries where healthcare is publicly funded, simply must better-understand the relationship between the built environment and health. The enormous potential for physical activity to improve lifespan, quality of life, and happiness, while reducing disease prevalence, car dependency, and healthcare spending suggests it is central in the equation of community health and overall sustainability. In countries like Canada where tax dollars are paid by all members of the community, policymakers and city councillors have a responsibility to prioritize the highest collective benefit - or return on investment - for the sustainability and viability of their city from an environmental, economic, and public health standpoint. To fulfill their fiscal responsibility to provide fair and equitable representation in investment decisions, planning departments would be wise to prioritize creating habitats – both built and natural - that nudge all demographics (i.e., all ages, ethnicities, and abilities) toward healthier lifestyles. This would set up residents up for success and give them the best chance to be effective stewards of their own health. Our healthcare costs, quality of life, economic strength, and environmental sustainability are all directly linked to community health. As the personal and national costs of living with chronic diseases continue to rise with the NCD epidemic, designers must adapt to understand the positive role they should be playing, and hence, to make use of the available evidence to inform design and treat the health and wellbeing of future generations as something we are capable, even responsible, for safeguarding.

52 Amy Tomczyk, "About the Vitality Project," *Blue Zones,* October 8, 2009, https://web.archive.org/web/20091008043656/http://www.bluezones.com/vitality-project-about.

53 Sarah Stultz, "Vitality Project Leader: 'You've Pulled It Off,'" *Albert Lea Tribune,* October 14, 2009, https://www.albertleatribune.com/2009/10/vitality-project-leader-youve-pulled-it-off/.

Chapter 3

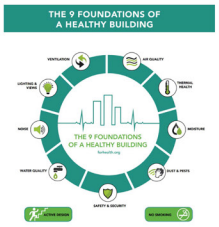
Movement Legacy Framework

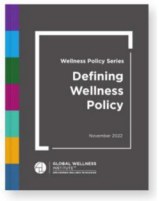
Chapter 3 Movement Legacy Framework

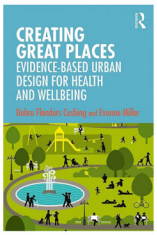
A new design framework named the Movement Legacy Framework is outlined in this chapter that specifically targets improved physical activity prevalence through a series of principles that aim to be both clearly defined and easy to apply in the real world. By translating the existing literature into a series of easily digestible design principles, the hope is for this framework to become a useful tool amongst students, architects, urbanists, public health professionals, doctors, educators, artists, city councillors, and laypeople alike.

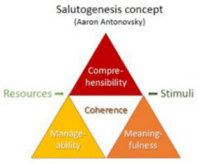
Improved physical activity was selected as the target behaviour due to its centrality in the greater health sustainability equation: it elicits a more robust list of health benefits when compared to other modifiable risk factors (i.e., diet, smoking, sleep, etc.); it is widely accessible due to low entry cost and variety of activities; it can be programmed; it is proven to benefit the health of all ages and demographics; it is measurable in a variety of ways; and it specifically combats the greatest epidemic of our time by effectively lowering risk of all NCDs. Being a universal behaviour shared across all cultures, ages, and ability level grants the framework a truly global reach that can create positive changes for health, at scale. Keeping physical activity at the centre of the framework's goals will give designers the best possible chance to affect positive physical and mental health outcomes for their specific user populations, while directly complementing environmental, social, and economic sustainability.

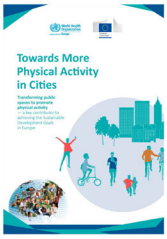
After expanding my understanding of the relevant sciences, I conducted









09 | The ten health and wellness publications that were critically analyzed as a part of the research methodology to develop the Movement Legacy Framework

a critical analysis of ten health and wellness publications (e.g., reports, frameworks, standards, etc.) that have been developed thus far. The purpose of the investigation was to analyze the similarities, strengths, and weaknesses of the existing publications. Several exciting revelations were noted, including comprehensive support for some specific design elements that can foster health in a variety of ways. Also noted was a lack of evidence-based scrutiny in many of the frameworks, particularly in the general health and wellness discourse surrounding contemporary architecture projects. The ten frameworks examined were: The WELL Building Standard;[54] HOK Wellness Framework; [55] A Visual Reference for Evidence-Based Design, by Jain Malkin;[56] Harvard's School of Public Health Report: The 9 Foundations of a Healthy Building; [57] DIALOG's Community Wellbeing Framework; [58] World Health Organization and Gehl Institute's Report for More Physical Activity in Cities; [59] The Global Wellness Institute's Wellness

54 WELL, "WELL Standard," *WELL Standard,* accessed September 26, 2022, https://v2.wellcertified.com/en/wellv2/overview.

55 HOK, "The Architecture of Well-Being,"accessed October 23, 2022, https://www.hok.com/ideas/research/the-architecture-of-well-being/.

56 Jain Malkin, *A Visual Reference for Evidence-Based Design* (Concord, CA: Center for Health Design, 2008), 8-12.

57 Joseph G. Allen, *9 Foundations of a Healthy Building* (Harvard T.H. Chan School of Public Health, 2017), 6-7. https://9foundations.forhealth.org/.

58 DIALOG, "Community Wellbeing Framework," accessed October 20, 2022, https://dialogdesign.ca/community-wellbeing-framework/.

59 World Health Organization, Regional Office for Europe, *Towards More Physical Activity in Cities: Transforming Public Spaces to Promote Physical Activity – a Key Contributor to Achieving the Sustainable Development Goals in Europe*, 2017, https://apps.who.int/iris/handle/10665/345147.

Six Pillar Approach:

***10** | An overview of the Movement Legacy Framework, highlighting three groups the six pillars fall into: Nudge Group, Destination Group, and Evidence Group*

Architecture and Design Initiative; [60] Aaron Antonovsky's development of Salutogenic Design Principles; [61] Creating Great Places, by Cushing and Miller; [62] and the Center for Health Design Framework. [63] These ten publications were analyzed using the following parameters: goals/pillars; strategies/methodology; applicable scale; outcomes/evaluation; suggestions for further development; identified challenges; and noted limitations.

Standards such as the WELL Performance Rating,[64] and DIALOG's Community Wellbeing Framework[65] are very thorough but limited in different ways. For example, due to its breadth, DIALOG's framework is weakened by attempting to account for too broad a picture of health. The WELL Performance Rating is limited by the fact it is an exclusive service/third party consultant, geared primarily towards job performance, which puts it out of reach for most who do not work at Fortune 500 companies. Jain Malkin's book outlines a comprehensive list of evidence-based design principles and strategies, but is primarily geared towards

60 Global Wellness Institute, "Wellness Architecture & Design Initiative Resources," accessed October 17, 2022, https://globalwellnessinstitute.org/initiatives/wellness-architecture-design-initiative/wellness-architecture-resources/.

61 Aaron Antonovsky, "The Behavioral Sciences and Academic Family Medicine: An Alternative View," *Family Systems Medicine* 10, no. 3 (1992): 291.

62 Debra Flanders Cushing and Evonne Miller, *Creating Great Places: Evidence-Based Urban Design for Health and Wellbeing* (Milton: Routledge, 2019), 7-13.

63 The Center for Health Design, "Topics," accessed November 9, 2022, https://www.healthdesign.org/topics.

64 WELL, "WELL Standard."

65 DIALOG, "Community Wellbeing Framework."

hospital settings for inpatient populations, and is not well-adapted for the urban or public health scales.[66] HOK's architectural framework for well-being is innovative in its scaled approach, namely, how it applies each of its six principles at two scales, first at the scale of the individual, and secondly, at the scale of the city. The inclusion of clearly defined strategies and case studies add richness and accessibility to a broad audience of designers. However, the overarching aim of the framework is to foster holistic well-being, which is difficult to define, and even more difficult to measure.[67]

The Centre for Health Design, Allen's report from Harvard's School of Public Health, and the Global Wellness Institute's wellness framework are all similar in that they highlight a very broad group of factors that can affect health. The Centre for Health Design and Allen's report are anchored in a more technical, building systems approach,[68] while the Global Wellness Institute presents a broader idea of health which includes economic impact, biophilic principles, and air pollution guidelines.[69] Research findings on factors such as lighting, heating, ventilation, air quality, infection control, noise, and thermal health are presented in the three approaches, but are not easily transferable to an urban scale for public health, nor do they highlight the importance of physical activity in maintaining good health.

The collaborative report by the Gehl Institute and WHO presents several excellent strategies for designing for health at the urban scale. Strengths of the report includes its step-by-step approach to design, detailed analyses of case studies, and its narrow focus on physical activity.[70] Limitations include its incorporation of findings from the fields of neuroscience and environmental psychology, and its applicability to the scale of the building. Both the book by Cushing and Miller and the article by Antonovsky are very well-supported by scientific literature. They present critical findings from the fields of neuroscience, salutogenetic design, coherence theory, sustainability, and prospect-refuge theory as they pertain to occupant health in the built environment.[71] Also presented are design strategies for different ages and ability levels, which allows the principles to be applied to a broader audience, an important detail for a new framework geared towards public health outcomes. A greater focus on the centrality of physical activity for its role in health, how best to incorporate the research, and suggestions specifically how to measure health outcomes would strengthen both these publications.

In contrast to these existing frameworks, the Movement Legacy Framework presents the literature in a more easily accessible manner so it may be disseminated to a broader audience. To maximize the positive impact the future built environment can have on health in as wide a variety of contexts, programs,

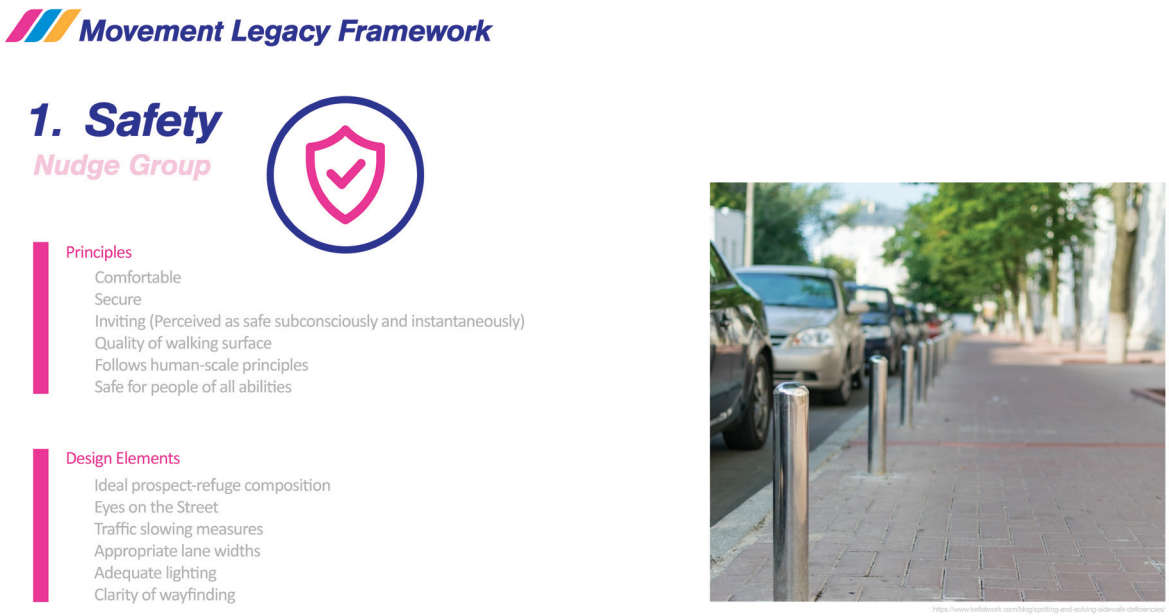
66 Malkin, *A Visual Reference for Evidence-Based Design*, 8-12.
67 HOK, "The Architecture of Well-Being."
68 The Center for Health Design, "Topics."; Allen, *9 Foundations of a Healthy Building*, 6-7.
69 Global Wellness Institute, "Wellness Architecture & Design Initiative Resources."
70 World Health Organization, Regional Office for Europe, *Towards More Physical Activity in Cities,* 10-11.
71 Cushing and Miller, *Creating Great Places: Evidence-Based Urban Design for Health and Wellbeing,* 8-12; Antonovsky, "The Behavioral Sciences and Academic Family Medicine,"291.

and scales as possible, the MLF focuses on physical activity as the most critical lifestyle behaviour for improving public health outcomes. Grounded in six pillars, the Movement Legacy Framework presents ideas and methods from several scientific disciplines, which can positively impact population health using design as the mechanism to nudge occupants towards physical activity. The six pillars were established in an iterative fashion during both the critical analysis of the existing ten frameworks and the general scientific literature review. Principles from various publications and scientific fields were consolidated based on their inherent similarities, perceived implementation/design elements, and their applicability/adaptability to a multi-scalar approach. In this way, the research was iteratively united into as few pillars as possible to simplify and strengthen the approach of the MLF. Borrowing principles from evidence-based design methodologies, salutogenic principles, 15-minute city principles, urbanist approaches from the Gehl Institute, as well as the latest neuroscience and environmental psychology findings, The Movement Legacy Framework is broad in its research base, but very pointed in its target goal: to improve physical activity rates. The six pillars (Safety, Choice, Joy, Nature, Movement, and Measurability) are explained in greater detail throughout this chapter, as are the three categories into which they are organized: The Nudge, Destination, and Evidence Groups.

The Nudge Group captures many of the research ideas and design elements which "nudge" users towards specific behaviours. The principles are primarily based in neuroscience and evolutionary biology and operate via many mechanisms that are subconscious, and often rooted in our drive to spot danger, avoid predators, and favour safer environments. The Destination Group includes those principles and elements which revolve around user experience and contribute to the excitement and staying power of a place. These principles aim to strengthen identity creation, biophilia, fun, engagement, happiness, and socialization rates. The Evidence Group comprises the pragmatic bones of the framework. Guidelines are laid out for how to specifically target physical activity behaviour change. Research planning, assessment tools, implementation suggestions, and suggested modes of recording and disseminating data are some of the steps covered. The importance of formulating a hypothesis, testing it, and building the research body over time are all highlighted.

3.1 Safety

The development of the Movement Legacy Framework began with the questions: Why do some cities have fantastic physical activity rates while others have terrible rates? What are the invisible forces creating barriers to physical activity? Can they be identified, measured, eliminated, and ultimately replaced with sensitive design elements that instead foster movement? A better understanding of the barriers to physical activity and active transportation was required, and led to research in the fields of neuroscience, evolutionary biology, active transportation, and urbanism.



11 | A summary of Pillar #1: Safety, image shows bollards between high speed traffic and pedestrian travel on a sidewalk, which improves sense of safety

Neuroscientists have studied design with increasing interest since 2002, when the Academy of Neuroscience for Architecture grew out of an American Institute of Architects (AIA) convention. Researchers who understand design are currently studying the relationship between incoming stimuli and the resulting bodily processes such as secreting hormones like cortisol, neurochemical levels including serotonin and dopamine, and how our neural pathways respond. Our brains interpret sensations and perceptions before we are even aware that this process is happening, making subliminal perception of our environment contexts both powerful and invisible.[72]

Appropriate colour and lighting choices help us subconsciously create cognitive maps (i.e., mental spatial images) to help navigate spaces. For example, the use of adequate lighting and warm colours can help to create a sense of welcome and can simultaneously assist in making wayfinding more easily perceptible. Both design moves will help users feel more comfortable in the space.[73] This is of paramount importance, as strong correlations between environmental stressors and absolute mortality rate have been shown in medical research now for decades.[74] In a related vein, high quality surfaces and infrastructure that is durable and easily accessible will create an environment that is perceived as safe by all. Sensitivity to barrier-

72 Upali Nanda, Debajyoti Pati, and Katie McCurry, "Neuroesthetics and Healthcare Design," *HERD* 2, no. 2 (2009): 131-33.

73 Keely Menezes, "Programming For People," in *Programming for Health and Wellbeing in Architecture*, ed. Keely Menezes, Pamela Oliveira-Smith, and Vernon Woodworth (Routledge, 2021), 57-60.

74 S. Samueloff and Mohamed K. Yousef, *Adaptive Physiology To Stressful Environments* (Boca Raton, FL: CRC Press, 1987), 21.

free paths of travel must be part of the designer's approach to ensure all ability levels can access and enjoy the space with equal effort and comfort.

People tend to feel safest when they are in well-defined spaces with easily perceived edges. Researcher William Holly Whyte noted changes in behaviours based on these conditions and observed that people are most likely to sit in well-defined edge locations, such as steps, walls, and ledges even if they are in the mainstream of a busy plaza. He also found that people are most likely to stand next to fixed objects such as a bollard, signpost, or statue.[75] Architect and urban design consultant Jan Gehl has observed the same patterns and refers to this concept as the edge effect.[76] Our edge-hugging tendencies are rooted in evolutionary mechanisms for ensuring our safety and survival. The research now informs us that this edge-hugging movement pattern, called thigmotaxis, is an evolutionary mechanism associated with evading predators and environmental threats, and is seen across millions of species and millions of years.[77] Prospect and refuge theory states that we prefer environments that meet a basic human psychological need for both opportunities, where we can survey the surroundings, and safety, where one's back is secure.[78]

3.2 Choice

Having choices in life is a fundamental element of freedom that should be designed into all spaces for human occupancy. Nobody feels safe, comfortable, or excited to spend their time moving through a space with only one possible experience or outcome. By providing a variety of options for users to engage with a space, designers can infuse several essential ingredients that make the user experience more enjoyable and improves the chances of people returning. Choice is especially important for children who are more likely to want to move through a space when there are numerous opportunities for exploration and engagement.

Projects that include multiple occupancy types within close proximity, such as a mall that has both shops and restaurants, can certainly offer different user experiences on subsequent visits. However, a built environment that provides multiple options for often neglected design elements such as circulation, seating, and views, can offer users exponentially more combinations of unique experiences, and often at a fraction of what additional programming would cost. Opportunities to see new areas of a building or urban space, move through it in a new way, and sit where you might meet new people, can draw people back to a space that would otherwise feel exhausted of all opportunity after only one visit.

75 William H. Whyte, *The Social Life of Small Urban Spaces* (Washington, D.C: Conservation Foundation, 1980), 34.

76 Jan Gehl, *Cities for People* (Washington, DC: Island Press, 2010), 137.

77 Ann Sussman, *Cognitive Architecture: Designing for How We Respond to the Built Environment* (New York: Routledge, 2015), 20-22.

78 Jay Appleton, *The Experience of Landscape*, (Chichester ; Wiley, 1996), 58-62.

12 | A summary of Pillar #2: Choice, image shows a bifurcating park path, a design element that piques curiosity, provides opportunity for additional experiences, and improves the likelihood of users staying longer and also coming back

Our sensory apparatus and systems for interpreting sensory impressions are adapted to walking. When we walk at our usual speed of 4 to 5 km/h, we have time to see what is happening before us in great detail, but at the speed of a car, about 60 km/h, we cannot perceive these details. What's worse, since the introduction of the automobile as our primary means of transportation, we have started to design our cities for this speed, creating vast areas with little to no visual interest for those moving on foot. Without adequate visual stimuli and urban life designed for the speed of walking, streets and spaces seem much longer, become boring, and feel unsafe, effectively eliminating walking as one of the viable choices to navigate a city.[79] By contrast, designing with an understanding of prospect and refuge theory, we have the means to understand the proportions of the built environment that can succeed in providing this space for occupants, which in turn, encourages people to stay longer, supports unprogrammed activities, and allows for unexpected interactions between people and the space, which are all signs of a successfully designed project.[80]

79 Gehl, *Cities for People,* 97-101.
80 Appleton, *The Experience of Landscape*, 62.

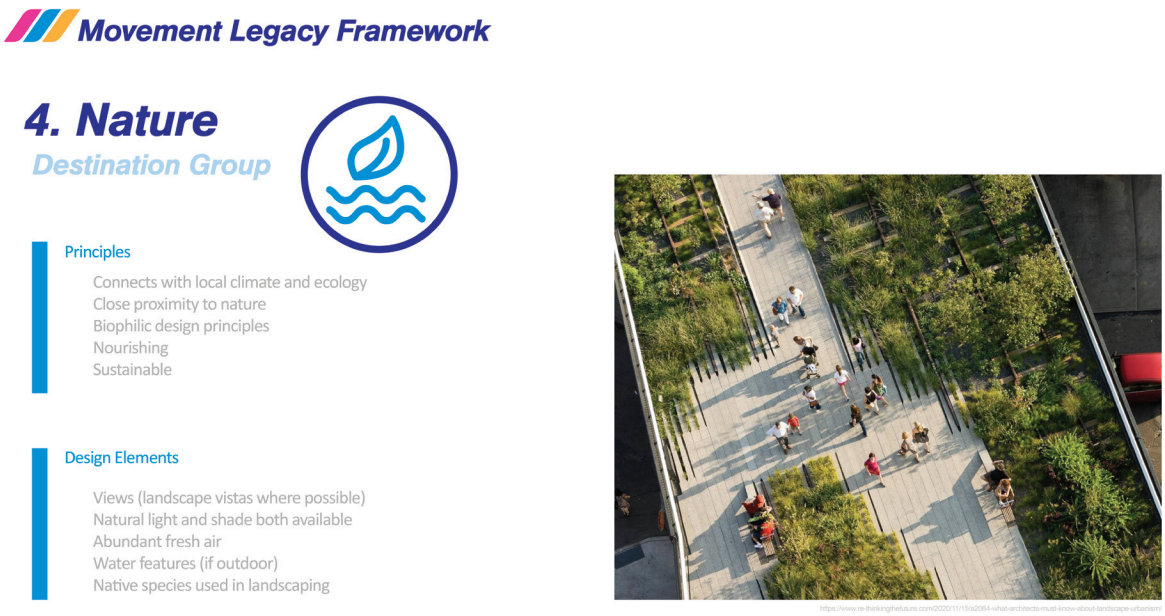
3.3 Joy

Joy can come from a wide variety of sources including receiving a letter or a phone call from an old friend, spending time with our pets, or playing and laughing with our favourite people. Researchers have long been interested in the ways that our environment is related to our thoughts, moods, and behaviours, or more simply, our psychology. Environmental psychology investigates and considers the interactions between people and their environments. Take for example your experience in the morning in your kitchen. You might wake up eager for the day excited for that first cup of coffee, but when you arrive in your kitchen it is disorganized in such a way that you can't find the coffee filters, the mugs are all dirty, and you stepped in a puddle of water in your socks. Your original feelings of eagerness and optimism about the day can be quickly transformed to a negative state of mind by stimuli in your environment. Our biology interacts with our environment and vice versa, and is layered with conditioning, identity construction, cultural meaning, and expectation.[81] To understand this complex relationship, designers must appreciate that stimuli in the built environment affects our behaviours, thoughts, and emotional states.[82]

We use colour to perceive and judge space, and to obtain behavioural cues. Dark interiors can hint that we should be quiet and calm, while coloured signage

81 Robert S. Tullis, "Placemaking: Programming Urbanism for Human Engagement," in *Programming for Health and Wellbeing in Architecture*, ed. Keely Menezes, Pamela Oliveira-Smith, and Vernon Woodworth (Routledge, 2021), 120-22.

82 Dak Kopec, *Environmental Psychology for Design* (New York: Fairchild Books, 2018), 31-32.



beckons our attention and instructs us. Colours can also impact our emotions and alter our mood. Joy is closely linked to excitement, and excitement is often associated with new or authentic experiences. Designing in such a way as to foster new and unique experiences for users should be a top priority for spreading joy. The use of colour can be a strategy for establishing conceptual and symbolic meaning for a place which can help establish a unique identity. The prevailing character or atmosphere of a place, or genius loci, is tied to its naturally occurring phenomena such as climate and geology, as well as to the cultural narrative and social imperatives. Designing with the intention of highlighting what is unique and beautiful about the site's ecology, its people, its history, and its unique place in the world are important for making spaces we can identify with, be excited about, and experience joy in.[83]

Socialization is fundamental to happiness, and as a social species who spend most of their time in the built environment, we need public spaces that are conducive to enjoying each other's company. Whether meeting up with a long-time friend, serendipitously getting to know a stranger, or simply watching a group of people throw a frisbee in the park, we are wired to want genuine community experiences, and crave a sense of belonging. To feel our best, we need opportunities to comfortably walk, sit, converse, dine, shop, and play in the urban public realm.[84]

***13 | opposite top,** A summary of Pillar #3: Joy, image shows pedestrians relaxing on a public bench that establishes genius loci with implementation of unique tile work from broken ceramics from community members in the specific Barcelona neighbourhood*

***14 | above,** A summary of Pillar #4: Nature, image shows pedestrians walking down a path with integrated green softscaping which is proven to have many health benefits including lowered stress and improved cognitive function*

83 Kopec, *Environmental Psychology for Design*, 142.
84 Tullis, "Placemaking: Programming Urbanism for Human Engagement", 110-112.

3.4 Nature

Research shows that our experience of the natural world can have a wide range of healing effects. Our species has co-evolved in relationship to the intricate and visually stimulating fabric of nature, so to fully comprehend the intricacies of the human species, we must be studied within the context of our environment.[85] In evaluating responses to environmental stimuli, researchers have found that our sensory experiences of natural environments impact our physiological responses, heart rate, blood pressure, galvanic skin response, and autonomous responses of the central nervous system. Resoundingly, the effects have been found to be positive in these domains, including reduced stress levels, improved creativity, improved short term memory and cognitive function, enhanced immune function, improved mood, decreased diastolic blood pressure and heart rate, and increased likelihood of physical activity.[86]

From a sustainability standpoint, pillar 4 is one of the most important in the framework. In their study on "The Economics of Biophilia", consulting firm Terrapin Bright Green determined that productivity costs relating to employees are on average 112 times greater than energy costs in the workplace. They concluded that business plans should account for the fact that increased productivity and employee satisfaction are associated with introducing elements of nature into the workplace from the outset of a project.[87] Further, they claim that in the $2.5 trillion healthcare industry in the US, simply increasing views from hospital beds to nature could yield over $93 million in annual savings nationwide as patients require less time in hospitals to recover from major surgery when they have a view to greenspace.[88]

Including more natural elements in architectural and urban design strategies further supports sustainability in two direct ways. First, we are healthier in them, and are more likely to include physical activity as part of a regular routine when we have parks, trails, and even small green interventions included in our built environments. Second, those built environments that reflect biophilic principles are conceived as extensions of our own biology and our ecosystem, elevating our awareness of environmental concerns, and compelling us to become stewards for them against wear, tear, and replacement.[89] Those natural features that are most

85 Vernon Woodworth, "Biophilia and Human Health," in *Programming for Health and Wellbeing in Architecture*, ed. Keely Menezes, Pamela Oliveira-Smith, and Vernon Woodworth (Routledge, 2021), 25.

86 Jie Yin et al., "Effects of Biophilic Interventions in Office on Stress Reaction and Cognitive Function: A Randomized Crossover Study in Virtual Reality," *Indoor Air* 29, no. 6 (2019): 1038-39.; Davis Harte, "Stress," in *Programming for Health and Wellbeing in Architecture*, ed. Keely Menezes, Pamela Oliveira-Smith, and Vernon Woodworth (Routledge, 2021), 42-44.; Jie Yin et al., "Physiological and Cognitive Performance of Exposure to Biophilic Indoor Environment," *Building and Environment* 132 (2018): 261-62.; Chanuki Illushka Seresinhe et al., "Happiness Is Greater in More Scenic Locations," *Scientific Reports* 9, no. 1 (2019), https://doi.org/10.1038/s41598-019-40854-6.

87 William D. Browning et al., "The Economics of Biophilia - Why Designing with Nature in Mind Makes Financial Sense," *Terrapin Bright Green*, 2015, https://www.lbhf.gov.uk/sites/default/files/section_attachments/the_economics_of_biophilia_-_why_designing_with_nature_in_mind_makes_financial_sense.pdf.

88 Browning et al., "The Economics of Biophilia - Why Designing with Nature in Mind Makes Financial Sense."

89 Nikos A Salingaros, "The Biophilic Index Predicts Healing Effects of the Built Environment," *Journal of Biour-*

15 | above, *A summary of Pillar #5: Movement, image shows a pedestrian bridge that makes walking and cycling a more pleasant experience than traveling by car*

unique to a place can also be used in design to fortify the character of a place, and contribute to regional pride and identity. Becoming truly sustainable in all domains is a complicated issue, but perhaps as we reintegrate nature into our built environment and receive the physiological and homeostatic benefits, we can recover our collective appreciation of our ecology and move closer to balance on larger scales to include our entire biosphere, on which all life depends.

3.5 Movement

Movement is the fifth and most important pillar with respect to the site selection process. Applying this pillar properly will demand an understanding of the previous four pillars. Designers must conduct thorough site analysis to accurately identify all the gaps in, and barriers to, the active transportation network. As will be explained throughout this chapter, there are several factors that can help to facilitate physical activity at a variety of scales, but the continuity of movement networks is the most important factor in this equation. People simply cannot move efficiently and will not move consistently through a city if the trails, sidewalks, pedestrian bridges, bike lanes, and other active transportation networks are fragmented, unsafe, unappealing, or non-existent.

To ensure movement is prioritized in design projects, the site analysis must include mapping exercises of existing and anticipated active transportation networks.

banism 8, no. 1 (2019): 14.

A review of municipal planning documents should be conducted to better understand the existing networks of multi-use trails, bike lanes and cycle tracks, sidewalks, crosswalks, and then cross-referenced with site visits to ensure what's captured in municipal planning documents as completed projects has in fact been built. Similarly, municipalities should be as clear and accurate as possible in city planning documents with respect to whether projects are proposed, approved, under construction, or complete. Using the lens of the entire MLF, designers should further be able to identify elements of the site that affect the likelihood of physical activity, both positively and negatively. The aim should be for a thorough inventory of site features to be identified, as described in pillars 1 through 5. For example, identified factors affecting physical activity might include aspects of safety such as poor lighting quality. Aspects of choice would include the lack of nearby programming, aspects of joy could possibly include a nearby popular park, and aspects of nature might look like a beautiful view to a lake. As designers analyze more sites and precedents through the lens of the MLF, they will develop their own skillset and critical eye for how the pillars are exhibited in the natural and built environment. Another way for designers to develop this sense is by carefully observing human movement patterns in everyday contexts, with the added impetus to question why the observed movement patterns and behaviours are the way they are combined with an openness to look to the research for answers.

In light of our current epidemic of noncommunicable diseases, there is a need for novel ways to increase opportunities for regular physical activity. These can include commuting, focused exercise, play, and pairing movement with socializing among others, and we should endeavour to make them as seamless and ordinary a part of our everyday environments and routines as possible. Paying attention to how the psychological experience of a place can alter our behaviours has helped researchers better understand motivations for physical activity in cities, and design more appropriately for these positive affects.[90]

A study conducted in Darmstadt, Germany revealed that good street connectivity (i.e., accessibility and walkability) was significantly associated with reduced stress, highlighting the importance of ensuring sidewalks, trails, paths, etc., are well connected. Visual complexity (i.e., higher levels of detail and interest in architectural facades) was also significantly related to reduced stress.[91] In another study, abdominally obese women receiving behavioural support using the Transtheoretical Model for Behaviour Change approach were shown to increase long-term physical activity levels. Participants were observed to change commuting habits from driving to active transportation means such as cycling and walking when infrastructure allowed for it.[92]

90 Jenny Roe, *Restorative Cities: Urban Design for Mental Health and Wellbeing* (London: Bloomsbury Visual Arts, 2021), 126.

91 Martin Knöll et al., "Public Space and Pedestrian Stress Perception: Insights from Darmstadt, Germany," in *Handbook of Global Urban Health*, eds. Igor Vojnovic, et al. (New York: Routledge, 2019), 280-82.

92 E. Hemmingsson et al., "Increased Physical Activity in Abdominally Obese Women through Support for Changed Commuting Habits: A Randomized Clinical Trial," *International Journal of Obesity* 33, no. 6 (June

3.6 Measurability

16 | A summary of Pillar #6: Measurability, image shows a post-occupancy tool counting how many cyclists are using a bike lane, a powerful tool for building a research case for future projects

The intention for The Movement Legacy Framework is to to remain flexible and as open to change as possible. One measure of success for the framework will be in its dissemination, as well as its receptivity of multidisciplinary collaboration, so that as new research is published, it can continue to follow current and future best practice, supported by evidence. The hard data supporting better health outcomes should be prominent in contemporary discourse throughout the profession, and our familiarity with the medical and physiological vocabulary should be developed to better connect design interventions to specific research. These medical and neuroscientific findings must be prioritized in architectural education and practice in specific, measurable ways.

The steps outlined in pillar 6 provide the steps for a comprehensive research plan methodology to ensure each project that utilizes the Movement Legacy Framework is adequately conceived with supporting research, and that it is hypothesized, recorded, documented, measured, analyzed, and shared. Doing so will ensure that findings from each subsequent project can be easily added to the research base, gradually expanding the knowledge around physical activity and the built environment.

Following the well-established model from evidence-based design, projects

2009): 650-52.

should establish a research plan with the following steps[93]:

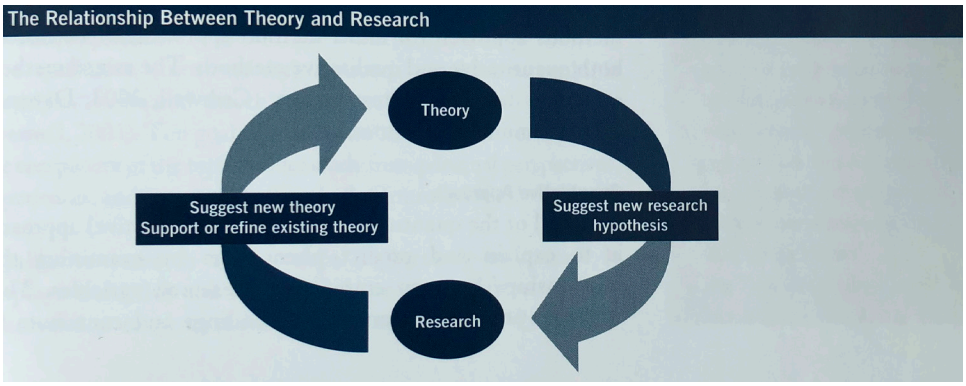
- Define evidence-based goals and objectives
- Find sources for relevant evidence
- Critically interpret relevant evidence
- Create and innovate evidence-based design concepts
- Develop a hypothesis
- Collect baseline performance measures
- Monitor implementation of design and construction
- Measure post-occupancy performance results

For larger projects, it can be important to have an interdisciplinary project team right from the conceptual design phase, all the way through to construction. Having multiple perspectives and expertise can be complementary and can help ensure the program and design goals are appropriate and do not leave any particular party out. Maintaining records will also be important throughout all design phases, including all drawings, sketches, annotated diagrams, and meeting minutes, and should be archived safely for later reference.[94]

A Post-Occupancy Evaluation (POE) is the study of a building once people are using it to address the successes and failures of design decisions. Evaluations can occur at various scales, from reviewing the effectiveness of a single piece of millwork to analyzing a master plan. Different from architectural criticism methodology which employs subjective and historical perspectives, POE gathers data systematically. These results are particularly valuable to designers because they become the data which is easily understood and readily applied to future design projects. POE is most accurate after six months of occupancy, after occupants have settled in and facilities have worked out kinks. Another POE at the 5-year mark typically yields valuable new information about whether the building continues to meet the expectations of the design and if it sustained the initial findings from the 6-month POE.[95]

It is important to appropriately select what should be measured. To accomplish this, a POE should follow a research plan that relates to studying the specific goals that were set out at the beginning of the planning and design phase of the project. A research plan ideally should include a collection of research studies/precedents, objectives, hypotheses, baseline data, outcome variables, and metrics. Objectives of the POE include the provision of feedback to the original design teams. This information can generate new knowledge and help to support future designs. If issues are uncovered in the POE, designers can seek clarification about how and why the problems arose. Closing this feedback loop between designer and end user will gradually improve the skillset of designers, improve designer-client

93 Tom McLaughlin and Vic Gephart, *Integrating Evidence-Based Design: Practicing the Healthcare Design Process*, 2nd edition (Concord, CA: The Center for Health Design, 2009), 2.
94 McLaughlin and Gephart, *Integrating Evidence-Based Design*, 122.
95 McLaughlin and Gephart, *Integrating Evidence-Based Design*, 123.



17 | Feedback loop relationship between theory and research, as per evidence-based design study handbook

relationships, and enhance practitioner credibility. Moving forward, designers will be able to make faster and better justified decisions during conceptual and schematic phases of design.

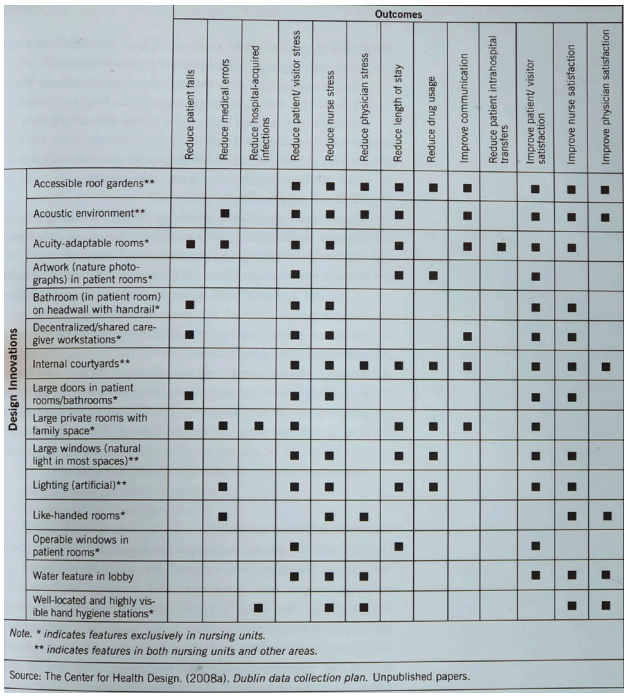
POE methodology can include (qualitative and/or quantitative)[96]:

- Observation
- Interviews
  - Focus groups
  - Unstructured
  - Utilizing existing data
  - Structured
  - Telephone
- Rating scale
- Questionnaire survey
- Drawings
- Documents
- Measuring:
  - Sound
  - Rates
  - Light
  - Traffic
  - Speeds
- Happiness (rating scale)
- Visits
- Users
  - Life expectancy (Vitality Compass online interactive tool)
  - Health data from apps, sleep quality trackers, Strava, etc.
- Expert experiential knowledge
- User experiential knowledge
- Transactions

As we are becoming a more urban society, with now over 50% of the planet's population living in cities, the significance of the relationship between built environment and our health presents critically important questions for architects. We are largely responsible for designing the built environment, where last year, Americans and Canadians spent 87% of their time,[97] and yet our collective

96 Xiaobo Quan, Lyn Geboy, and Rachael Ginsberg, *Building the Evidence Base: Understanding Research in Healthcare Design* (Concord, CA: The Center for Health Design, 2018), 23.

97 N. E. Klepeis et al., "The National Human Activity Pattern Survey (NHAPS): A Resource for Assessing Exposure to Environmental Pollutants," *Journal of Exposure Analysis and Environmental Epidemiology* 11, no. 3



Design Innovations	Outcomes: Reduce patient falls	Reduce medical errors	Reduce hospital-acquired infections	Reduce patient/ visitor stress	Reduce nurse stress	Reduce physician stress	Reduce length of stay	Reduce drug usage	Improve communication	Reduce patient intrahospital transfers	Improve patient/ visitor satisfaction	Improve nurse satisfaction	Improve physician satisfaction
Accessible roof gardens**				■	■	■	■	■	■		■	■	■
Acoustic environment**		■		■	■	■	■		■		■	■	■
Acuity-adaptable rooms*	■	■		■	■		■		■	■	■	■	
Artwork (nature photographs) in patient rooms*				■			■	■			■		
Bathroom (in patient room) on headwall with handrail*	■			■	■						■	■	
Decentralized/shared caregiver workstations*	■			■	■				■		■	■	
Internal courtyards**				■	■	■	■	■	■		■	■	■
Large doors in patient rooms/bathrooms*	■			■	■						■	■	
Large private rooms with family space*	■	■	■	■			■	■	■		■		
Large windows (natural light in most spaces)**				■	■		■	■			■	■	
Lighting (artificial)**		■		■	■		■	■			■	■	
Like-handed rooms*		■			■	■						■	■
Operable windows in patient rooms*				■			■				■		
Water feature in lobby				■	■	■					■	■	■
Well-located and highly visible hand hygiene stations*			■		■	■						■	■

Note. * *indicates features exclusively in nursing units.*
** *indicates features in both nursing units and other areas.*

Source: The Center for Health Design. (2008a). *Dublin data collection plan.* Unpublished papers.

familiarity with leading medical and scientific evidence is sorely lacking. Closing the gap between the growing body of medical research outlining our body's response to our environment and the architectural understanding of these concepts should be a priority for both the medical and architecture fields. Over time, this approach will yield a more robust set of specific design elements, each supported by specific evidence articulating its positive affect on physical activity rates. Once a critical mass of understanding is achieved in the design community, designing for healthy lifestyle change will become a new frontier for creativity in a similar way to how environmental sustainability has bred tremendous innovation in the creative community. In this way, it is truly impossible to imagine how the beautiful and bold designs of the future will look until we begin the collective journey as a profession to explore the unique ways site, culture, user group, and program can inspire novel ways to nudge us towards moving our bodies. With consistent efforts at scale, architects will be able to both effectively and beautifully design for physical activity, taking advantage of one of the best-known and most widely accessible means to reduce mortality rate, and ultimately step into their responsibility for public health and wellbeing.[98]

***18 | above,** An example of a research tool according to evidence-based design research plan whereby outcomes are organized and predicted based on previous*

***19 | opposite, top,** The future intentions for the Movement Legacy Framework beyond the scope of this thesis.*

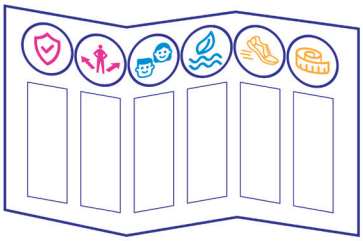
(June 2001): 251–52.

98 Igor Vojnovic et al., "The Renewed Interest in Urban Form and Public Health: Promoting Increased Physical Activity in Michigan," *Cities 23, no. 1 (Feb 1, 2006):* 17; Patricia P. Katz and Russell Pate, "Exercise as Medicine," *Annals of Internal Medicine 165, no. 12 (December 20, 2016):* 880.

Movement Legacy Framework

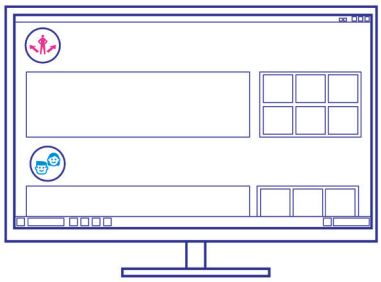
Future Intentions:

Summary Brochure



- A succinct summary of key findings and actionable design moves.
- For cheap and fast dissemination of information
- Includes imagery of great precedents
- Provides step by step approach to implementation
- To be shared with design community, municipalities, students, etc.

Website



- More robust version of the brochure, including hyperlinks to research
- Contact information, discussion forums
- Tool for sharing inspiring work that focuses on physical activity
- Tool for reaching other disciplines, encouraging research collaboration

3.7 Future Intentions

The post-graduation intentions for the Movement Legacy Framework are to package it in two interrelated formats. First, an open-access summary brochure will provide research highlights and a step-by-step guide to designing using the six pillars. Aiming to be accessible to as broad an audience as possible, the brochure will be a concise document, easily downloadable and printable from the website for physical distribution. Second is the interactive website that will serve as a robust platform for defining the pillars in greater depth, compiling precedents, and exchanging ideas with other disciplines, researchers, and designers, thereby establishing a collaborative community. Combined, the two resources will effectively disseminate the information where it can be used as an educational tool at architectural schools worldwide, a design tool for architects and urban planners, an advocacy tool to create a more informed voting public, and a bargaining tool in discussions with clients, policymakers, and municipalities.

3.8 Precedent Study

An analysis of precedents helped to uncover several ways the pillars of the MLF meet the ground as tangible design elements. A project by Dissing + Weitling in Copenhagen offers an elevated cycling path over a wharf area. This award-winning urbanism project creates a lively new public space that was previously difficult to negotiate, and lacked life. Bright colours, gentler gradients, and more efficient travel options improve ease of physical activity across the site, all while providing a fun experience of the harbour for all demographics.[99]

The bold use of colour along circulation paths in the BasketBar project in The Netherlands brings excitement to the site, emphasizes the active transportation areas, and makes the project stand out from the neighbouring urban fabric. Its unique combination of restaurant, bookshop, seating area, and elevated basketball court creates a new dynamic on the site whereby demographics of users who might not normally interact with each other might now be able to observe one another, chat, and establish new relationships, all while being physically active.[100]

A sauna project in Helsinki by Avanto Architects revitalizes what was an industrial port area of the city. Combining a restaurant, public sauna, and a climbable roof with terraces, the project adds a richness to the urban fabric where previously there was a void. This project brings users to the site in all seasons, and acts as a catalyst for physical activity along the shoreline in either direction.[101]

20 | opposite top, *Case Study: Bicycle Snake, an active transportation path project in Copenhagen.*

21 | opposite bottom, *Case Study: Bicycle Snake with design elements highlighted in context of Movement Legacy Framework.*

99 Dissing + Weitling, "Bicycle Snake," accessed April 3, 2023, https://dissingweitling.com/en/project/bicycle-snake.

100 NL Architects, "Basket Bar," accessed May 6, 2023, http://www.nlarchitects.nl/slideshow/92/.

101 ArchDaily, "Löyly / Avanto Architects," June 30, 2016, https://www.archdaily.com/790432/loyly-avanto-architects.

Case Study 1

Bicycle Snake

Copenhagen, Denmark

Dissing + Weitling

2010

An award winning urbanism project which pulls together a wharf area of previously incoherent public spaces and buildings. Bright colours, gentler gradients, and better curvature improve fluidity of movement through space, all while providing a joyful experience of the harbour. The Bicycle Snake has become an icon for Copenhagen's status as the world's leading bicycle city and a symbol of the city's praised urban qualities.

New perspective/experience of the oceanfront

Eyes on the street

Many ways to experience the space

Engaging for all ages. Family bonding

Size/scale and program prioritizes PA

(Not clear how usage is measured)

"Israels Plads Square / Cobe + Sweco Architects | ArchDaily." Accessed December 5, 2022. https://www.archdaily.com/880388/israels-plads-square-cobe.

Case Study 2

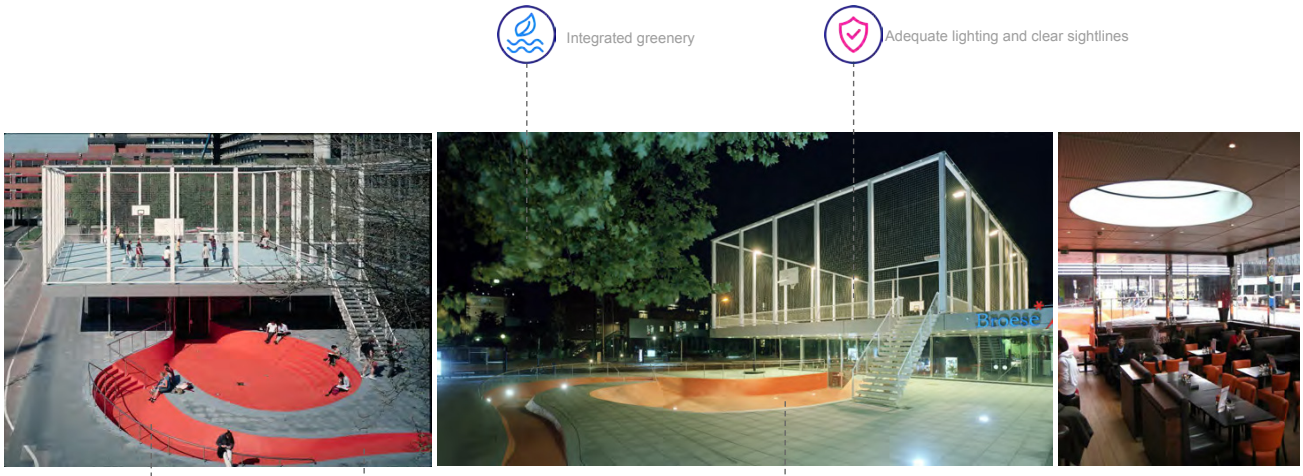
Basket Bar

Utrecht, Netherlands

NL Architects

2003

Basket Bar incorporates a restaurant, a bookshop, and outdoor seating area with a basketball court raised on a plinth. The sunken ‘orange pool’ is both an accessible ramp and skateboarding feature. This project encourages the co-mingling of individuals with varying physical abilities. The sunken glass volume supports the basketball court, which is surrounded by steel architectural mesh. The half court features a circular glass floor that visually connects the court with the restaurant and bar below.



Luuk Kramer, *Basket Bar*, 2003, Photograph, Utretcht, http://www.nlarchitects.nl/slideshow/92/

22 | top, *Case Study: Basket Bar, a project which combines a basketball court and restaurant in The Netherlands*

23 | above, *Case Study: Basket Bar, with design elements are highlighted in context of Movvement Legacy Framework.*

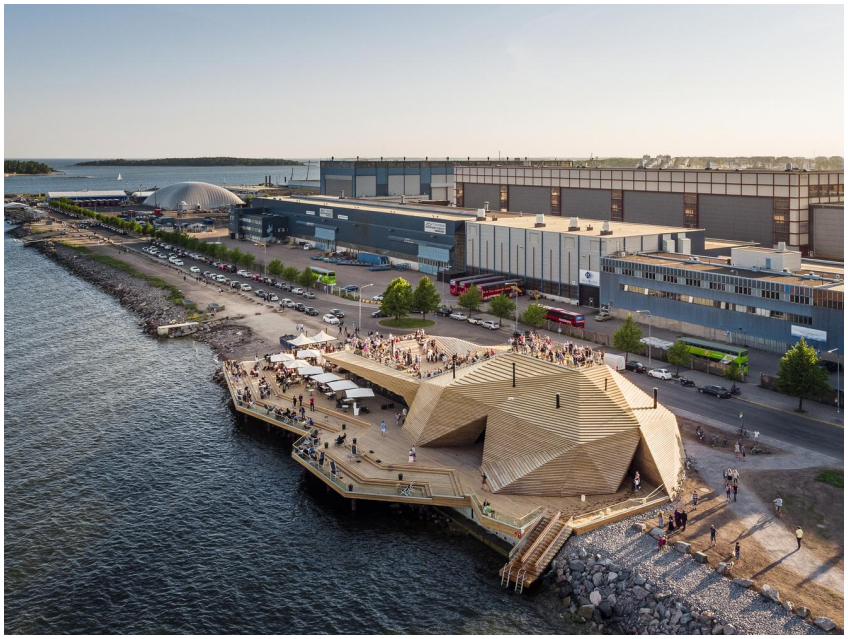
Case Study 3

Loyly

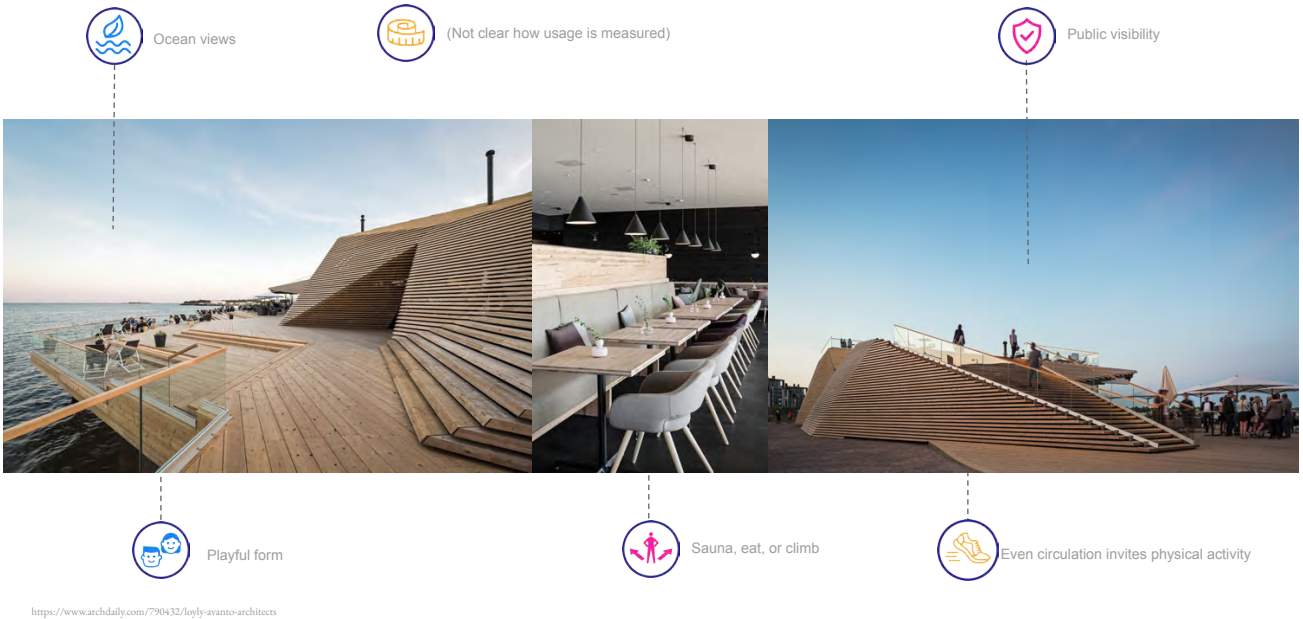
Helsinki, Finland

Avanto Architects

2016



Revitalizing what was an industrial portland area of Helsinki, the Loyly public sauna project breathes new life into the seaside area as it transitions into a residential area. A restaurant, and a unique roof which allows occupants to climb on top of the building differentiate this sauna from others, making it a truly public space, with many surprises.



https://www.archdaily.com/790432/loyly-avanto-architects

***24 | top,** Case Study: Loyly, a sauna and restaurant project from Helsinki, Finland.*

***25 | above,** Case Study: Loyly with design elements are highlighted in context of Movement Legacy Framework.*

Chapter 4

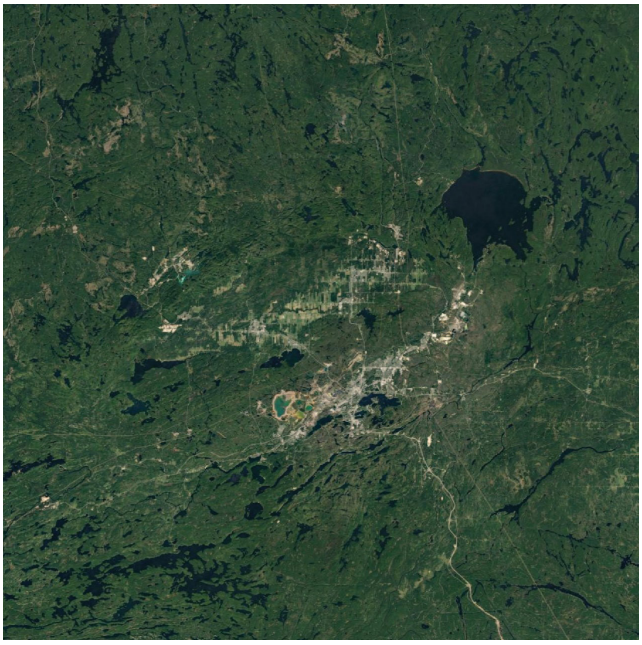
Obesity Capital of Canada

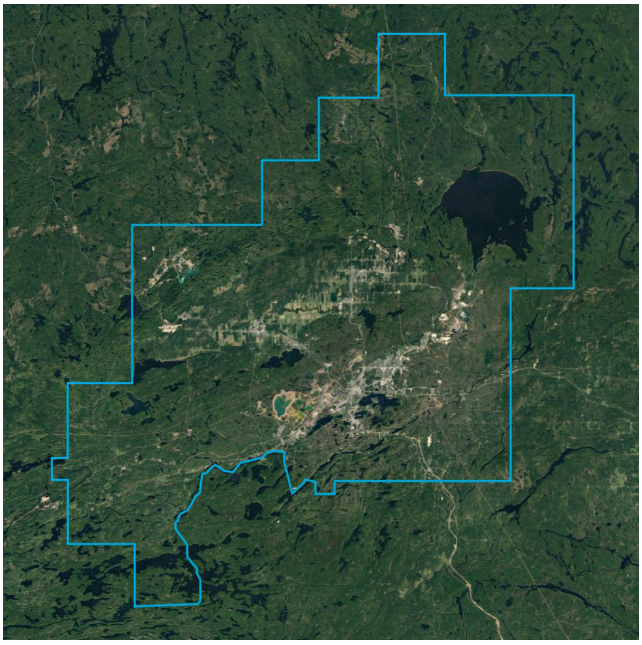
Chapter 4 Obesity Capital of Canada

This chapter provides historical and industrial context for Sudbury, Ontario. Its unique identity as a regional capital is explored and compared to nearby capital cities. By analyzing the dictating forces in its urban fabric creation, clues about where Sudbury's barriers to movement exist are uncovered. A brief history of Sudbury, a mapping exercise, demographic research, and a critique of city planning documents relating to health and/or the downtown core are presented.

4.1 An Industrial Urban Fabric

In the one hundred and fifty years since its inception as a mining outpost, Sudbury has developed into a small city of about 165,000 residents, and a regional capital of Northern Ontario. Its unique geology and topography, the very feature that elevated its standing as a resource-rich mining community, have unfortunately been the dictating forces in its urban development and planning - or lack thereof. The result is a tremendously low population density spread across the second largest municipality in Canada. The constellation of small towns responds to these factors, organized around key mine access points, train stations, and related mining infrastructure. The downtown core is no different, its twisted urban fabric emblematic of the patchwork of mining, railways, rocky outcrops, and lakes that came before. Creating further challenges to active transportation, and movement in general, is how the urban fabric of the downtown core is torn apart by several train tracks, fences, busy streets, as well as a large railyard in the center of town. The majority of Sudburians use personal vehicles as their primary means of transportation, and it is difficult to fault them for it. Parking lots are prioritized, while trails, boardwalks, cycle paths, and bike lanes are limited, and not contiguous enough to provide a viable means of transportation for most of the city's neighbourhoods. What's more, according to the most recent census data, Sudburians scored worse than the national average in three important





26 | Industrial prioritization: showing the response by the built environment, small towns, roads, rail, and mines to the natural geological formation, and ore deposits, of the Sudbury basin

27 | Sudbury the regional capital, great in area, but small in population when compared to Toronto and Ottawa

categories: Body Mass Index (overweight), Body Mass Index (obese), and Physical Activity Levels (150 minutes minimum).[102] With a new mayor and city council as of Fall 2022, as well as many champions in the cycling community, positive changes are on the horizon, but until they arrive, Sudbury provides a perfect test case for a new design framework for healthy active lifestyle change.

4.2 City Planning Documents

A comprehensive report outlining the state of affairs of all City-owned infrastructure in the categories of parks, open space, and leisure facilities was published in 2014. Included are such facilities as arenas, pools, soccer fields, trails, parkland, ski hills, dog parks, etc. The report conducted an exhaustive inventory of usage rates, demographic data, driving distance from, barriers to, and other such factors, and represented this information graphically throughout

102 Government of Canada, Statistics Canada, "Census Profile, 2016 Census - Greater Sudbury [Census Metropolitan Area], Ontario and Canada [Country]," February 8, 2017, https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CMACA&Code1=580&Geo2=PR&Code2=01&SearchText=Canada&SearchType=Begins&SearchPR=01&B1=All&TABID=1&type=0.

28 | A closer look at the urban fabric responding to mining, geology, lakes, and rail influences

the report. While this is necessary and helpful for understanding the situation for recreational and leisure infrastructure in Sudbury, the report is limited in its understanding and suggestions for future directions. There are 51 references to design issues/suggestions throughout the document, suggesting an awareness of the importance of design, but there is no informed framework to facilitate best practice. The concepts of urbanism and evidence-based design are not mentioned in the report.[103] Another report named "A New Vision for Downtown Sudbury" lays out ten guiding principles for a revitalized downtown. A short history of developments and initiatives is given, followed by a vision for an improved downtown which would see the development of: arts and culture; tourism; heritage preservation; innovative design; and environmental sustainability. The document makes no reference to physical activity or exercise.[104]

Two other documents published by the City of Greater Sudbury, both in 2018, aim

103 City of Greater Sudbury, *Parks, Open Space & Leisure: Master Plan Review,* June 2014, https://www.greatersudbury.ca/linkservid/71BB45BE-F9B0-D8D3-7E87CEDBDA48FC79/showMeta/0/%20Review/.

104 City of Greater Sudbury, *A New Vision for Downtown Sudbury: Guiding Principles, Strategies, Projects, and Programs,* December 14, 2005, https://www.greatersudbury.ca/linkservid/40919E1B-A4A9-F817-143C9C71D16AC491/showMeta/0/.

	Sudbury	% of pop.		Canada	% of pop.
Total population	164,689			35,151,728	
Perceived health, very good or excellent	90,400	55%		19,005,600	54%
Perceived health, fair or poor	21,900	13%		3,476,400	10%
Perceived mental health, very good or excellent	98,100	60%		21,008,600	60%
Perceived mental health, fair or poor	15,800	10%		2,235,700	6%
Body mass index, adjusted self-reporting, adult, overweight	**47,800**	**29%**	**+1%**	**9,783,000**	**28%**
Body mass index, adjusted self-reporting, adult, obese	**47,700**	**29%**	**+8%**	**7,284,000**	**21%**
Self-reported physical activity, 150 minutes per week, adult	**68,500**	**42%**	**-4%**	**15,957,400**	**46%**
Life satisfaction, satisfied or very satisfied	143,400	87%		28,074,500	79.87%
Has a regular health care provider	148,400	90%		26,364,300	75.00%

to define the issues and outline strategies towards a healthier population. The first aims to establish a ten-priority framework for public health in Sudbury by establishing an upstream strategy, whereby efforts are proactive through public policy and prevention, establishing a clear priority on the individual's well-being, with population health being considered with the more upstream approaches. The ten population health priorities include Indigenous youth, resiliency, families, mental health, compassionate city, play opportunities, housing, holistic health, age-friendly strategies, and healthy streets. In the 24-page document, exercise is mentioned only once, while physical activity, obesity, cardiovascular disease, and evidence-based design are not mentioned at all.[105] The second report represents the city's plan to address the health, safety, and well-being of the community.[106] The city's Population Health, Safety and Well-Being Advisory Panel was established as a result of this report. Consisting of 26 individuals including city staff, councillors, community representatives, social services staff, educational leaders, and health experts, the panel has shared data and other evidence needed to inform the actions and advise what the current needs of Sudbury are to ensure citizens' safety and well-being. While correctly identifying mental health, addictions, affordable housing, social isolation, and lack of programs as contributing factors to a sub-optimal overall urban population health, the report is limited. Not once in this 44-page document are the terms exercise, physical activity, cardiovascular disease, evidence-based design, or obesity mentioned,[107] all of which are critical to understanding and measuring the broader picture of public health.

29 | above, *Compiled census data comparison between Sudbury and Canada on several health metrics, with overweight, obesity, and physical activity rates highlighted*

30 | opposite top, *World Health Organization report for more physical activity in cities, and Sudbury's response to it*

31 | opposite bottom, *An analysis of a collection of Greater City of Sudbury planning documents*

105 City of Greater Sudbury, *Population Health: A Call to Action 2018-2028,* 2018, accessed November 21, 2022, https://www.greatersudbury.ca/city-hall/reports-studies-policies-and-plans/report-pdfs/population-health-call-to-action/.

106 City of Greater Sudbury, *Population Health, Community Safety & Well-Being: A Made in Greater Sudbury Solution,* June 1, 2021, https://www.greatersudbury.ca/city-hall/reports-studies-policies-and-plans/report-pdfs/population-health-june-2021/.

107 City of Greater Sudbury, *Population Health, Community Safety & Well-Being: A Made in Greater Sudbury Solution.*

World Health Organization Guidebook 2018-2030:

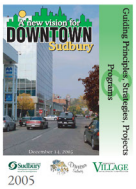
- 100-page toolkit
- Identifies clear goals and steps
- Adaptable to local cultures and contexts
- Policy-driven
- Resource sharing
- Tips to establish national strategy

Summary of alignment with WHO Physical Activity Goals:

- **No mention** of WHO Global Action Plan
- **No mention** of physical activity guidelines
- **No mention** of networks of infrastructure that people use to exercise (i.e. trails, sidewalks, paths)
- **No mention** of measuring the effectiveness of design interventions
- Number of times ***Physical Activity*** is mentioned: 1
- Number of times ***Exercise*** is mentioned: 1

2018

2021



2005

2018

Chapter 5

Projects

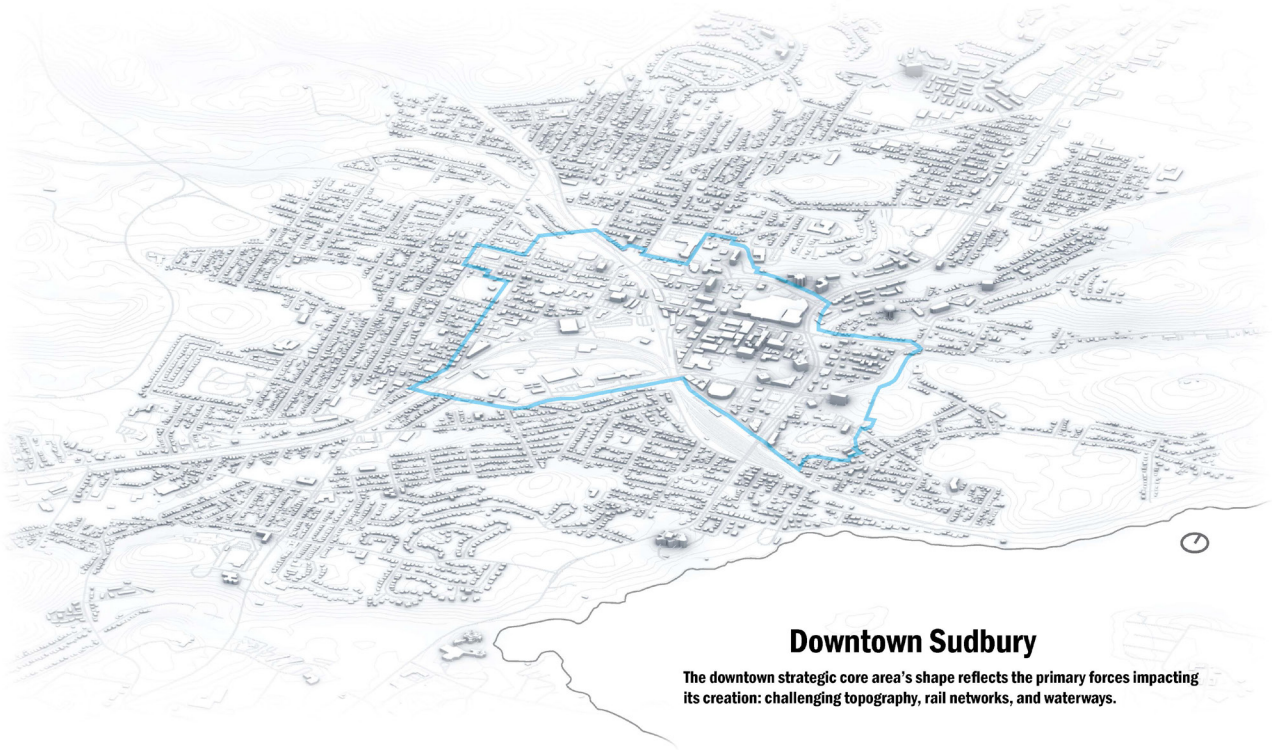
Chapter 5 Projects

In this chapter, design interventions are proposed which will provide better access to "Health Infrastructure", such as trails, parks, paths, boardwalks, and facilities that provide safe, comfortable, and engaging spaces for physical activity. A thorough review of the City of Greater Sudbury's official planning documents have revealed a lack of implementation of evidence-based design principles.[108] A deep analysis of how Sudbury's car-centric urban infrastructure creates both cognitive and physical barriers to an outdoor, movement-oriented lifestyle has also been conducted. Comparing these data sets with best practices gleaned from the research and analysis of precedents has informed opportunities for design solutions at six different sites, at a variety of nested scales. These design interventions leverage the medical evidence to provide new engaging circulation routes that better connect neighbourhoods (e.g., paths, trails, sidewalks, boardwalks), eliminate barriers to access (e.g., dominating car culture, lack of safety, gaps in the infrastructure, driver attitudes), and infuse the urban fabric of Downtown Sudbury with nodes at key locations (e.g., new buildings to catalyze a shift towards healthy active lifestyle). All are needed to put Sudburians on the path towards complete agency over their health, and that of generations to come.

32 | Axonometric map series 1 of 7

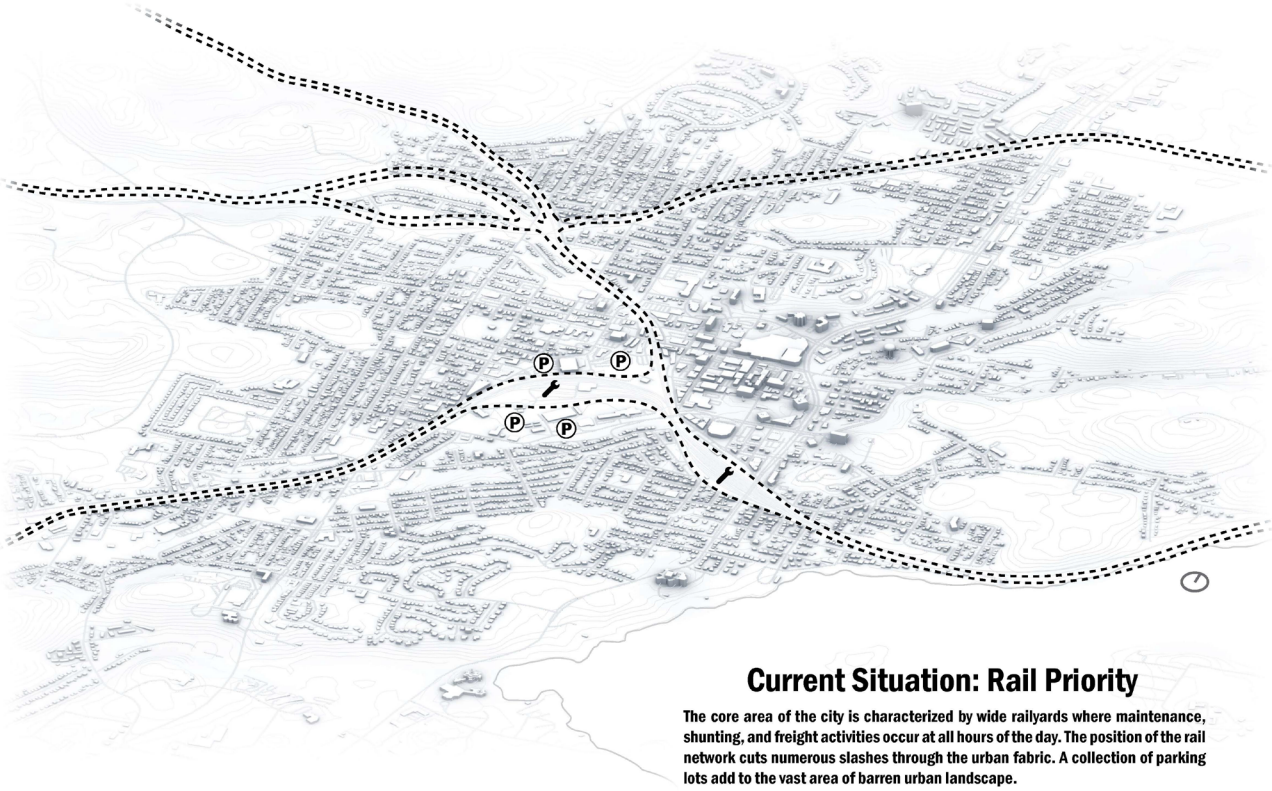
33 | Axonometric map series 2 of 7

108 City of Greater Sudbury, *Parks, Open Space & Leisure: Master Plan Review*; City of Greater Sudbury, *A New Vision for Downtown Sudbury: Guiding Principles, Strategies, Projects, and Programs*; City of Greater Sudbury, *Population Health: A Call to Action 2018-2028*; City of Greater Sudbury, Population Health, Community Safety & Well-Being: *A Made in Greater Sudbury Solution*.



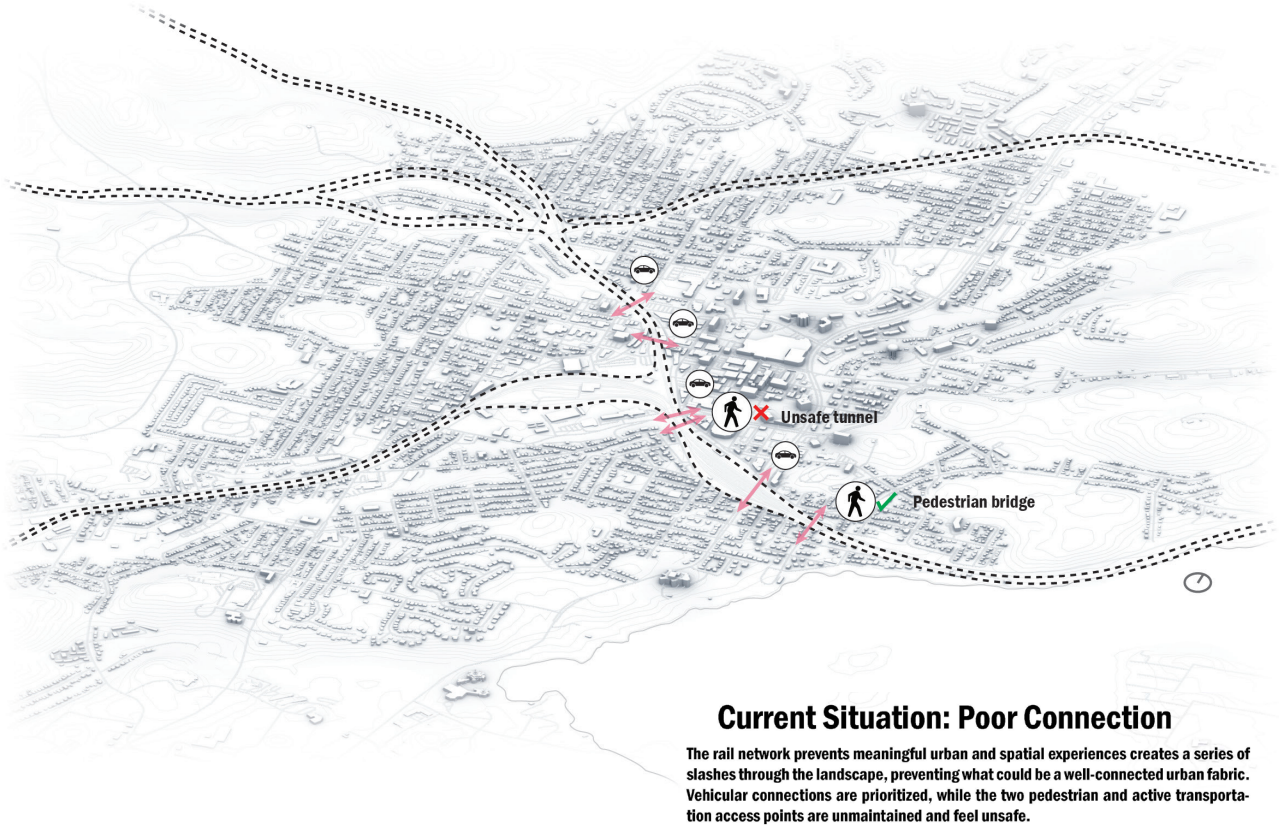
Downtown Sudbury

The downtown strategic core area's shape reflects the primary forces impacting its creation: challenging topography, rail networks, and waterways.



Current Situation: Rail Priority

The core area of the city is characterized by wide railyards where maintenance, shunting, and freight activities occur at all hours of the day. The position of the rail network cuts numerous slashes through the urban fabric. A collection of parking lots add to the vast area of barren urban landscape.



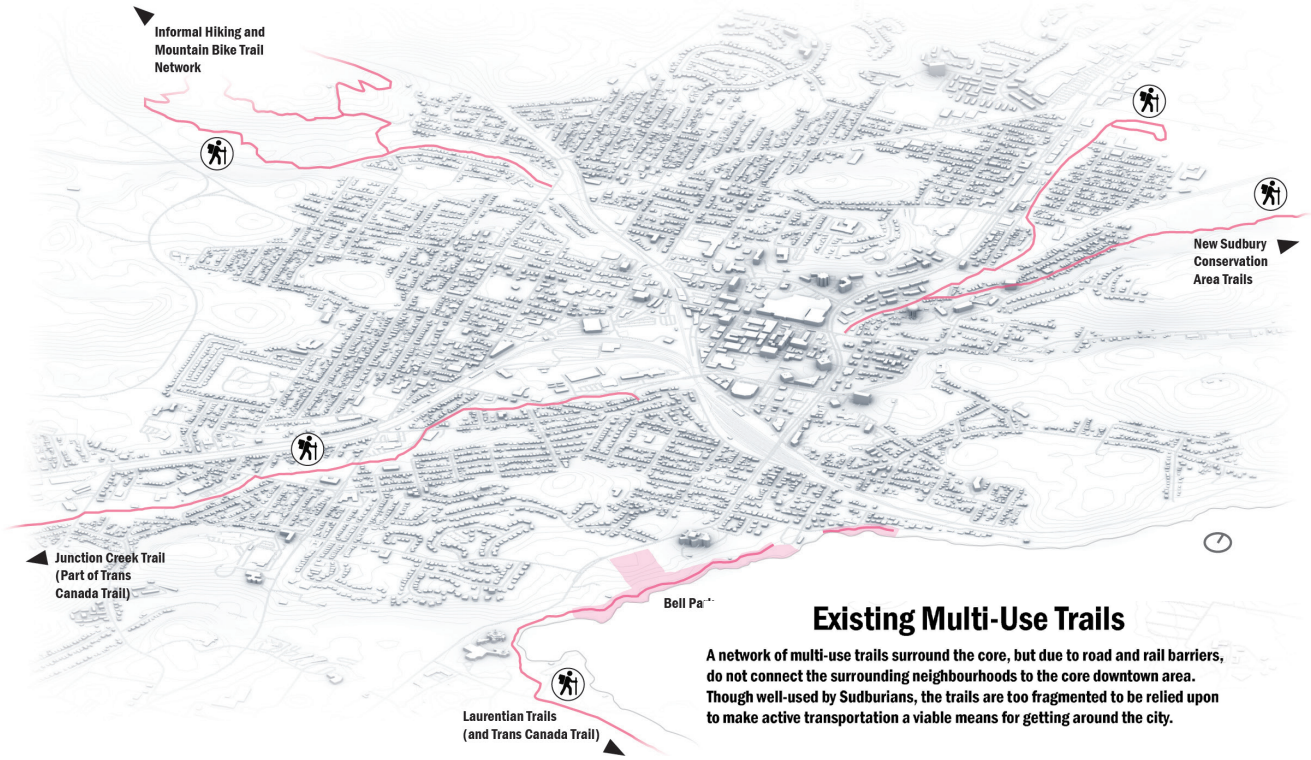
5.1 Mapping and Site Selection

34 | Axonometric map series 3 of 7

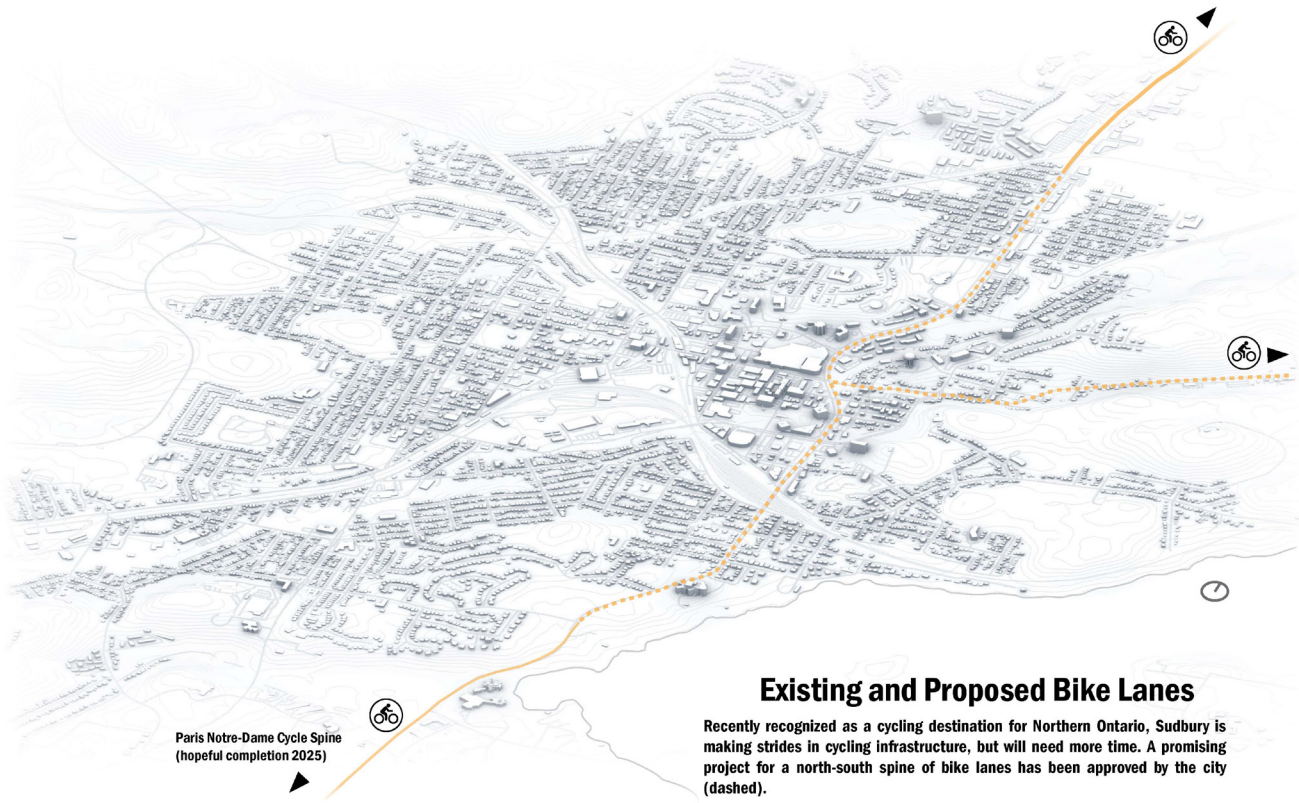
35 | Axonometric map series 4 of 7

Pillar five (Movement), guided my selection of six sites in downtown Sudbury, where active transportation is not currently a widely adopted mode of travel. Sudbury's urban fabric features many barriers to movement including several railways, poor lighting, fencing, large trainyards, busy streets, and fragmented sidewalk and trail networks.[109] The research suggests the most important step for improving physical activity levels is first understanding where and how physical activity is happening. Through a series of mapping exercises, municipal document analysis, site visits, photo documentation, first-hand experience, and interviews with cycling groups, three severely under-programmed sites that were creating barriers to movement were identified. Thus, these three sites held great potential to catalyze a significant increase in active transportation amongst Sudburians. Interspersed between the three primary sites, three smaller complementary satellite sites were chosen for a total of six design interventions, which when combined, overcome many of the movement barriers and establish a new multimodal movement corridor in downtown Sudbury. Examining the sites through the lens of the MLF brought to light weaknesses and inherent qualities of each, and informed programmatic

109 City of Greater Sudbury, "Transportation Master Plan," accessed December 6, 2022, https://www.greatersudbury.ca/live/transportation-parking-and-roads/road-plans-and-studies/transportation-master-plan/.

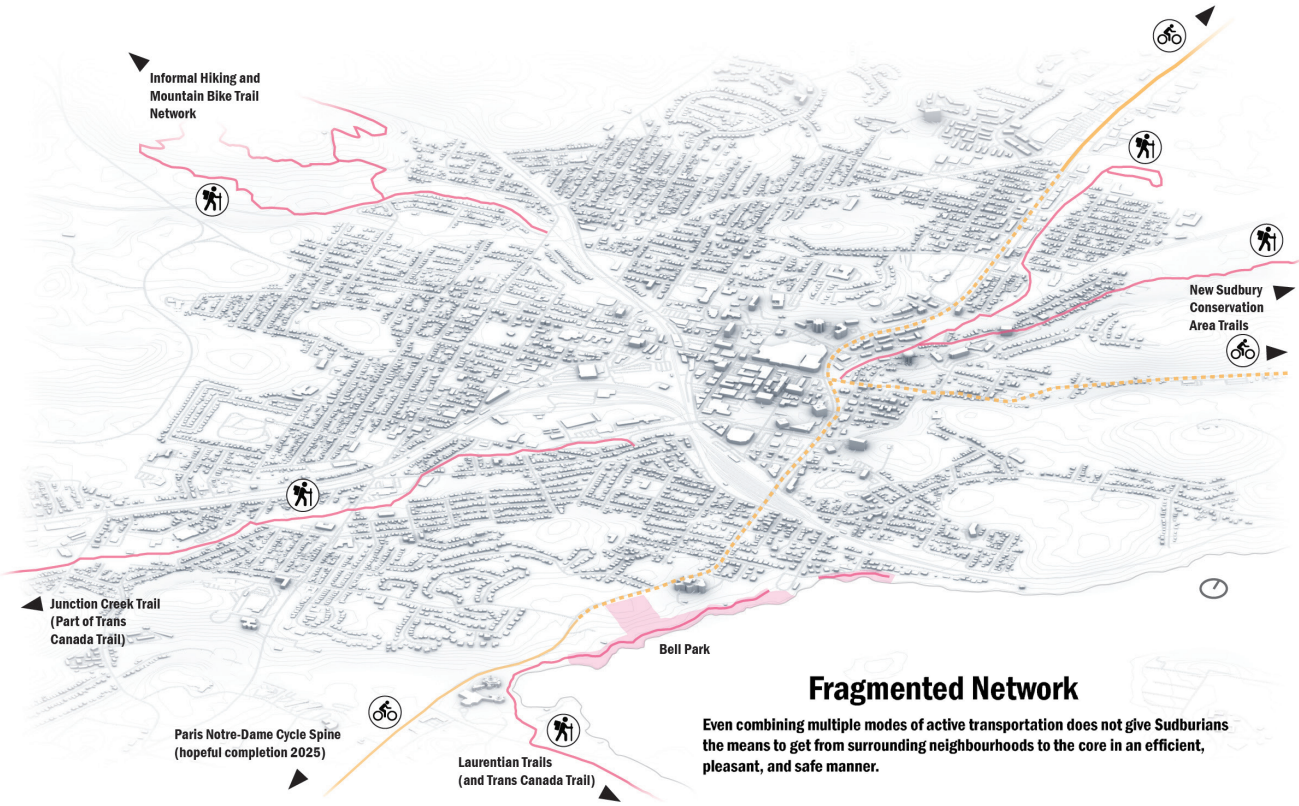


choices. The selected programs leverage unique qualities of each site such as beautiful views, interesting topography, adjacent urban features, and natural landscape elements. By combining unexpected typologies in exciting new ways, these six interventions help to stitch together a more connected urban tissue, better facilitating healthy active lifestyles for the thousands of residents living near Sudbury's downtown core.



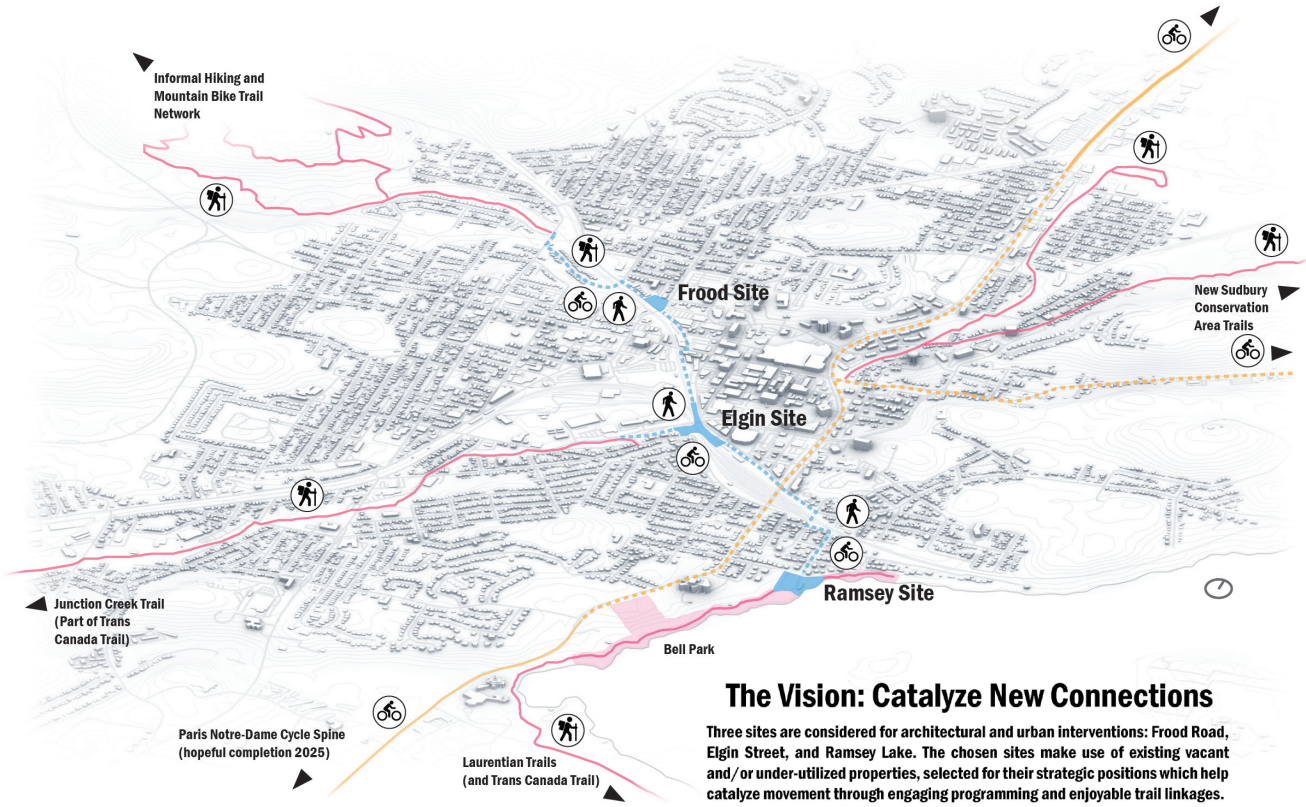
Existing and Proposed Bike Lanes

Recently recognized as a cycling destination for Northern Ontario, Sudbury is making strides in cycling infrastructure, but will need more time. A promising project for a north-south spine of bike lanes has been approved by the city (dashed).



Fragmented Network

Even combining multiple modes of active transportation does not give Sudburians the means to get from surrounding neighbourhoods to the core in an efficient, pleasant, and safe manner.



36 | Axonometric map series 5 of 7

37 | Axonometric map series 6 of 7

38 | Axonometric map series 7 of 7

5.2 Grow ‘n Go (Frood Road Site)

Just northwest of downtown on a prominent corner of two busy streets, Frood Road and College Street, sits the first of three primary - and severely underutilized – sites which will receive design interventions through the lens of the Movement Legacy Framework. Before it burned down in September of 2008, the United Steelworkers Hall stood on this property and served as a union hall but also as a popular venue for weddings and banquets. Now the property serves as a large gravel private parking lot, devoid of any public or cultural significance. Near this site lies a very poorly lit and vandalized existing pedestrian tunnel which does not connect easily to bike lanes or trails. This is the first of three satellite sites receiving a proposed design intervention. Taking advantage of an existing retaining wall, I am proposing new seating, lighting, crosswalks, and continuity of bike lanes to connect with the Rainbow Routes trail network to the northwest.

On the main Frood Road site, the lack of daily life is inversely proportional to the enormous number of empty cars parked there all day long. The busy adjacent streets do not include bike lanes or even maintained sidewalks on all adjacent streets, leading pedestrians into a wall of dirty snow if they obey the walk sign

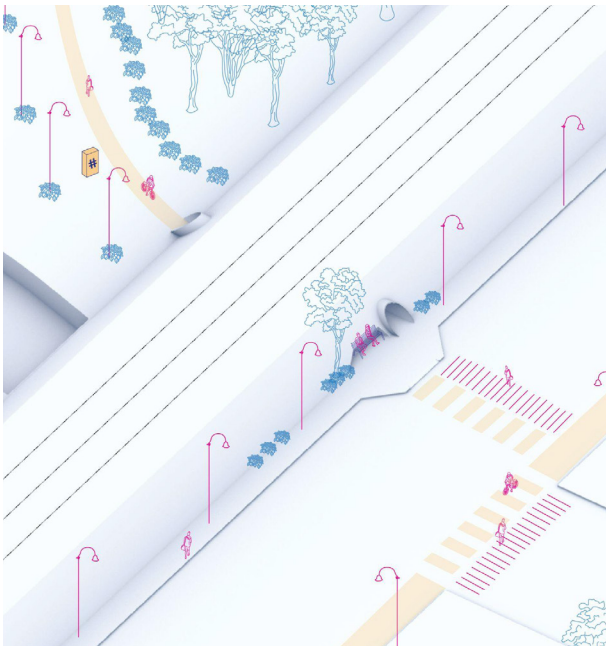
39 | opposite top, *Collage of pedestrian tunnel near Frood Site including site photo, annotated map, and design proposal for new crosswalks, plantings, seating, and lighting*

40 | *Site photos of the Grow ‘n Go site looking northwest*

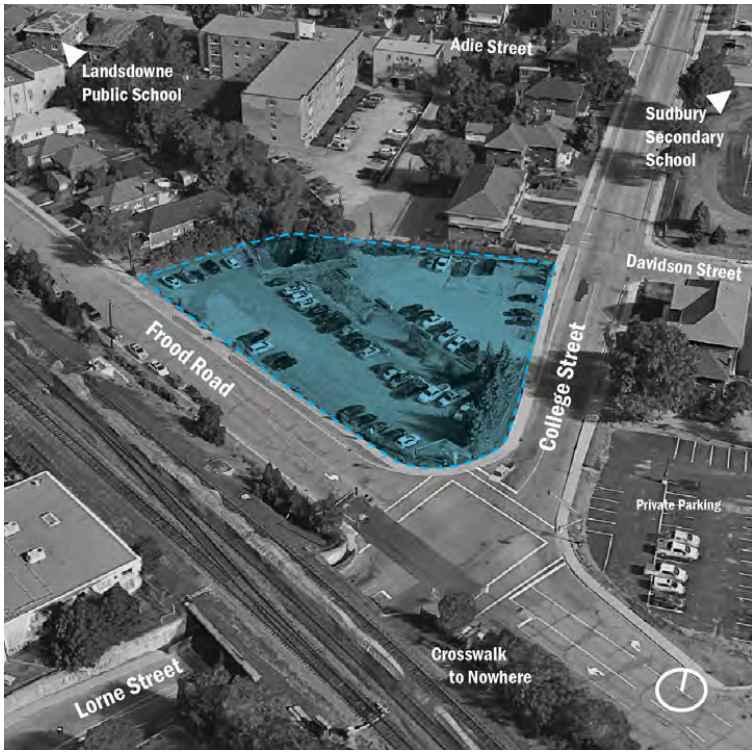
41 | *Site photos of the Grow ‘n Go site looking southwest towards nearby underpass*

42 | *Aerial map of the Frood Road site delineating the proposed project area*

Existing pedestrian tunnel

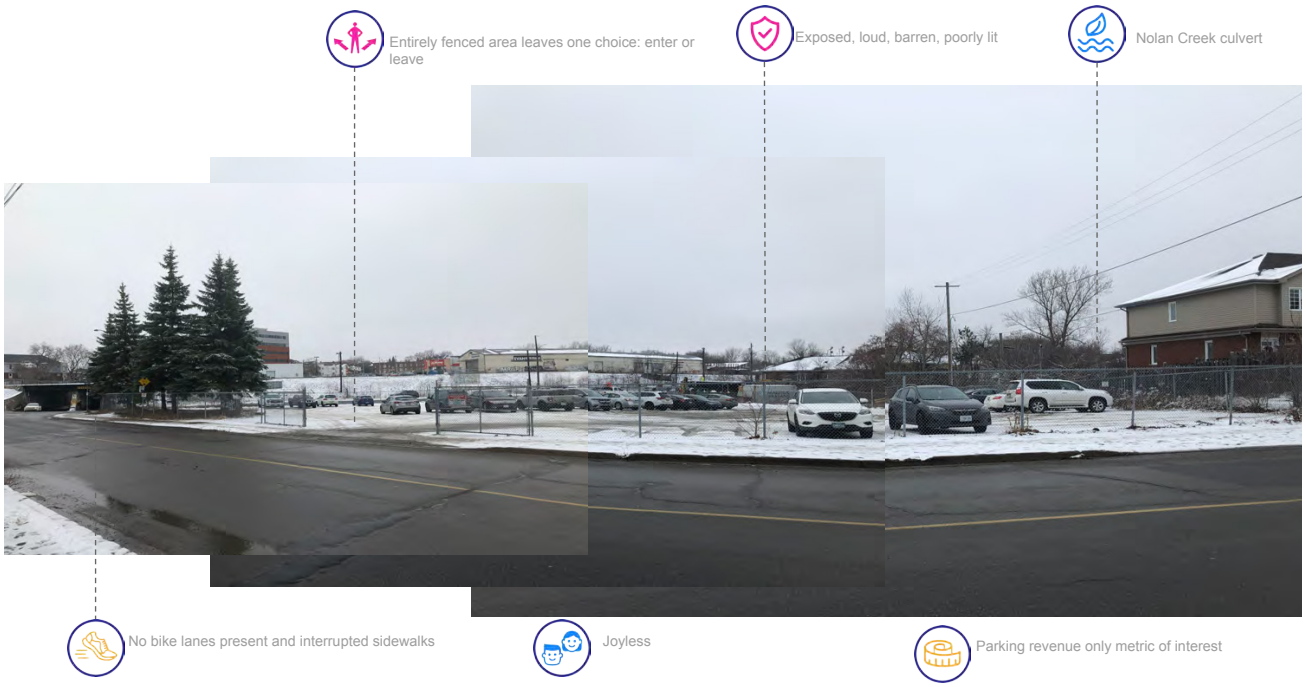


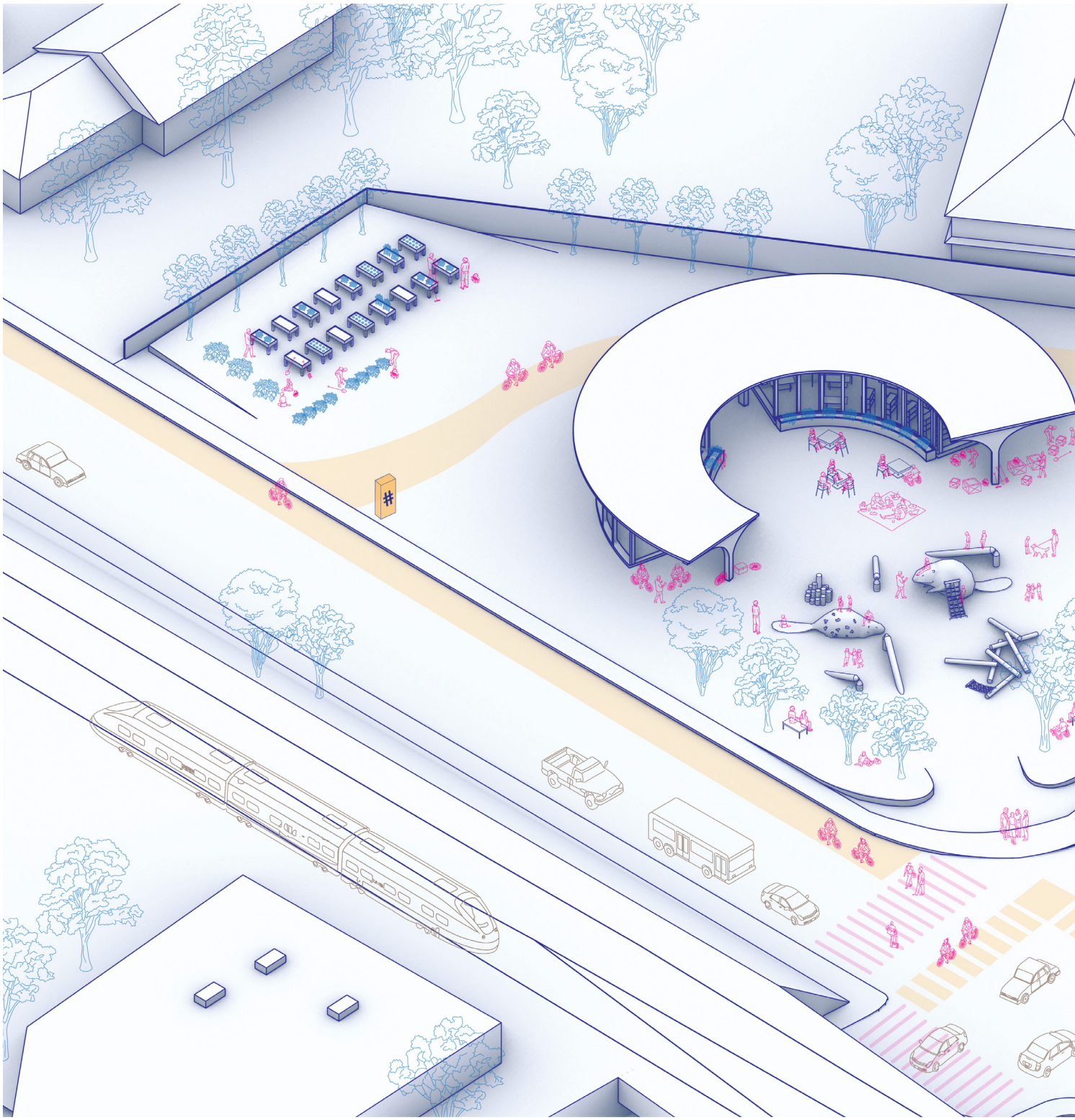
Proposed Pedestrian Tunnel Revitalization

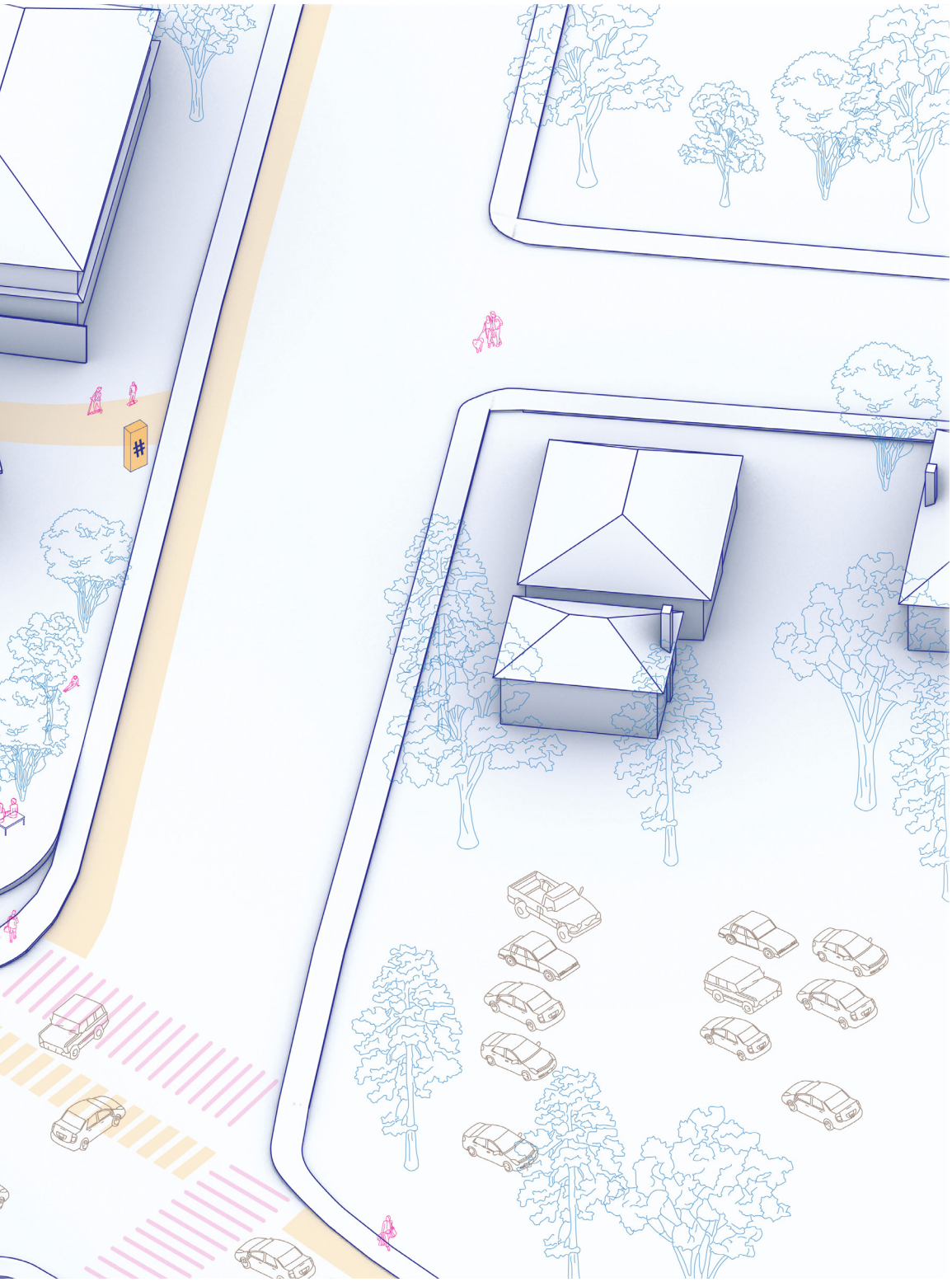


during winter. For this site I am proposing a bicycle repair shop, community garden/food forest with a small supporting greenhouse, and playground. These programs were selected in response to the adjacent neighbourhood makeup. Situated at the edge of the downtown core, with residential neighbourhoods to the north and west, it was important to select programming that served the needs of the community and fostered an interest in active transportation culture. With few community gardens and parks in the area, these programs will fulfill an immediate need of nearby residents and young families, and as a convenient secondary benefit, the bike repair shop will offer many an introduction to active transportation they may not have otherwise had. From this dynamic relationship, more residents might be introduced to cycling than would be the case if the bike repair shop existed alone on its own site. The building is divided into two distinct masses, arranged radially underneath a bold, unifying roof. Dividing the building programs into separate masses creates better porosity for views, daylighting for the greenhouse, and fluidity of movement across the site, while simplifying storage and security measures for both programs. The western half of the building is for bicycle rental and repair, with the northern half being devoted to greenhouse space with gardening tool and seed storage. These would be staffed by a single employee, with help from a volunteer network, following models of other community gardens in Sudbury. A “risky” playground located on the corner brings movement, joy, and family life to a neighbourhood that has very few parks. Exciting playground features referencing local plants and animals reflect the unique ecological identity of the area, and foster ecological learning alongside play, socialization, and exercise. Proposed bike lanes on both adjacent streets, as well as a multimodal movement shortcut across the back of the site improve efficiency of pedestrian and cyclist movement. Roof overhangs from the building provide outdoor spill-out space where gardeners and cyclists can work in inclement weather.

43 | Panoramic photo of Frood site overlaid with principles of the Movement Legacy Framework


Entirely fenced area leaves one choice: enter or leave
Exposed, loud, barren, poorly lit
Nolan Creek culvert
No bike lanes present and interrupted sidewalks
Joyless
Parking revenue only metric of interest

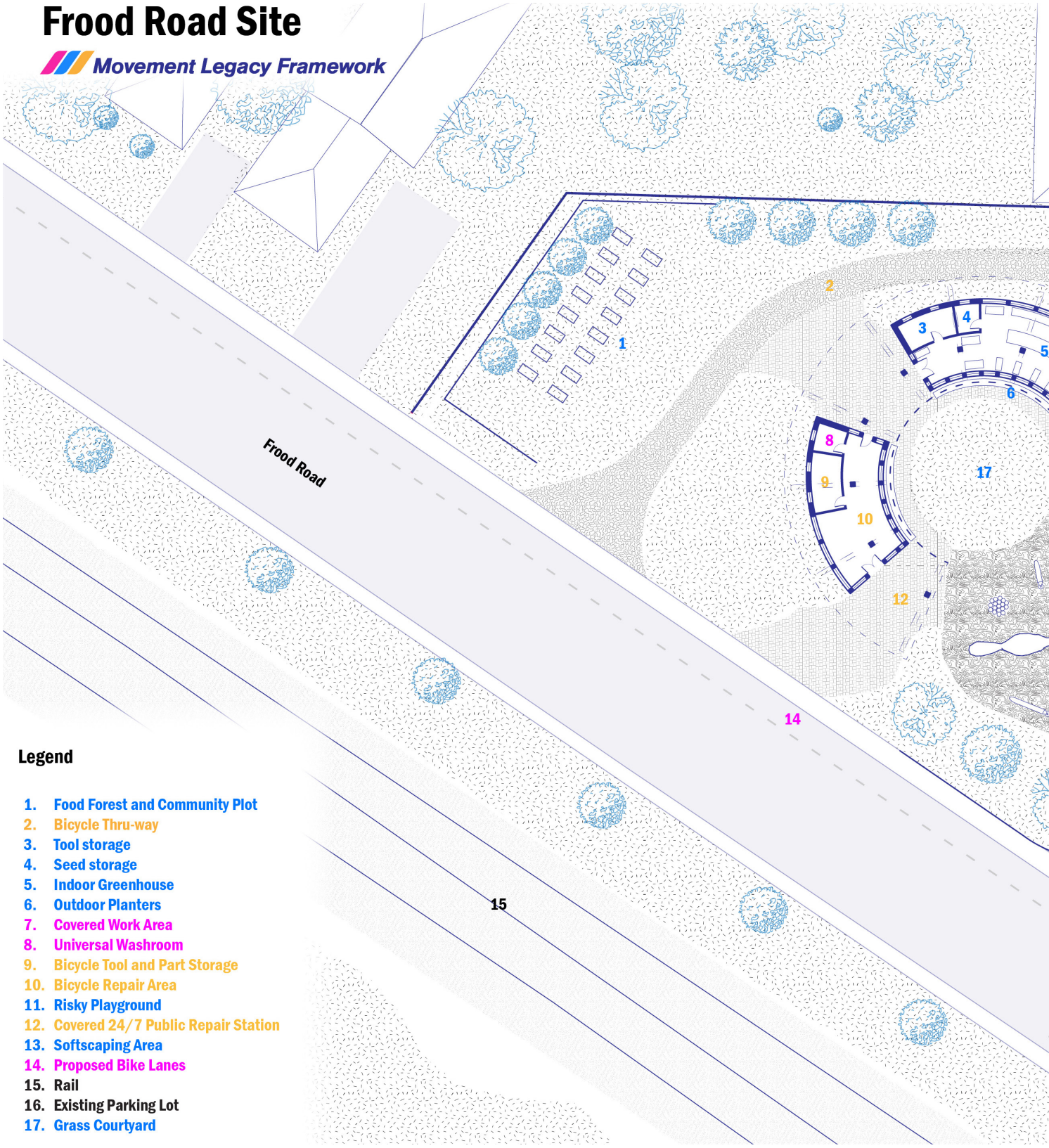




44 | Axonometric of Grow 'n Go project, a bicycle rental and community garden

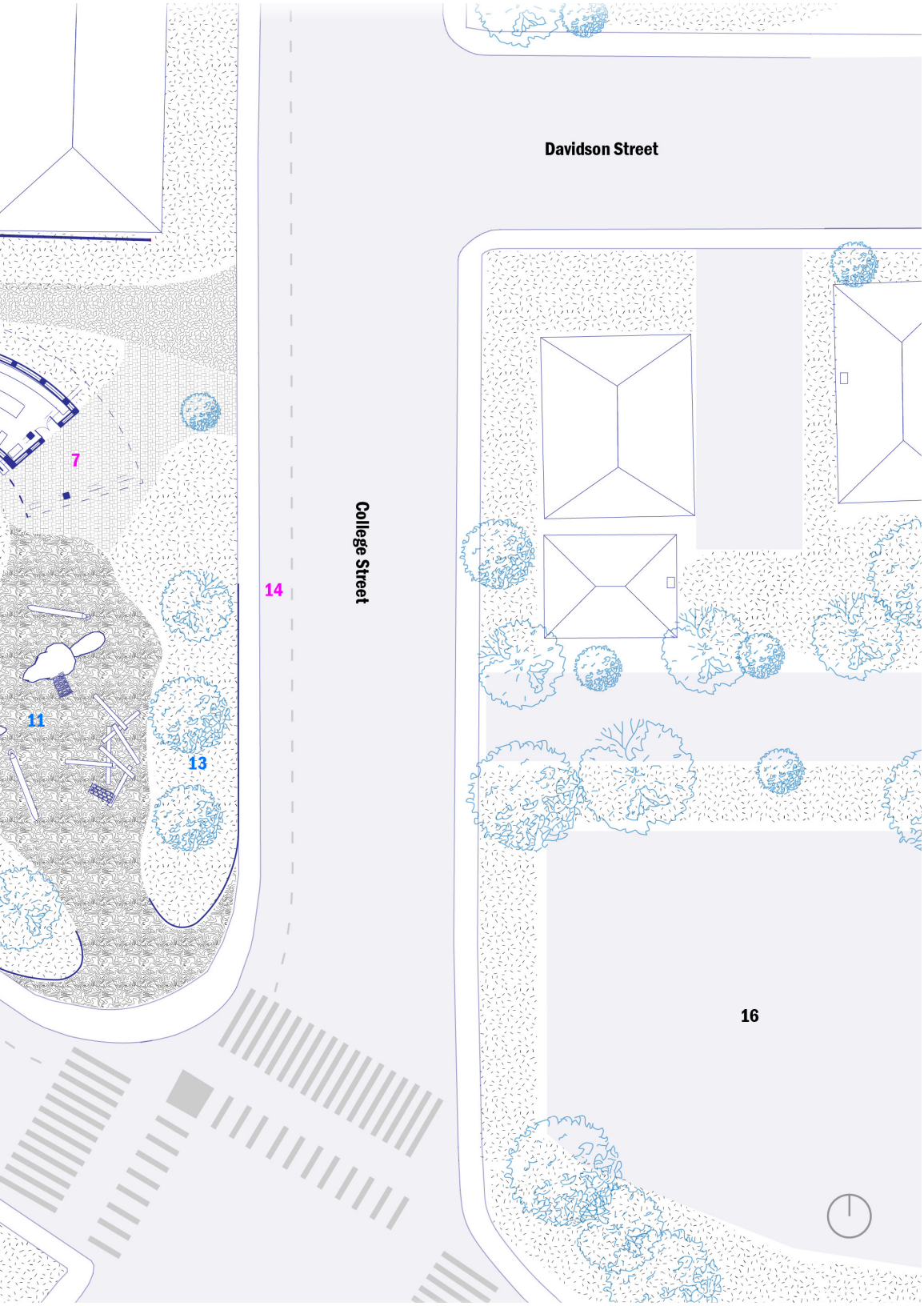
Frood Road Site

Movement Legacy Framework



Legend

1. Food Forest and Community Plot
2. Bicycle Thru-way
3. Tool storage
4. Seed storage
5. Indoor Greenhouse
6. Outdoor Planters
7. Covered Work Area
8. Universal Washroom
9. Bicycle Tool and Part Storage
10. Bicycle Repair Area
11. Risky Playground
12. Covered 24/7 Public Repair Station
13. Softscaping Area
14. Proposed Bike Lanes
15. Rail
16. Existing Parking Lot
17. Grass Courtyard



***45 |** Floor Plan of Grow 'n Go design proposal, a bicycle rental and community garden. Colours correspond to Movement Legacy Framework design elements*

***46 |** View of playground and inner courtyard of the Grow 'n Go project*

***47|** View towards the building from the community garden and food forest at the west edge of the site*

5.3 Sudbury Nexus (Elgin Street Site)

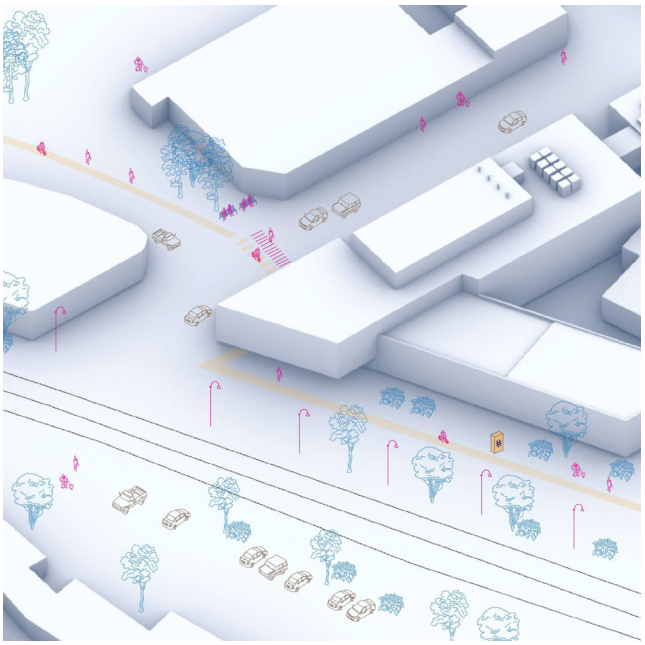
In the heart of downtown, outside the front doors of the McEwen School of Architecture, a pedestrian and cycling crosswalk is proposed for Elgin Street at what is likely the J-walking capital of Sudbury. This satellite site intervention will link the new Frood Road interventions to the existing Elgin Greenway trail that runs alongside the train tracks. Moving to the southeast, we arrive at the primary Elgin Street site, the location for the new Sudbury Nexus project. This property is located at the intersection of several vehicle and rail transportation routes that collide with one another to create several barriers to pedestrian movement. Save for one extremely long, uninviting pedestrian tunnel with no seating, gardens, or visible end point, there is no place for pedestrians to cross the tracks for half a kilometer in either direction. Railway maintenance and parking lots dominate the site, giving no safe or enjoyable options for pedestrians who might be interested in getting outside and enjoying the day. Proposed for this site is a massive excavation of soil underneath the tracks to daylight a long-culverted section of Junction Creek and provide a new nexus for seamless active transportation connections to all the surrounding trail networks near downtown. By encapsulating the new train bridge section in an illuminated, sculptural Corten steel wrap, adjacent businesses will

***48 | opposite top,** Collage of area in front of McEwen School of Architecture including site photo, annotated map, and design proposal for new crosswalks, plantings, bike counters, and lighting*

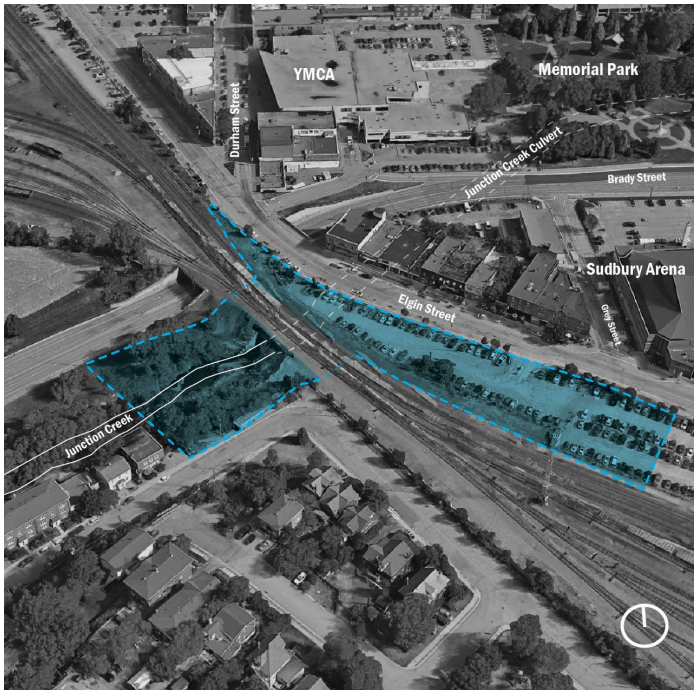
***49 |** Site photos of the Sudbury Nexus site looking towards railyard*

***50 |** Aerial map of the Sudbury Nexus site delineating the proposed project area*

Existing condition at McEwen
No mid-block crosswalk for students



Proposed Pedestrian and Cyclist Crossing



be spared some of the shrieking train noise. The new linear park design includes several uniquely programmed zones including a small square called the Sudbury Sports Square at the end near the Sudbury arena where sports fans could enjoy community rallying events before and after home games. There is also a sloped and terraced lawn area perfect for picnics, numerous new seating features, a community stage which can be appropriated for all sorts of performances, and a daylit, re-naturalized length of Junction Creek. A multi-use trail winds its way through the site, seamlessly connecting it to the existing and proposed trail systems in five different directions. Pedestrian counters are proposed at each connection point which will provide the necessary data to better understand the movement patterns and long-term effectiveness of the project. The existing ramp and staircase located directly in front of the shops on Elgin Street are maintained to provide yet another access point from the street above to the park area below, offering people of varying abilities numerous options for how to navigate the site and enjoy all of the same amenities as all other park-goers.

51 | ***Panoramic photo of Sudbury Nexus site overlaid with principles of the Movement Legacy Framework***

52 | ***Panoramic photo of Sudbury Nexus site overlaid with principles of the Movement Legacy Framework***

The choices are drive, or drive

Usage not measured

No sidewalk

Exposed, loud, barren, poorly lit

Devastated greenspace

Especially joyless

Tunnel gives only one choice

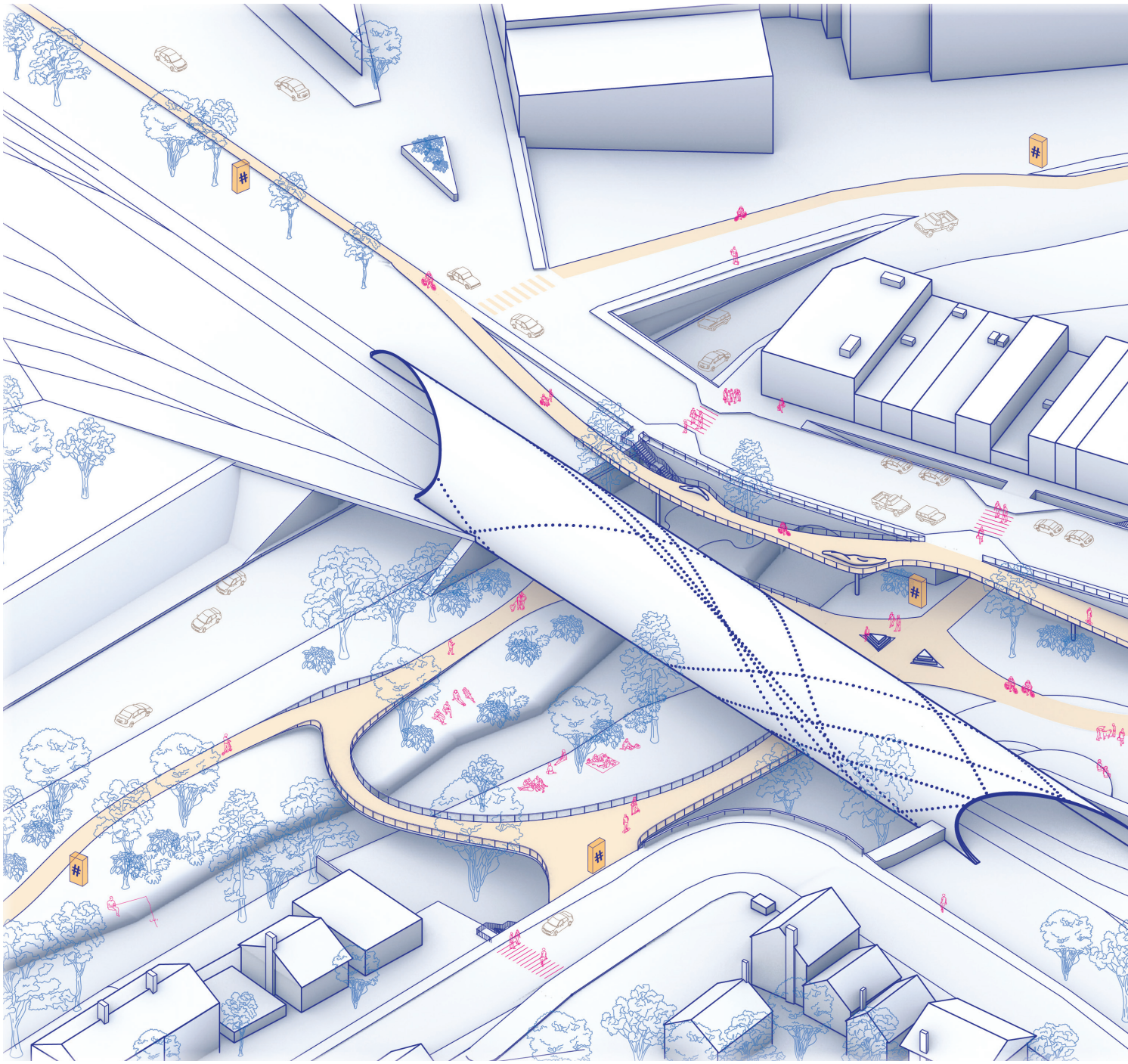
Exposed, loud, barren, poorly lit

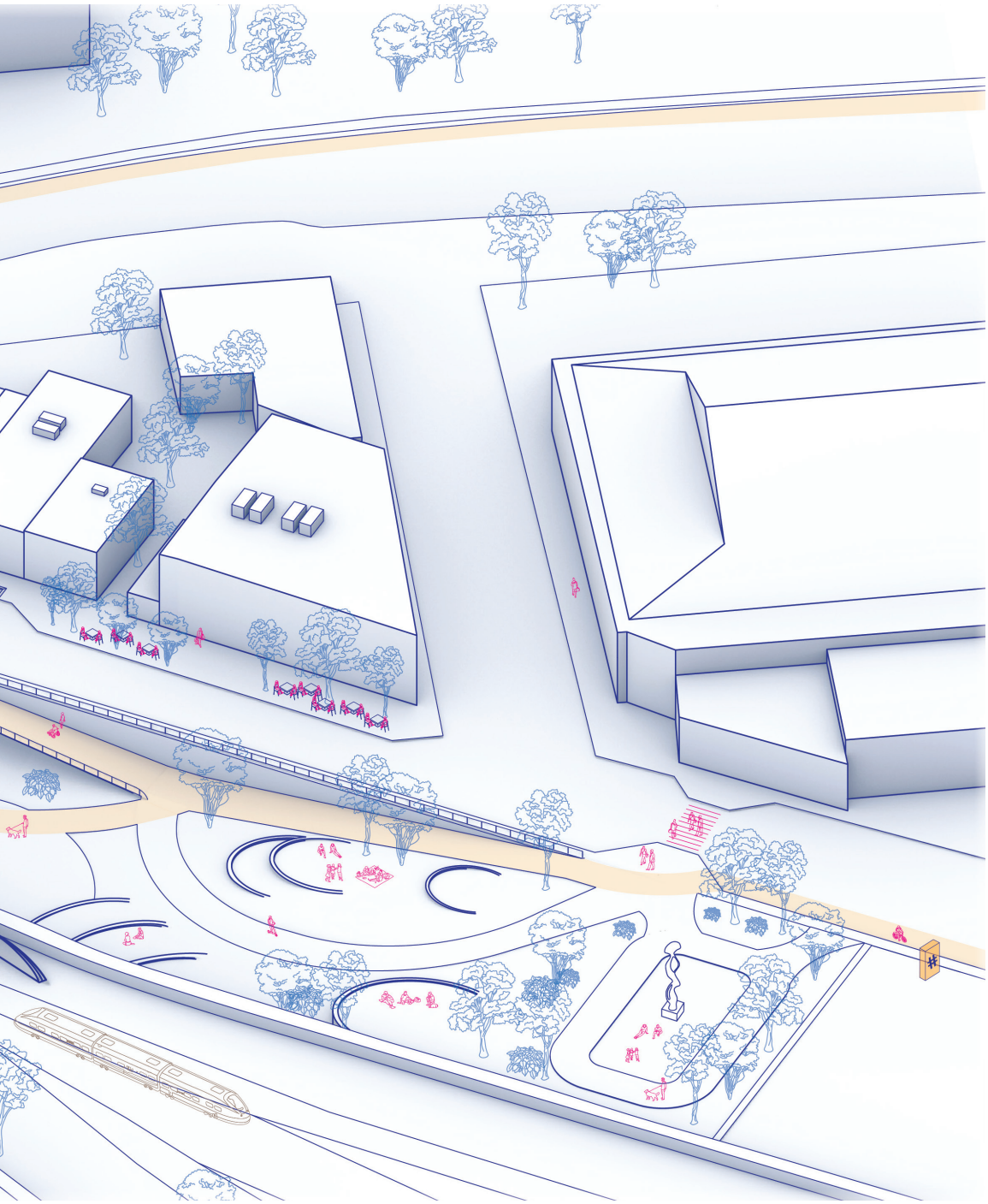
Junction Creek nearby

Joyless

Usage not measured

Crosswalk

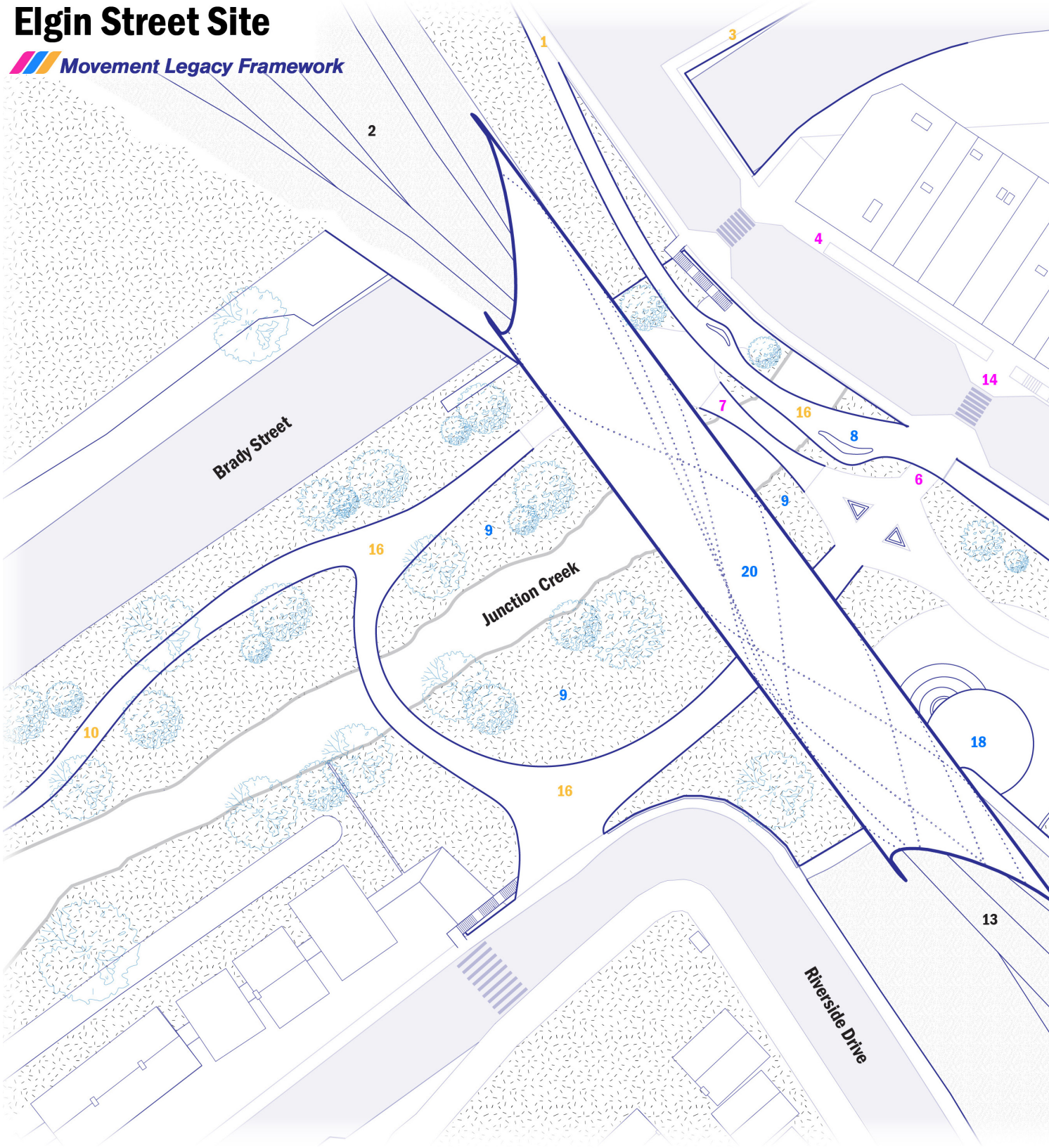




***53 |** Axonometric drawing of Sudbury Nexus site, an urban park and active transportation project*

Elgin Street Site

Movement Legacy Framework



***54** | Plan, Sudbury Nexus site, an urban park and active transportation project*

55 | View from newly excavated area next to renaturalized area of Junction Creek

***56 |** View from top of sloped linear park area looking towards illuminated Corten-wrapped train bridge*

5.4 Loving the Lake Centre (Ramsey Lake Site)

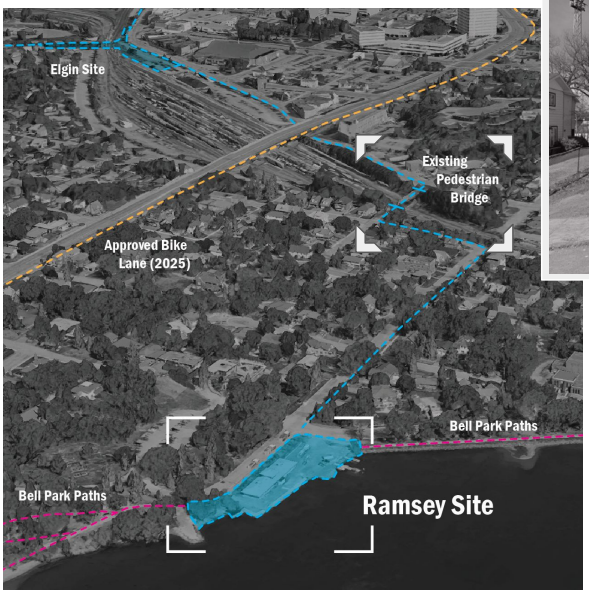
Half a kilometer southeast of the primary Elgin Street site there is a pedestrian bridge which crosses over the railyard. This crossing is the second of only two designated pedestrian connections which overcome the rail barrier and facilitate pedestrian movement in and out of the downtown core. The first is the pedestrian tunnel discussed and photographed in the Elgin Street site analysis. In its current state, the bridge is rusting and does not have sufficient lighting along its length or at either end to feel truly safe. Proposed for this existing pedestrian bridge are small parkettes for each end with new seating, plantings, signage, lighting, and movement counters. To further extend the proposed movement corridor, bike lanes are continued from Elgin Street, over the bridge, onto Edmund Street and beyond.

57 | opposite top, *Collage of pedestrian bridge area including site photo, annotated map, and design proposal for new crosswalks, plantings, bike counters, and lighting*

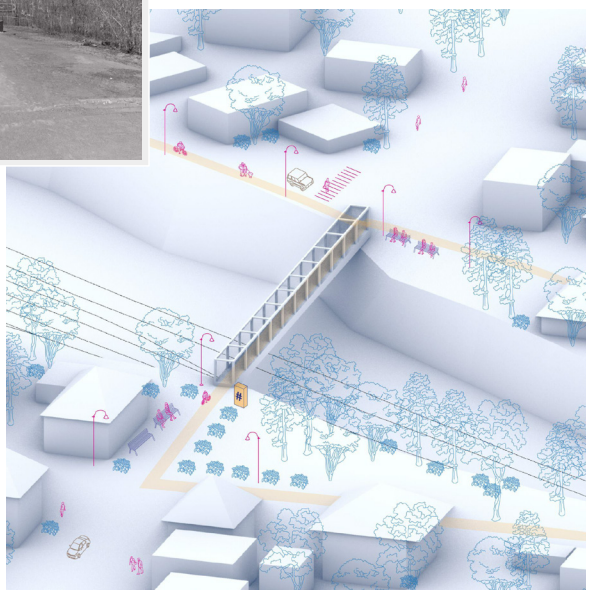
58 | *Site photo of the Ramsey Lake site looking towards end of boardwalk*

59 | *Existing single storey building*

The third primary design proposal is situated on the shore of Ramsey Lake, on a property that currently disrupts the continuity of the beautiful waterfront Bell Park trail. The property features an existing single-storey building, which at one point housed the Sudbury Canoe Club, surrounded by an austere gravel landscape along the water's edge. The building is currently used as storage, occasionally



Existing Pedestrian Crosswalk:
No seating, minimal lighting,
uneven surfaces



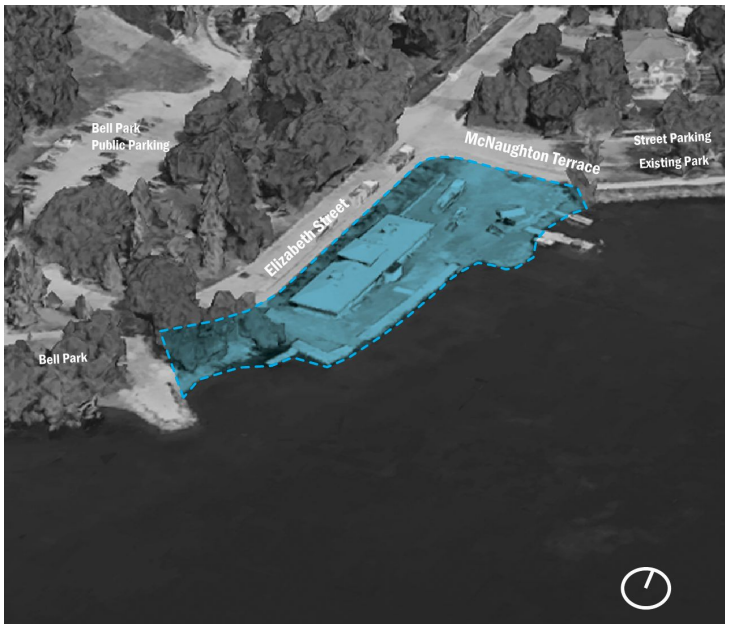
Proposed Pedestrian Bridge Parkettes

opened for people to put their skates on in wintertime but given the amazing views and ecological qualities of the site, is considerably under-utilized. For this site, I have selected programs that honour its historical past by providing programming to reconnect the public with the lake. A public sauna, restaurant, and cafe/ change room area are set into the existing berm and are oriented to maximize views to the water. Sloped rooftop access at both ends of the building provides a new vantage point for people of all abilities to enjoy views of the lake. Outdoor programming includes fireplaces, waterside boardwalk, outdoor dining, and a splash pad for the summer that converts to a skating pad in the winter, further activating the Ramsey Lake skating path which is a very popular winter activity for Sudburians. A sculpture installation called the Walk of Champions celebrates the incredible history of Sudbury Canoe Club's many Olympians since its inception in 1902. The building masses share a covered breezeway to provide shelter at the entry points. By orienting the sauna more southward, sauna-goers also benefit from some additional privacy from the public boardwalks and restaurant patio. The form integrates seamlessly with the existing park and boardwalk, improving the fluidity of movement across the site, and providing a number of new ways to navigate and engage with the space.

60 | Ramsey Lake wildlife

61 | Aerial map of the Ramsey Lake site delineating the proposed project area

62 | Panoramic photo of site overlaid with principles of the Movement Legacy Framework



Poorly lit and no pedestrian or cyclist lanes

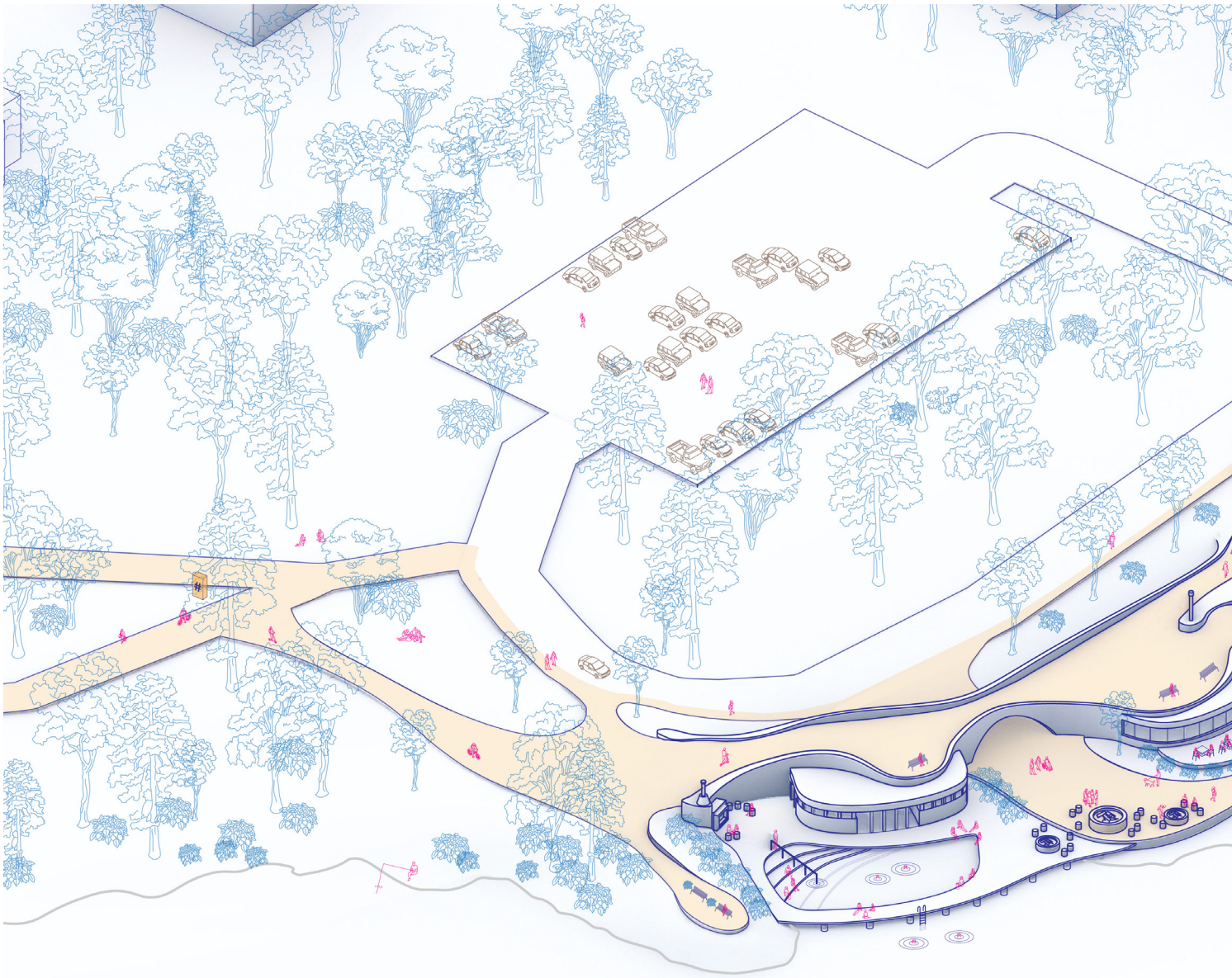
No options to engage with on site

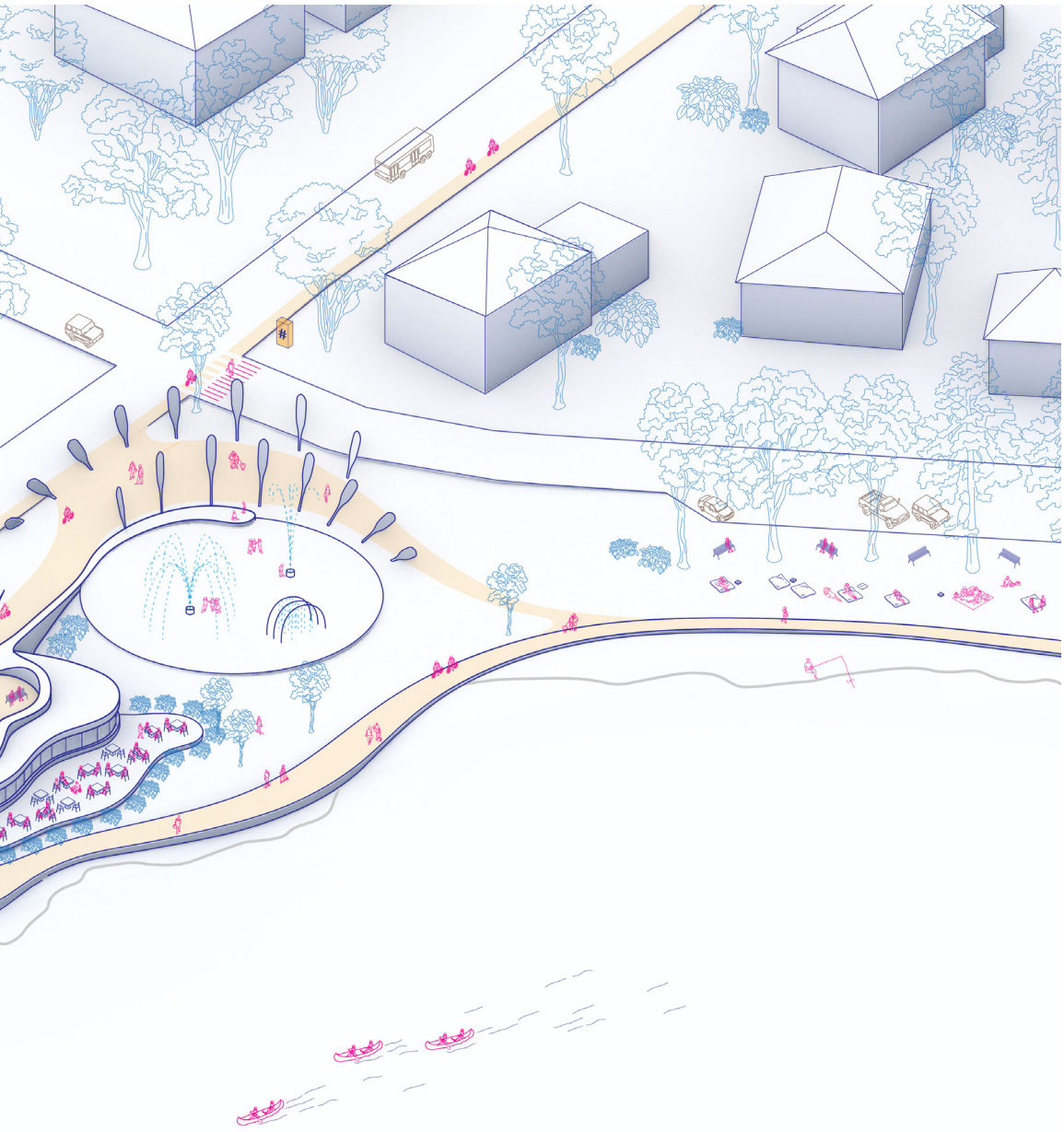
Some of Sudbury's most mature hardwoods/lake vista

Existing boardwalk has good physical activity usage

Unprogrammed site creates a gap in joyful park elements

Old site of Sudbury Canoe Club, since moved.

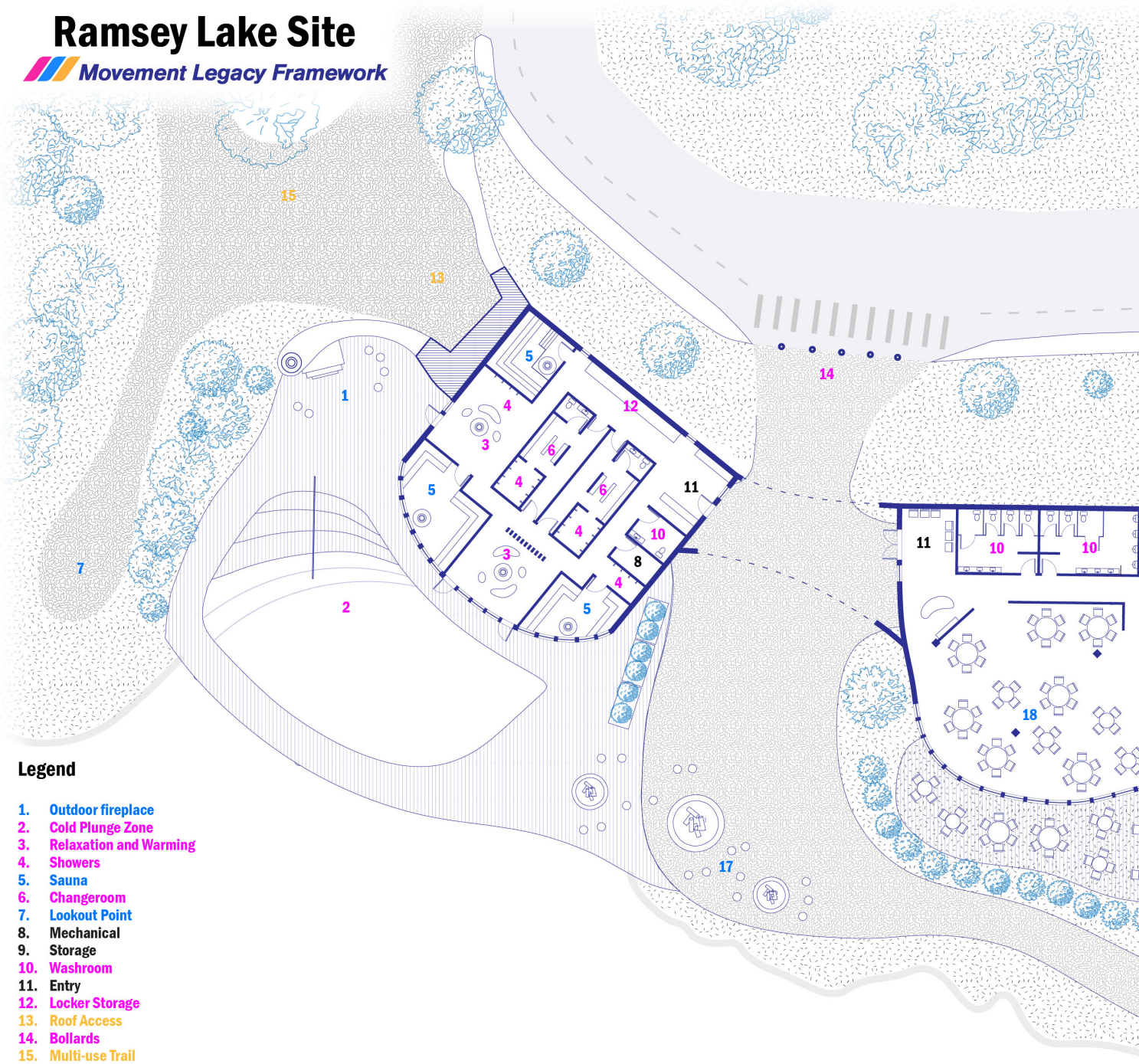




***63 |** Axonometric, Loving The Lake Centre, a public sauna and restaurant project integrated into the existing landscape*

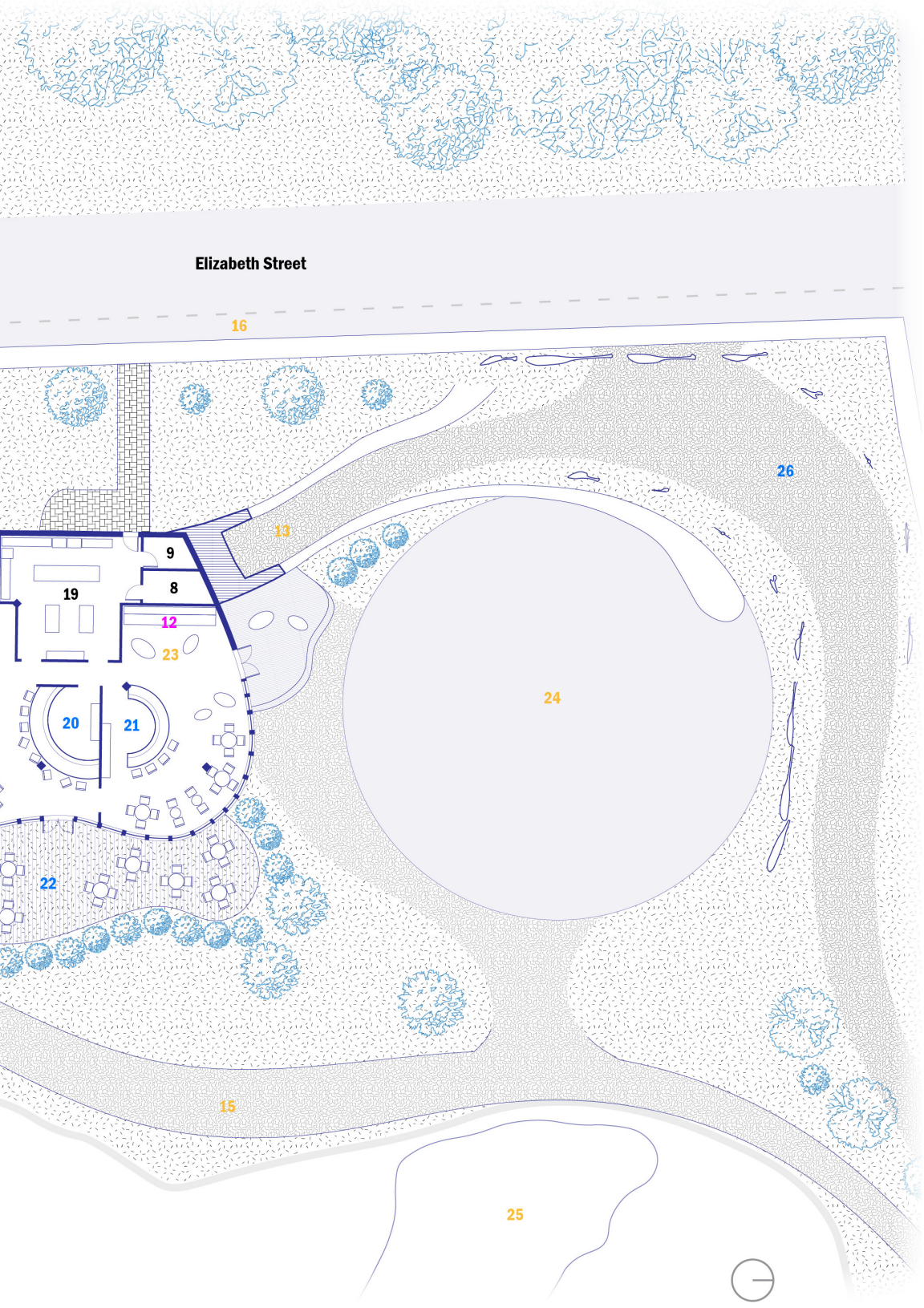
Ramsey Lake Site

Movement Legacy Framework

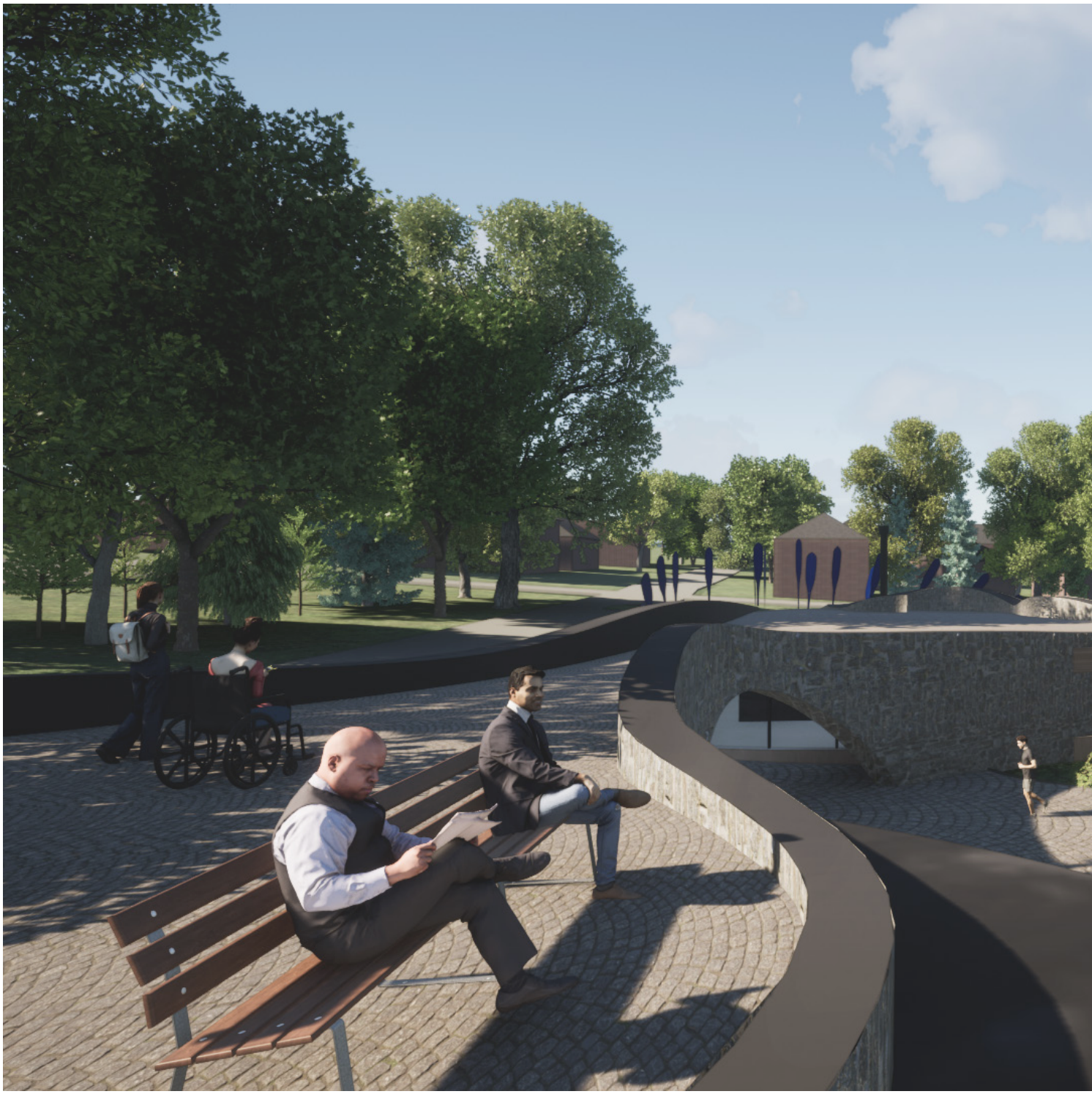


Legend

1. Outdoor fireplace
2. Cold Plunge Zone
3. Relaxation and Warming
4. Showers
5. Sauna
6. Changeroom
7. Lookout Point
8. Mechanical
9. Storage
10. Washroom
11. Entry
12. Locker Storage
13. Roof Access
14. Bollards
15. Multi-use Trail
16. Bike Lane
17. Community Fireplace
18. Restaurant Dining Room
19. Kitchen
20. Bar
21. Coffee Bar
22. Patio
23. Skate Tying Area
24. Splash Pad/Skating Pad
25. Skating Path Terminus
26. Walk of Champions - Sudbury Canoe Club est. 1902



64 | Plan, Loving The Lake Centre, with Movement Legacy Framework design elements represented by pillar group colour



***65 |** View from the public sauna rooftop which is a barrier-free walkway, seamlessly integrated into the existing park landscape*

66 | View from the sauna docks towards the restaurant

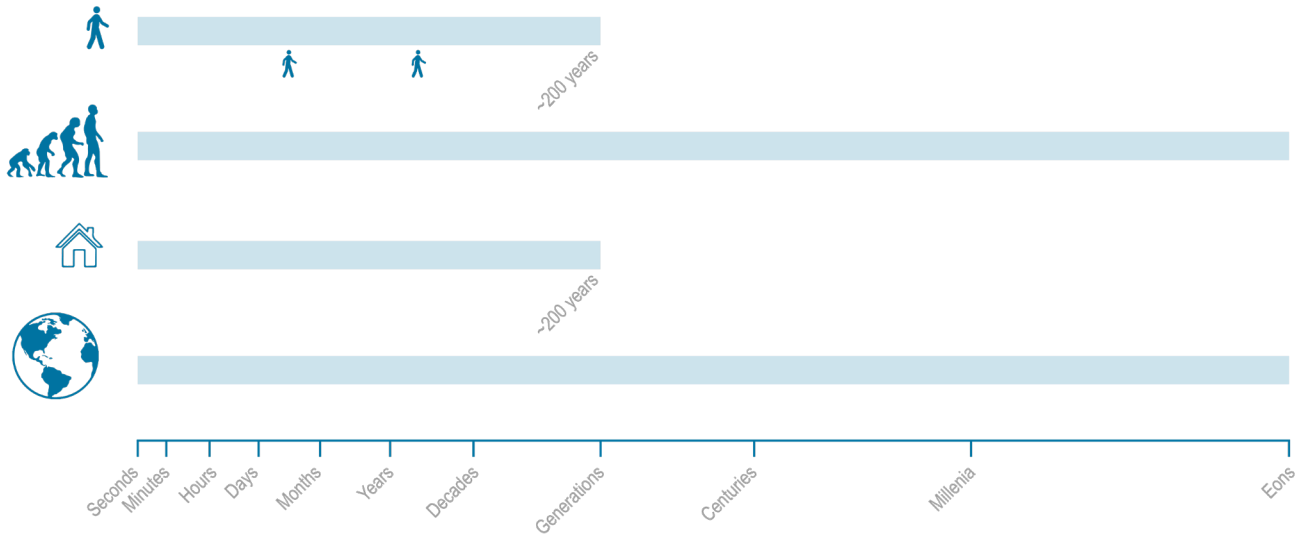
Conclusion:

An Upgradeable Future

Conclusion: An Upgradeable Future

Better health outcomes through physical activity are well within the reach of Sudburians, and all communities around the world, and they need not compete against invisible forces imposed on them by naïve, negligent, or short-sighted architects or urban planners. By leveraging the vast and ever-growing body of research helping us understand how the environment shapes behaviour, we as designers can better serve individuals, communities, and entire populations through more deliberate design of the built environment. In the context of Sudbury, the Movement Legacy Framework has contributed to six design interventions, connected by a strengthened network of active transportation infrastructure to provide our community with a safer, more accessible, better connected, and more enjoyable means of transportation that will improve quality of life for the city's residents, including those not yet born through each person's legacy of epigenetic inheritance. This approach needs to be explored and improved with each successive project to best harness our ability as designers to make a positive contribution to the triad of environmental, cultural, and health sustainability.

The expanding intersection of medicine and design paints an incredibly hopeful situation for public health and opens a very exciting and optimistic avenue for future designers. We cannot choose the world we are born into, just like we cannot choose our genetics. However, we can choose to take ownership of our built environment and our lifestyle behaviours. Oddly enough, when we consider the approximate lifespans of those specific elements we have agency over, namely one to three generations of family epigenetic markers, and the buildings we design, we see that they roughly parallel each other. The decisions we make for both our lifestyle and our designs will affect our own lives and extend into those of our children and grandchildren, highlighting the significance of these decisions within the greater context of the species' and planet's timelines. By identifying barriers, and then stitching our cities together with spaces that nudge us towards a healthier lifestyle, we may be able to affect massive change for those members of our family, as well as broader community health. My hope is that we



67| Typical lifespan of three generations compared to the lifespan of the species, a typical building, and the planet

reach a critical mass of architects and urban planners who appreciate and relish the profound bioethical responsibility to design for better health outcomes, and through multidisciplinary collaboration and continued innovation, we may one day wield a powerful toolkit for affecting positive change for sustainability of both the planet and its species.

When urban and architectural design facilitates movement, communities are more likely to choose active transportation methods over driving, mitigating our dependency on fossil-fuels. The broad accessibility to - and significant impact of - physical activity galvanizes its centrality in the picture for comprehensive public health. When we nurture our physical health, improvements to mood, cognitive function, relationships, sex life, professional life, and longevity follow, bringing positive changes to community mental health, economic strength, and environmental sustainability. Designing for the holistic health of our communities will require a retooling of both government policy and design theory. Architects and designers must recognize their ethical responsibility for health in the greater sustainability equation and take action to contribute to a viable future for population and planet longevity.

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