The River is the Solution:
Infrastructure of Dwelling in Calgary's Urban Landscape

by

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ABSTRACT

This thesis explores the architectural implications of flooding through the lens of landscape urbanism. Developing a critical understanding of ecological discourse, I consider dualism as the underlying cause of climate disruption and examine the role infrastructure in mediating the relationship between nature and culture. Through a design methodology that involves data-driven mapping, typological analysis, and systematic site selection, I frame the thesis position in the context of Calgary, Alberta and propose design strategies at three interconnected scales to accommodate, absorb, and accept flooding as a natural process of riparian ecosystems. From this investigation, I draw several conclusions evaluating the administrative boundaries typically used to define territory in order to reach a more inclusive understanding of human inhabitation within ecological systems. By working with the river, not against it, infrastructure can create a framework for dwelling that enables cities to embrace the challenges of an unpredictable future.

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Thank you.

CHAPTER 1: INTRODUCTION

The intent of this thesis is to demonstrate that architecture can challenge our assumptions about nature and encourage us to reconsider our place in a changing world. As a result of climate change, many cities are facing the risks of more frequent and intense flooding. Some experts say that we should build a dam to keep rising waters out, while others say that we should clear the floodplain and let the river follow its own path. However, both of these approaches reflect a prevailing view that natural forces are a problem, reinforcing the underlying dualism between nature and culture that has led to the current ecological crisis. In its capacity to mediate between natural and built environments, infrastructure should negotiate the risks inherent to ecological processes while creating opportunities for collective inhabitation. Through design research, I intend to answer the question:

How can cities develop an inclusive relationship to and within ecological systems?

It would be impossible for me to ignore my own experiences in influencing my decision to pursue this topic. Growing up in Calgary, I lived across the street from the banks of the Elbow River. On a hot summer day, I would spend hours wading in the cold water, collecting rocks and catching minnows. Experiences like this form part of my identity and shape the way I navigate the city. Since the major flood of 2013, I have seen a change in attitudes towards the river. It is now something to be feared, rising waters to be kept away at all costs. I cannot deny that the flood was a devastating event; many people lost their homes, and some lost their lives. But it has become clear to me that the risks of flooding are only the symptoms of something much more destructive: a deeply ingrained assumption that cities are somehow excluded from having to work within the vicissitudes of nature.

In the following chapters, I develop a critical understanding of current ecological discourses in the natural and social sciences. Situating myself within the architectural practice of landscape urbanism, I examine the role of infrastructure in mediating the relationship between nature and culture. Through a design methodology that involves data-driven mapping, typological analysis, and systematic site selection, I

frame the thesis position in the context of Calgary, Alberta. I then propose design strategies at three interconnected scales to accommodate, absorb, and accept flooding as a natural process of riparian ecosystems.

From the thesis response, I draw several conclusions evaluating the administrative boundaries typically used in designing infrastructure. In an ecological paradigm, we should think of these boundaries as thresholds rather than limits. We should look for opportunities to align technical and social requirements. We should explore alternative models of ownership that do not exclude land from ecological responsibility. Finally, we should shift our focus from keeping water out to letting water in, acknowledging the entire urban landscape as a continuous watershed. By working with the river, not against it, infrastructure can create a framework for dwelling that enables cities to embrace the challenges of an unpredictable future.

CHAPTER 2: THE NATURE OF CITIES

> The true idea of a harmony of nature... is by its very essence discordant, created from the simultaneous movements of many tones, the combination of many processes flowing at the same time along various scales, leading not to a simple melody but to a symphony at some times harsh and at some times pleasing.[1]

My understanding of the dialectic between nature and culture emerged from the field of ecology. Ecology is an interdisciplinary science that studies the interactions between living organisms and their environment.[2] However, as Chris Reed and Nina-Marie Lister argue, ecology "has been co-opted to refer to almost any set of generalized ideas about environment or process, rendering the term essentially meaningless."[3] For the purposes of this thesis, a more specific definition is necessary. In this chapter, I will seek to develop a critical understanding of ecology, highlight the importance of ecological thinking in light of environmental disruption, and consider the potential for architecture to bridge the divide between natural and built environments. Within this inclusive understanding of ecological systems, the forces of nature are seen not as a problem but as an opportunity to improve inhabitation within the urban landscape.

Defining Ecology

In recent years, the field of ecology has undergone a paradigm shift from concerns of order and stability to those of dynamics and resilience.[4] An ecological system (or ecosystem) can be defined as a set of living and non-living things interacting in a given environment.[5] Since the emergence of ecology as a science in the early twentieth century, ecologists have proposed various models to explain how ecosystems function. According to Reed and Lister, these models tend to fall

1. Daniel B. Botkin, *Discordant Harmonies: A New Ecology for the Twenty-First Century* (New York: Oxford University Press, 1990), 8.
2. Robert Leo Smith and Stuart L. Pimm, "Ecology," *Encyclopaedia Britannica*, August 16, 2016, accessed July 15, 2017, https://www.britannica.com/science/ecology.
3. Chris Reed and Nina-Marie Lister, "Parallel Genealogies," in *Projective Ecologies*, ed. Chris Reed and Nina-Marie Lister (Cambridge, MA: Harvard University Graduate School of Design, 2014), 23.
4. Ibid., 24–28.
5. Kathleen C. Weathers, David L. Strayer, and Gene E. Likens, "Introduction to Ecosystem Science," in *Fundamentals of Ecosystem Science*, ed. Kathleen C. Weathers, David L. Strayer, and Gene E. Likens (Waltham, MA: Elsevier, 2013), 3.

into two major categories: linear succession and complex systems.[6] Early models of linear succession describe the steady and predictable growth of ecosystems towards a climax condition, which remains relatively stable unless acted upon by external forces.[7] However, emerging discourses understand ecological systems as complex and open-ended networks.[8] A constant state of flux arises from the dynamic interactions between flows of matter and energy.

C.S. Holling and M.A. Goldberg outline four properties inherent to ecological systems.[9] The *systemic* property describes the complex feedback mechanisms between many components. The *historical* property responds to the past, reflecting the evolution of an ecosystem over time. The *spatial* property represents the heterogeneous distribution of an ecosystem's components and functions in space. The *nonlinear* property concerns the existence of thresholds and limits that prevent constant growth. Together, these properties describe the basic structure of all ecosystems.[10]

The paradigm shift towards complex systems is reflected in the way we understand how ecosystems respond to change. Holling defines resilience as persistence in the structure of a complex system.[11] A resilient ecosystem is able to absorb incremental changes in its environment while maintaining the basic structure of its relationships.[12] There is an important distinction between stability and resilience; while stability implies resistance to change, resilience implies adaptation. Reed and Lister explain that change is integral to ecosystems and is sometimes a necessary condition for growth and regeneration.[13] We can attribute any perceived stability in an ecosystem to relatively slow rates of change in comparison to our perception

6. Reed and Lister, "Parallel Genealogies," 24–28.
7. Ibid., 25.
8. Ibid.
9. C. S. Holling and M.A. Goldberg, "Ecology and Planning," in *Projective Ecologies*, ed. Chris Reed and Nina-Marie Lister (Cambridge, MA: Harvard University Graduate School of Design, 2014), 111–113.
10. Ibid., 113.
11. C. S. Holling, "Resilience and Stability of Ecological Systems," *Annual Review of Ecology and Systematics* 4 (1973): 17, accessed December 9, 2016, http://www.jstor.org/stable/2096802.
12. Holling and Goldberg, "Ecology and Planning," 107.
13. Reed and Lister, "Parallel Genealogies," 25.

of time.[14] However, Daniel B. Botkin warns that while some rates of change are acceptable, others are not.[15] Relating to the concept of resilience, unacceptable change can be described as rapid change to which an ecosystem is unable to adapt while maintaining its underlying properties. As Lister writes, "such changes may result in a reorganization of the system's structures and functions into a new, or alternate steady state."[16] It is this transformative potential that allows ecosystems to persist in the face of unacceptable change.

We are undergoing a period of unacceptable change. We know that the average global temperature is rising at an unprecedented rate.[17] We know that the frequency and intensity of extreme weather events are increasing.[18] We are almost certain that this change is caused primarily by an increase in greenhouse gas emissions from human activities.[19] Climate change demands that we re-evaluate the organization of our cities; according to the United Nations, cities cover only 2% of the earth's land area but account for up to 70% of greenhouse gas emissions.[20] If we acknowledge cities as ecosystems, encompassing the systemic, historical, spatial, and nonlinear properties that allow complex systems to adapt and evolve, then we must confront the possibility that the only way to overcome climate change is through a radical transformation of our relationship to the urban environment.

14. Ibid., 26.
15. Botkin, *Discordant Harmonies*, 11–12.
16. Nina-Marie Lister, "Resilience," in *Projective Ecologies*, ed. Chris Reed and Nina-Marie Lister (Cambridge, MA: Harvard University Graduate School of Design, 2014), 276.
17. Intergovernmental Panel on Climate Change, "Synthesis Report," *Climate Summit 2014*, (Geneva, Switzerland: IPCC), 2, accessed July 15, 2017, https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf.
18. Ibid., 7.
19. Ibid., 4.
20. United Nations Human Settlements Program, "Hot Cities: Battle Ground for Climate Change," *Global Report on Human Settlements 2011* (Nairobi, Kenya: UN-HABITAT), 1, accessed December 9, 2016, http://mirror.unhabitat.org/downloads/docs/E_Hot_Cities.pdf.

Ecology in Three Dimensions

How do we adapt to climate change when we are the ones responsible for it? Reed and Lister argue, "given the uncertainty inherent to ecosystems in a complex systems paradigm, coupled with the uncertainty around climate disruption, it is likely necessary to change the way we design and manage interventions in our ecosystems."[21] In *This Changes Everything*, Naomi Klein calls for an upheaval of the social, political, and economic systems that underlie contemporary society.[22] While Klein implicates global capitalism as the fundamental problem, Félix Guattari offers a more holistic understanding of the ecological crisis. According to his philosophy, ecology is the relationship between nature and culture that exists in three dimensions: mind, society, and environment.[23]

In Guattari's writings we uncover a critical understanding of the current field of ecology as simultaneously:

- a nascent subjectivity
- a constantly mutating socius
- an environment in the process of being re-invented[24]

The three ecologies can be seen as axes forming a three-dimensional field that contains many different concepts or ideas about nature.[25] Rooted in Cartesian philosophy, dualism is based on the belief that mind and environment are fundamentally different. This binary opposition places subjectivity and objectivity on separate axes of understanding our relationship to a *nature* that exists outside of the structures of human society. As a result, we tend to define natural environments subjectively (based on a feeling or emotion) and built environments objectively (based on an observation or fact). I argue that any clear distinction between *natural* and *built* is an artificial one, rooted in a flawed narrative of nature as something

21. Reed and Lister, "Parallel Genealogies," 27.
22. Naomi Klein, *This Changes Everything: Capitalism vs. The Climate* (Toronto: Knopf, 2014).
23. Félix Guattari, *The Three Ecologies*, trans. Ian Pindar and Paul Sutton (London: Athlone Press, 2000).
24. Ibid., 68.
25. Christopher Hight, "Designing Ecologies," in *Projective Ecologies*, ed. Chris Reed and Nina-Marie Lister (Cambridge, MA: Harvard University Graduate School of Design, 2014), 97.

distinctly separate from culture. All environments are socially constructed because in order to perceive nature we must enter into a reciprocal relationship with it. In doing so, we give it meaning through the structures of memory and knowledge. As Reed and Lister explain, "the apparent contrast between humans and nature can be delineated... only via a set of models that are intrinsically human."[26] If we understand natural and built as different ways of describing an inclusive nature, we move beyond dualism towards what may be defined philosophically as a neutral monism.[27] In this view, mind and environment are mediated by a third and distinct element, society.

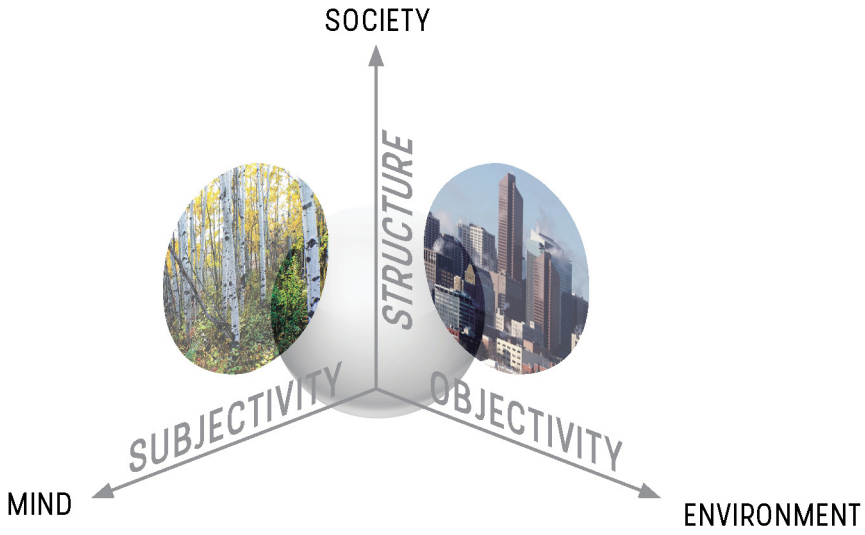
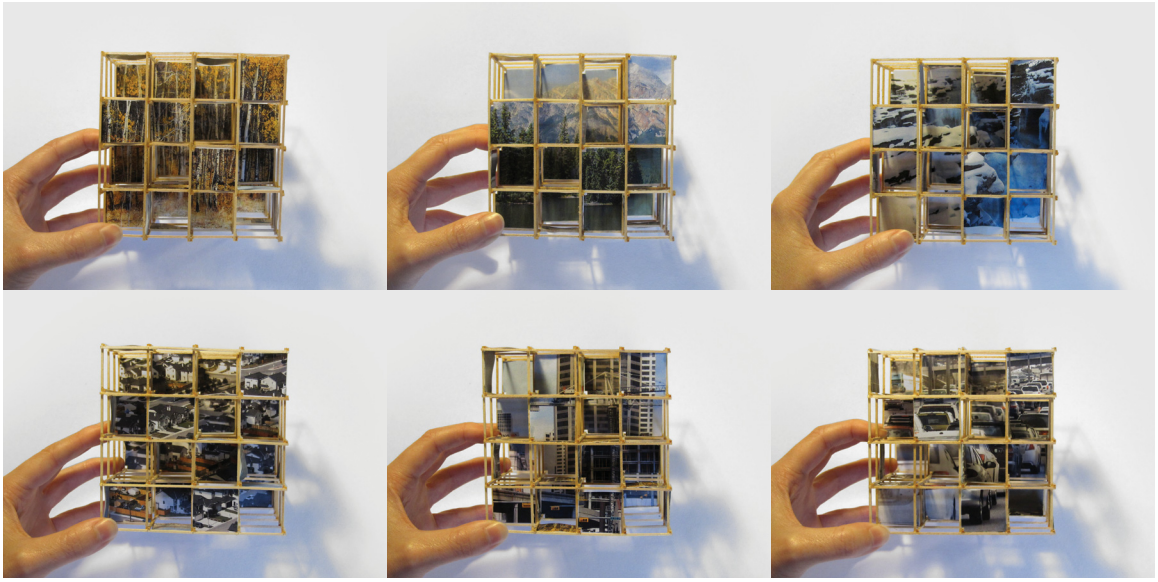
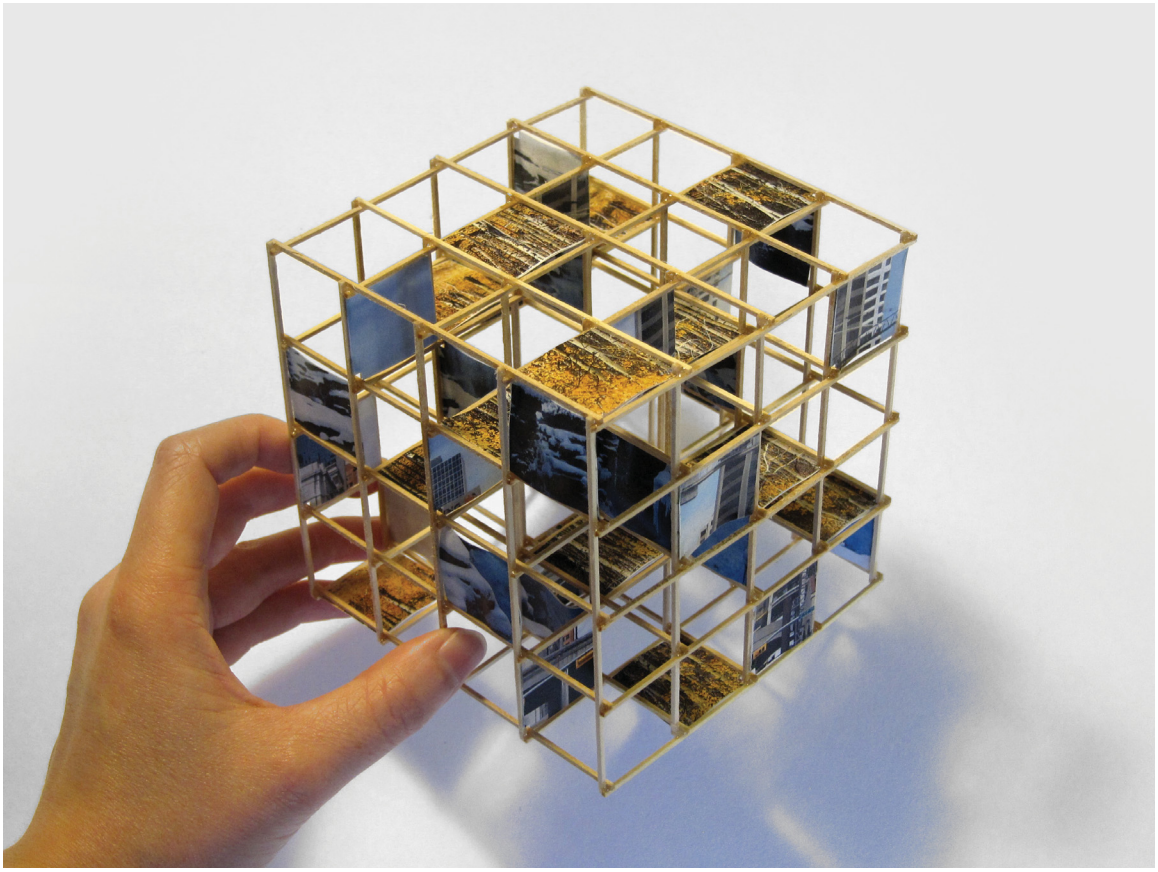


Diagram conceptualizing the relationship between nature and culture within the dimensions of mind, society, and environment. Natural and built environments are shown as two-dimensional reflections of a three-dimensional sphere, representing nature. Photographs by James Bremner and Bernard Spragg.

26. Reed and Lister, "Parallel Genealogies," 30.
27. Dustin Dewynnne, "Dualism vs. Monism," *Wikimedia Commons*, July 24, 2012, accessed July 15, 2017, https://commons.wikimedia.org/wiki/File:Dualism-vs-Monism.png.





Interactive model explaining how the distinction between natural and built is socially constructed. Fragments of photographs are embedded in a supporting framework. When viewed directly, each side of the cube reveals an image of an environment typically perceived as natural or built. A complete understanding can only be gained by rotating the cube and viewing it from various angles.

Nature is inextricably bound to identity and place; there is no nature without culture, and there is no culture without nature. The language I am using to describe my position is subtle yet important. It is not about *co-existing* with nature; the very idea of nature as something that exists outside of our experiences prevents a more holistic connection to the land that sustains us. Botkin writes, "current knowledge about the biosphere is out of step with current beliefs about nature, which is one of the main impediments to progress on environmental issues."[28] Therefore, a solution to climate change cannot be found in a simple restructuring of the ways in which we manage environmental systems. More importantly, it calls for a radical restructuring of the ways in which we as humans relate to our environment—an ecology that encompasses not only our knowledge of the natural world but also our place within it.

Urban Landscapes

This thesis aims to bridge the divide between natural and built environments through the social structures that give rise to both. In "Ecology and Landscape as Agents of Creativity," James Corner demonstrates that current approaches to environmental management represent particular modes of relating to the natural world in which humans can either reverse or control environmental processes.[29] Both ideologies see natural forces as a problem, essentially reinforcing the dualism between nature and culture that has led to the current ecological crisis. In each case, "only the symptoms of ecological distress are dealt with, while causal cultural foundations—the social structures that underlie dualism, alienation, domination, and estrangement—are ignored and unchanged, if not actually upheld."[30] In "Terra Fluxus," Corner asserts that this underlying dualism has led to the separate architectural disciplines of *landscape* and *urbanism*, a distinction that places cities in fundamental opposition to nature.[31] The emerging practice of landscape

28. Botkin, *Discordant Harmonies*, 8.

29. James Corner, "Ecology and Landscape as Agents of Creativity," in *Projective Ecologies*, ed. Chris Reed and Nina-Marie Lister (Cambridge, MA: Harvard University Graduate School of Design, 2014), 49–52.

30. Ibid., 51–52.

31. James Corner, "Terra Fluxus," in *The Landscape Urbanism Reader*, ed. Charles Waldheim (New York: Princeton Architectural Press, 2006), 21–33.

urbanism seeks to unite the two estranged disciplines through "the development of a space-time ecology that treats all forces and agents working in the urban field and considers them as continuous networks of inter-relationships."[32] From these writings emerges an understanding of natural forces as active agents in the designing of cities, uniting natural and built environments in the three-dimensional sphere of nature.

Having recovered a critical understanding of ecology as the fundamental relationship between nature and culture, I return to the concept of resilience. As defined earlier, resilience is the ability of an ecosystem to adapt to change while maintaining its underlying structure. However, when faced with unacceptable change, we are called upon to rearrange the social structures that bind our cities together. This radical paradigm acknowledges nature as integral to our identity and to our future.

32. Ibid., 30.

CHAPTER 3: THE INFRASTRUCTURE OF DWELLING

> A city is as much an *infrastructure of ideas* as it is a gathering of people, a layout of streets, an arrangement of buildings, or a collection of political, economic, and social institutions. The infrastructure of ideas neither precedes nor follows the building of a physical and social infrastructure, but is inseparable from them.[33]

Reflecting the inner workings of the urban realm, infrastructure refers not only to the physical networks used for transportation, energy, and water management in cities but also to the social systems necessary to cultivate and sustain a resilient community. This chapter will critically evaluate the definition of infrastructure, its relationship to the field of architecture, and its role in encouraging an inclusive connection to nature. As the infrastructure of dwelling, architecture is the framework around which urban landscapes take form.

Defining Infrastructure

The role of infrastructural systems is to mediate between natural forces and human inhabitation.[34] These systems are often used to convert energy from the natural environment into useful form. For example, a hydroelectric dam converts the kinetic energy of flowing water into electrical energy for household lights and appliances. Infrastructure may also function to moderate the impact of natural events such as floods, hurricanes, or earthquakes. In the same example, the dam regulates the flow of water downstream, preventing the river from overflowing its banks during a period of heavy rainfall.

At its best, infrastructure facilitates the connection between nature and culture, mitigating the risks inherent in ecological processes while creating opportunities for collective inhabitation. However, Gregory J. Haley writes, infrastructure has often been used as "an instrument of separation and disconnection, severing relations rather than bringing together."[35] Efforts towards the architectural

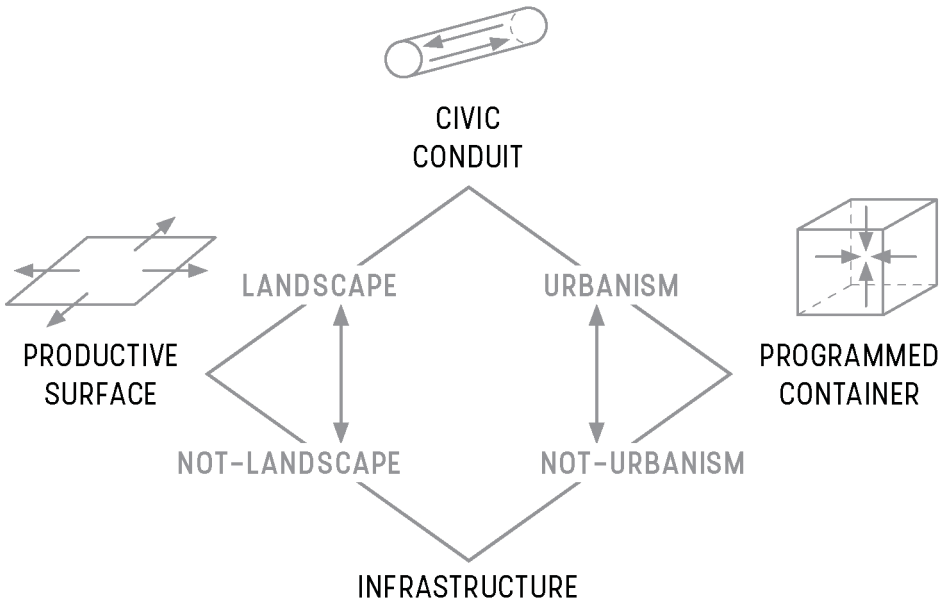
33. Carl Smith, *City Water, City Life: Water and the Infrastructure of Ideas in Urbanizing Philadelphia, Boston, and Chicago* (Chicago: University of Chicago Press, 2013), 2.
34. Gregory J. Haley, "The Mediating City: A New Infrastructural Ecology" (paper presented at the Architecture_MPS conference *The Mediated City*, Woodbury University, Los Angeles, California, October 1–4, 2014): 1, accessed December 9, 2016, http://architecturemps.com/los-angeles.
35. Ibid.

integration of large-scale engineering technologies since the Industrial Revolution have ultimately given way to the implementation of mono-functional infrastructure that is either segregated from the city or buried beneath its surface.[36] Elizabeth Mossop explains that infrastructural systems have become overly standardized; "these ubiquitous urban environments have been considered and evaluated solely on technical criteria and somehow exempted from having to function socially, aesthetically, or ecologically."[37]

Infrastructure in the Expanded Field

Mason White argues that infrastructure should become an essential part of the architect's vocabulary.[38] Borrowing his methodology from Rosalind Krauss' "Sculpture in the Expanded Field,"[39] White problematizes current understandings of infrastructure as a set of negations; infrastructure is any part of the built environment that is *not-landscape* and *not-urbanism*. This definition suggests that infrastructure has nothing to do with architectural practice. Instead, White positions infrastructure within an expanded field, framed by the complex definitions of *landscape* and *urbanism*. This framework opens up infrastructure to spatial disciplines through the formats of *productive surface*, *civic conduit*, and *programmed container*.[40] The expanded field constitutes the architecture of the built environment, making visible the dynamic relationships between people and the places they inhabit.

36. Ibid., 2-3.
37. Elizabeth Mossop, "Landscapes of Infrastructure," in *The Landscape Urbanism Reader*, ed. Charles Waldheim (New York: Princeton Architectural Press, 2006), 171.
38. Mason White, "Disciplinary Thievery," *Oz Journal* 34 (2012): 4–13, accessed December 9, 2016, doi:10.4148/2378-5853.1498.
39. Rosalind Krauss, "Sculpture in the Expanded Field," *October* 8 (spring 1979): 30–44, accessed December 9, 2016, http://www.jstor.org/stable/778224.
40. White, "Disciplinary Thievery," 6.



Expanded field diagram situating infrastructure within the oppositional axes of landscape and urbanism; modified from White, "Disciplinary Thievery."

Urban Dwelling

As the physical expression of inhabitation, architecture is the infrastructure of dwelling. In "Building, Dwelling, Thinking," Martin Heidegger argues that dwelling is the manner in which humans inhabit the earth.[41] Dwelling is fundamentally a preserving of the fourfold: earth, sky, divinities, and mortals.[42] Together as a singular entity, the fourfold can be understood as nature itself. However, Heidegger argues, the preserving of nature cannot be accomplished without its presencing through the cultivation and construction of things; a thing allows for the existence of a location, which in turn provides room for the fourfold to enter into a site by arranging the site into spaces. Building is the act of dwelling, or as Heidegger states, "the nature of building is letting dwell."[43] This paradoxical view of building as preserving is integral to an inclusive understanding of nature. The built environment should not be placed in opposition to nature but rather acknowledged as part of it.

41. Martin Heidegger, "Building Dwelling Thinking," in *Poetry, Language, Thought*, trans. Albert Hofstadter (New York: Harper & Row, 1971), 146.
42. Ibid., 147–149.
43. Ibid., 157.

The urban landscape becomes the space in which ecology and infrastructure collide. The word ecology is derived from the ancient Greek *oikos*, meaning household.[44] Encompassing the relationships of the nuclear family, *oikos* was the basic unit of *polis* or society.[45] According to Rod Giblett, the dualism between nature and culture is manifested in *oikos* and *polis*, representing the private and public spheres of urban life.[46] This structure has persisted as the predominant mode of dwelling in contemporary society. However, the current ecological crisis challenges this dichotomy. Elaine Kelly writes, "the deconstructive force of climate change is foundationally disruptive: it calls into question the very conditions of dwelling."[47] The home is no longer a place of shelter from the forces of nature but the very grounds upon which these forces are negotiated.[48]

The specific condition I am confronting is that of private land ownership, at least as it currently exists in most North American cities. According to Robert Gilman, the idea of owning land "is so deeply embedded in our fundamental cultural assumptions that we never stop to consider its implications or alternatives."[49] Legally speaking, ownership is a framework that imparts exclusive rights to use and modify the land (notwithstanding building codes, land use bylaws, etc.)[50] I argue that private land ownership is a sort of social infrastructure propagating the Not In My Back Yard (NIMBY) attitude that is so pervasive when it comes to dealing with environmental issues.

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44. Smith and Pimm, "Ecology."
45. J. Roy, "'Polis' and 'Oikos' in Classical Athens," *Greece & Rome* 46, no. 1 (1999): 1, accessed December 9, 2016, http://www.jstor.org/stable/643032.
46. Rod Giblett, *People and Places of Nature and Culture* (Chicago: University of Chicago Press, 2011), 41–42.
47. Elaine Kelly, "Does Deconstruction Matter? Being 'at Home' in the Era of Climate Change," *Continuum* 27, no. 1 (2013): 50, accessed December 9, 2016, doi:10.1080/10304312.2013.737195.
48. Ibid., 42.
49. Robert Gilman, "The Idea of Owning Land," *In Context* 8 (winter 1984), accessed July 15, 2017, http://www.context.org/iclib/ic08/gilman1.
50. Ibid.

How can we take any meaningful action on climate change if the majority treats land as a commodity to be excluded from the public domain? This question need not be an all-or-nothing power struggle between individual freedom and state control.[51] Besides standard social housing models where buildings are publicly owned, there are other options. In a community land trust (CLT) model, land is owned by a not-for-profit organization and leased to users, who own their buildings. The CLT regulates land use and ensures that development meets the long-term needs of the community, while users retain the ability to build, modify and gain profit from their homes.

CLTs may provide a viable alternative to private land ownership in cities where infrastructure is needed to mitigate the risks posed by climate disruption. By considering the urban landscape as a continuous fabric rather than a collection of individual parcels, communities would have greater agency in implementing mitigation strategies that are sensitive to the existing context and improving social conditions by providing affordable housing. This system would encourage beliefs and actions that reflect a more inclusive ecological understanding because it precludes NIMBY; nobody owns the land, but everyone is responsible for it.

Climate change highlights the need for infrastructure that is both technologically and socially responsible. Over the next few decades, the effects of climate change and urbanization will challenge the limits of our interactions within nature. As designers of the urban landscape, architects must consider how infrastructure gives shape to these interactions. Haley writes, "the future challenges of infrastructure are as much questions of collective values and ecological co-existence as they are of efficiencies and sustainability… Our future as a species will depend on how we distribute our resources, and how in the process we reimagine our place in this world and reconfigure… our concept of urban growth, the organization of our society, and our relation to and within nature."[52] It is through a restructuring of the relationship between the home and the city that the infrastructure of dwelling has the potential to bring nature and culture into alignment.

51. Ibid.

52. Haley, "The Mediating City," 3.

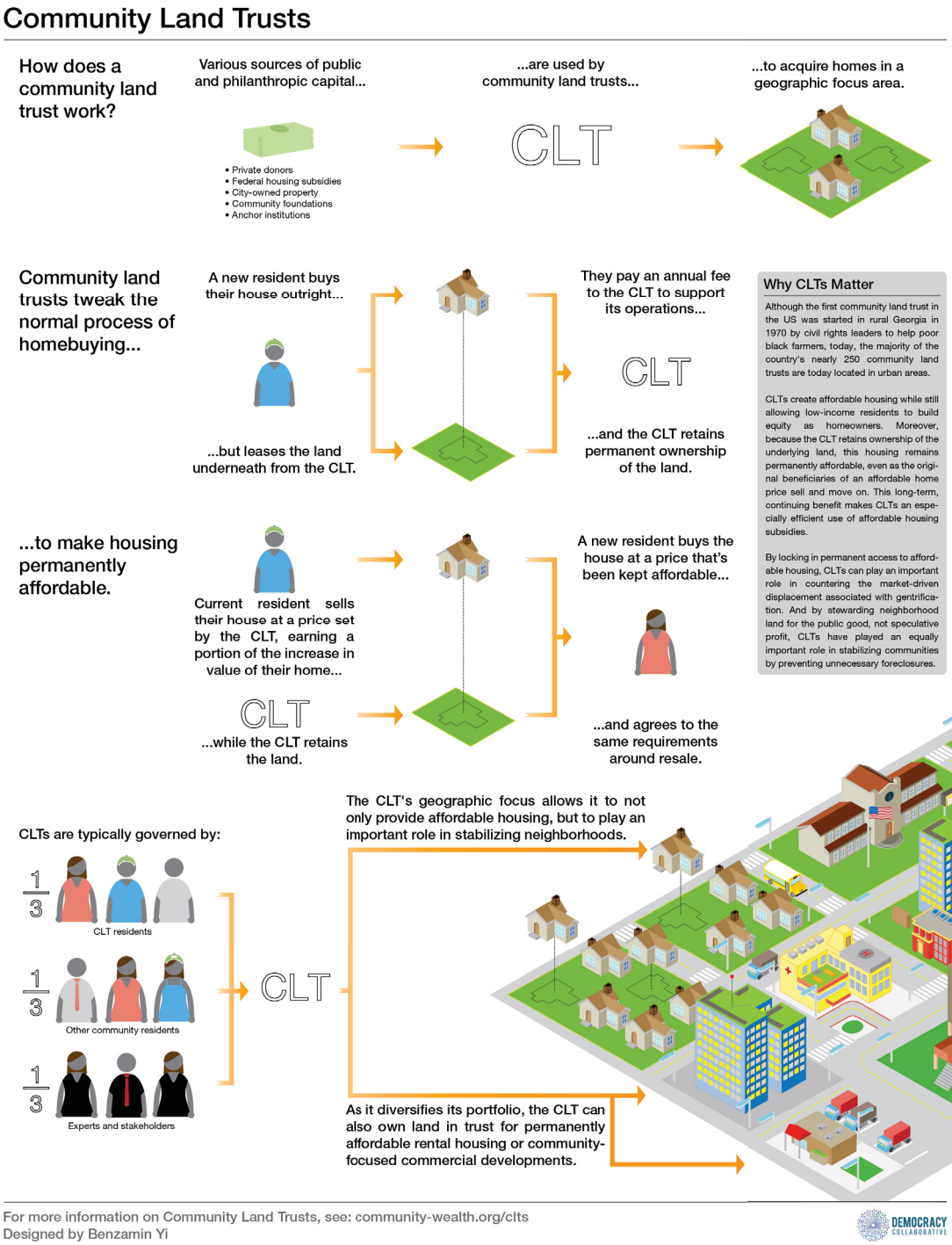


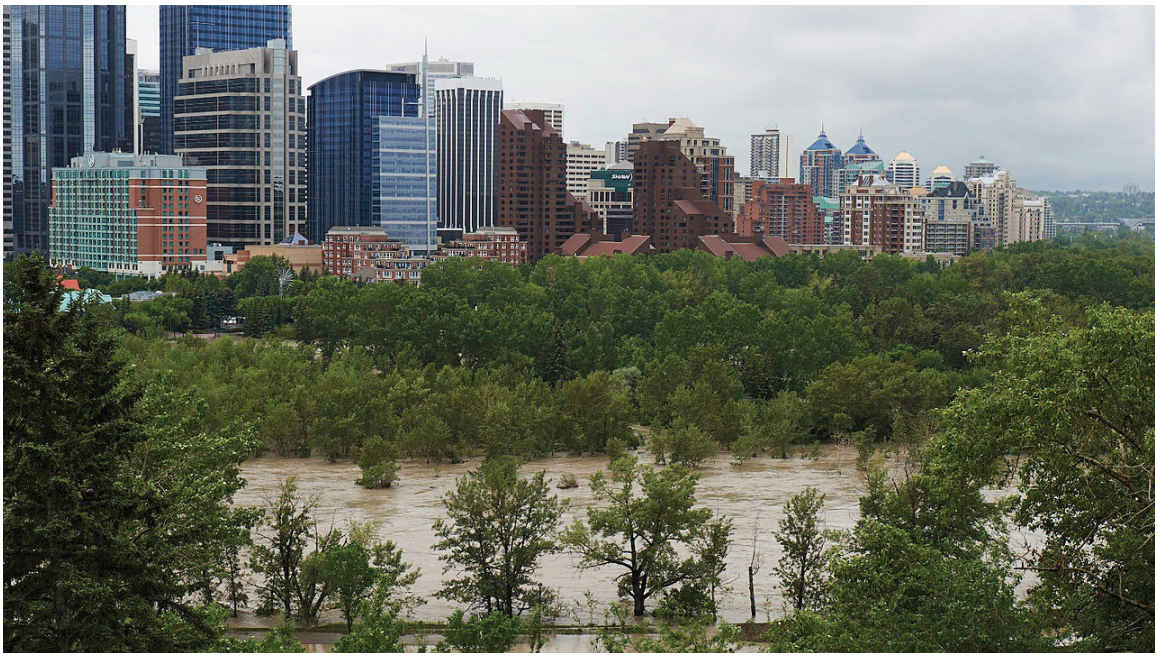
Diagram explaining the basic organization of a community land trust for affordable housing; from John Duda, "Infographic: Community Land Trusts."

CHAPTER 4: THE RIVER IS NOT THE PROBLEM

> Although we engage in ecological relationships, we have difficulty seeing the places where we live as ecological spaces... The structures that keep us dry and warm establish boundaries for the spaces we inhabit. These physical boundaries mediate our relationships with natural processes as they set frameworks for our interactions with other people.[53]

In June 2013, Calgary and surrounding areas in Southern Alberta experienced widespread flooding. It displaced over 100,000 people, damaged thousands of homes, and carried a six billion dollar price tag.[54] The flood was caused by a prolonged period of heavy rain and runoff from an unusually deep late-spring mountain snowpack.[55] This extreme event was considered a 100-year flood, meaning that there is a one percent chance of a flood of equal or greater magnitude occurring in any given year.[56] However, due to the effects of climate change, flooding is expected to become more frequent and intense.[57] Currently, many conflicting voices are contributing to the discussion on flood mitigation. I think what is lacking is a strategic vision: one that looks beyond short-term reactions in order to participate in the ongoing discourses of ecology, infrastructure, and landscape urbanism.

53. Frederick Steiner, *Human Ecology: How Nature and Culture Shape Our World* (Washington: Island Press, 2016), 40.
54. "Alberta Flood: By the Numbers One Year Later," *CBC News*, Jun 15, 2014, accessed July 15, 2017, http://www.cbc.ca/news/canada/calgary/alberta-flood-by-the-numbers-one-year-later-1.2676657.
55. Scott Sutherland, "Three Years Later: What Caused the 2013 Alberta Floods?" *Weather Network*, June 21, 2016, accessed July 15, 2017, https://www.theweathernetwork.com/news/articles/why-was-southern-alberta-so-vulnerable-to-flooding-in-2013/29800.
56. Ibid.
57. City of Calgary, "Calgary's Climate Program," accessed July 15, 2017, http://www.calgary.ca/UEP/ESM/Pages/Energy-Savings/Climate-Change.aspx.



The Bow River rushes through Prince's Island Park in downtown Calgary during the 2013 flood; photograph by Sean Esopenko.

The Elbow River reaches its peak as it floods Riverdale Avenue in the community of Elboya; photograph by Peter Wilson.

Two of the main strategies that have been put forward are property buyouts and an off-stream dry reservoir. Following the flood, the Government of Alberta established the Floodway Relocation Program, whereby the province offered to purchase any property in the floodway for its most recently assessed value.[58] Only seventeen property owners opted for the buyout in Calgary, resulting in a scattering of boarded-up and abandoned homes, which have since been removed or demolished.[59] However, there has not yet been a consensus on what to do with the vacant properties; the provincial government has considered putting them back on the market[60] or turning them into landscaped areas.[61] Furthermore, the intention of the buyout program to clear the floodway was not realized.

Several properties were left abandoned after government buyouts were offered in an attempt to clear the floodway; photograph by Lyle Aspinall.

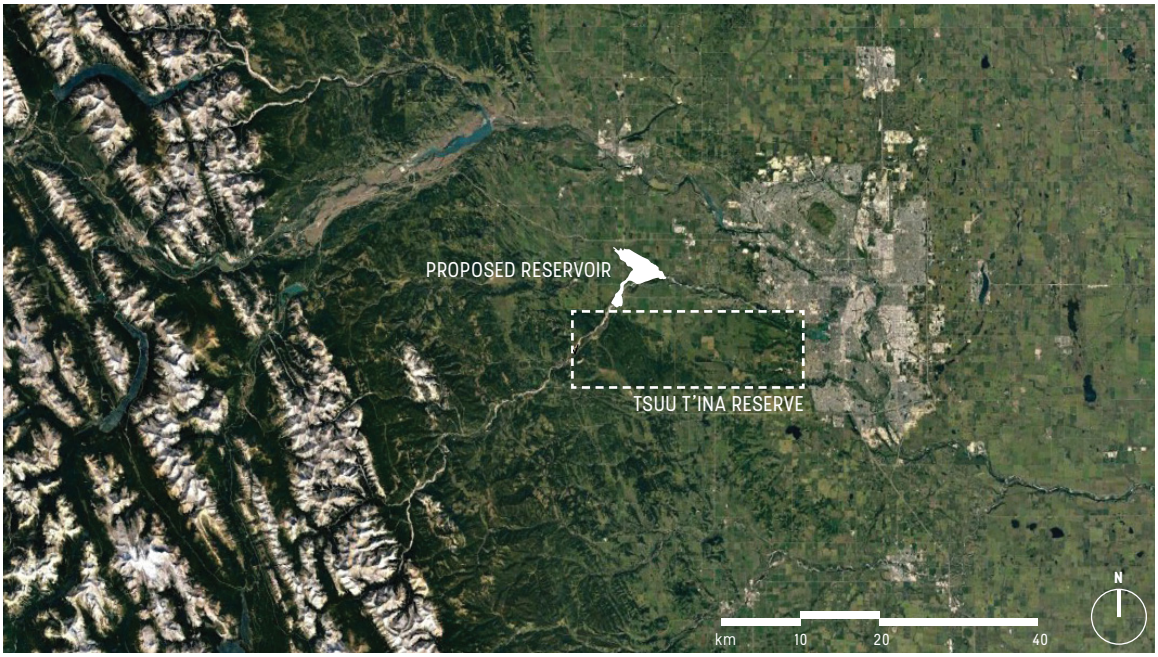
58. "Alberta to Support Relocation from Floodways," *Alberta Government News*, August 22, 2013, accessed July 15, 2017, https://www.alberta.ca/release.cfm?xID=3482784398BCF-9405-835A-2DE3B19C7F64F031.

59. Erika Stark, "Wrecking Ball to Hit 17 Calgary Homes Bought Out After 2013 Flood," *Calgary Herald*, August 13, 2014, accessed July 15, 2017, http://calgaryherald.com/news/local-news/wrecking-ball-to-hit-17-calgary-homes-bought-out-after-2013-flood.

60. Greg Clark, "Calgary-Elbow Update," *Calgary River Communities Action Group Blog*, April 9, 2017, accessed July 15, 2017, http://protectcalgary.com/update-mla-greg-clark-elbow-bow-flood-mitigation-new-city-calgary-chief-resiliency-officer.

61. City of Calgary, "Flood Affected Property – Frequently Asked Questions," accessed July 15, 2017, http://www.calgary.ca/PDA/pd/Pages/Flood/Flood-affected-property-frequently-asked-questions.aspx.

The provincial government has also committed to building an off-stream dry reservoir and dam along the Elbow River, about 15 kilometers upstream of Calgary. The reservoir would cover 3,610 acres of land currently used for farming, and is intended to manage floodwaters equivalent to the 2013 event.[62] However, the Tsuu T'ina First Nation, whose reserve lands lie directly adjacent to the proposed dam, is opposing the project, wary of its potential negative impact on their community.[63] Tsuu T'ina is citing the United Nations Declaration on the Rights of Indigenous People, which mandates that the government secure "free, prior and informed consent"[64] for actions that affect indigenous lands. It is unclear at the time of writing this thesis whether or not the project will go forward.



Satellite image showing the location of the proposed dry reservoir adjacent to the Tsuu T'ina Reserve; data from Alberta Environment and Parks, *Springbank Off-Stream Reservoir*; and Google Earth, *Elbow River Valley*.

62. Alberta Environment and Parks, "Springbank Off-Stream Reservoir," accessed July 15, 2017, http://aep.alberta.ca/water/programs-and-services/flood-mitigation/flood-mitigation-projects/springbank-road.aspx.
63. Eva Ferguson, "Tsuut'ina Nation Joins Fight Against Proposed Springbank Dam," *Calgary Herald*, March 8, 2017, accessed July 15, 2017, http://calgaryherald.com/news/local-news/tsuutina-nation-joins-fight-against-proposed-springbank-dam.
64. Ibid.

Early on in my research, it became evident to me that the choice between building a dam or clearing the floodplain seemed to be missing the bigger picture. Both approaches establish an all-or-nothing position in relation to floods, reinforcing the nature versus culture dualism ingrained in our cultural narrative. I began searching for a different way of understanding the relationship between people and land. The solution came in the form of a news article published in the *New York Times*. Resulting from a decades-long struggle over ownership of Te Urewera national park, the government of New Zealand had reached an agreement with the Tūhoe tribe of Māori people.[65] As part of the settlement, the government renounced formal ownership of the land and acknowledged Te Urewera as a legal person. What this agreement means is that the land is no longer considered a national park, but an independent living entity with all the legal rights and responsibilities of personhood.[66] Since then, a similar agreement has granted personhood to the Whanganui River, which the Whanganui tribe considers to be "an indivisible and living whole."[67] Two guardians, one chosen by the government and one by the tribe, are appointed to speak on behalf of the river and advocate for its long-term vitality.[68] This groundbreaking legislation has brought international attention to an emerging narrative that challenges the idea of private land ownership and transcends the dualistic boundaries of nature and culture. The people of Whanganui have a saying: "I am the river and the river is me."[69]

65. Bryant Rousseau, "In New Zealand, Lands and Rivers Can Be People (Legally Speaking)," *New York Times*, July 13, 2016, accessed July 15, 2017, https://www.nytimes.com/2016/07/14/world/what-in-the-world/in-new-zealand-lands-and-rivers-can-be-people-legally-speaking.html?_r=0.

66. Ibid.

67. Colin Dwyer, "A New Zealand River Now Has The Legal Rights Of A Human," *National Public Radio*, March 16, 2017, accessed July 15, 2017, http://www.npr.org/sections/thetwo-way/2017/03/16/520414763/a-new-zealand-river-now-has-the-legal-rights-of-a-human.

68. Ibid.

69. Rousseau, "In New Zealand, Lands and Rivers Can Be People (Legally Speaking)."

Could this understanding of the river as a living entity be applied in an urban context through an arrangement similar to a community land trust (where people own their buildings, but not the land)? It is beyond the scope of this thesis to discuss the legal or economic implications of such an arrangement. However, the rest of this chapter will explore its architectural implications through a design methodology that involves data-driven mapping, typological analysis, and systematic site selection. Although I am describing these phases linearly, each has built upon and woven back into one another as the thesis evolved.

The Whanganui River wanders across the North Island of New Zealand; photograph by Kathrin and Stefan Marks.

Data-Driven Mapping

I started by mapping the watershed as a means of framing the thesis position in the context of Canadian prairie cities. This exercise was driven by open-source data and processed using Geographic Information System (GIS) software. While data analysis may be seen as an objective method of understanding the urban landscape, each dataset is based on different subjective assumptions about the relationship between people and land. The layering of data-driven spatial information can begin to illuminate common values about nature and the ways in which these values influence urban development.

THE WEATHER

THE CALGARY DAILY HERALD

5 O'CLOCK EDITION

FORTY-SIXTH YEAR, No. 9909. CALGARY, ALBERTA, MONDAY, JUNE 3, 1929 22 PAGES

HUNDREDS OF CITY HOMES MENACED BY RIVERS

Baldwin Gov't Votes to Hand In Resignation

Cabinet Conference Monday Decides to Ask King for Official Release

MacDONALD TO AGAIN TRY MINORITY GOVT

For Second Time in Five Years British Labor Will Try to Carry On

Ghost River Dam Menaced by Floods

Worst Floods Since '02 Ravage Calgary And South Districts

All Residential Areas Now Rivers Are Completely Covered Monday

Rivers Still Rising On Monday Afternoon

Bowness and St. George's Parks Wrecked—Animals At Zoo Drowned

Twenty-Fifth Avenue Bridge Is Washed Out

Two Streams Pouring Flood Waters Over Big Sections of the City

THE SITUATION AT A GLANCE

Swollen Highwood Flowing Through High River Streets

Business Places Isolated by Water and Many Homes Cut Off

Livestock Being Carried Down Stream

Townspeople Watching Big Emergency Dams With Deep Anxiety as Water Rises

SEVEN SEATS STILL IN DOUBT; LABOR HOLDS SAFE LEAD

KING'S BIRTHDAY OBSERVED QUIETLY

HIS MAJESTY KING GEORGE

HEAVIEST RAIN IN YEARS STRIKES SOUTHERN ALBERTA

Bow and Elbow Rivers Continue to Rise Far Above Danger Levels

Dominion Water Power Officials Think Peak Has Been Reached

HEAVY RAIN REPORTED FROM JUMPING POUND; CREEK TEARING BANKS

The Day in Parliament

CANADA CONVEYS CONGRATULATIONS TO KING GEORGE

King George Sixty-Four, Ill in Bed

By THOMAS T. CHAMPION Staff Correspondent of the Canadian Press

The Weather

HERE AND ELSEWHERE

SHOWERY

LIGHT RAILWAY SPAN AT GHOST WASHED OUT

NOTED B.C. SPORTSMAN, "CON" JONES, IS DEAD

ESCAPED CONVICTS AT LETHBRIDGE LEAVE NO TRAIL FOR THE POLICE

Cold Rain Falling In Mountains; May Not Affect Floods

The Broadcasting Station CFAC The Calgary Daily Herald

When—

THE CALGARY HERALD

Front page newspaper clipping exemplifying the nature versus culture dualism ingrained in our cultural narrative; from "Hundreds of City Homes Menaced by Rivers," *Calgary Daily Herald*, June 3, 1929.

Watershed Regions

It may seem obvious, but all rivers start from somewhere and lead to somewhere else. To appreciate the full magnitude of this statement I needed to zoom all the way out. The first map shows the major watershed regions of Canada overlaying the provinces and territories. Each colored area represents a region of land, known as a watershed or drainage basin, where surface water drains into the same outlet. The highlighted area is the Nelson River watershed, spanning from the glaciers in the Rocky Mountains of Southern Alberta, across Saskatchewan and Manitoba, feeding into the Nelson River before emptying into Hudson Bay. In contrast to administrative boundaries such as provinces, ecological boundaries such as watersheds are probably better reflections of the ways in which land was understood and navigated prior to European colonization.

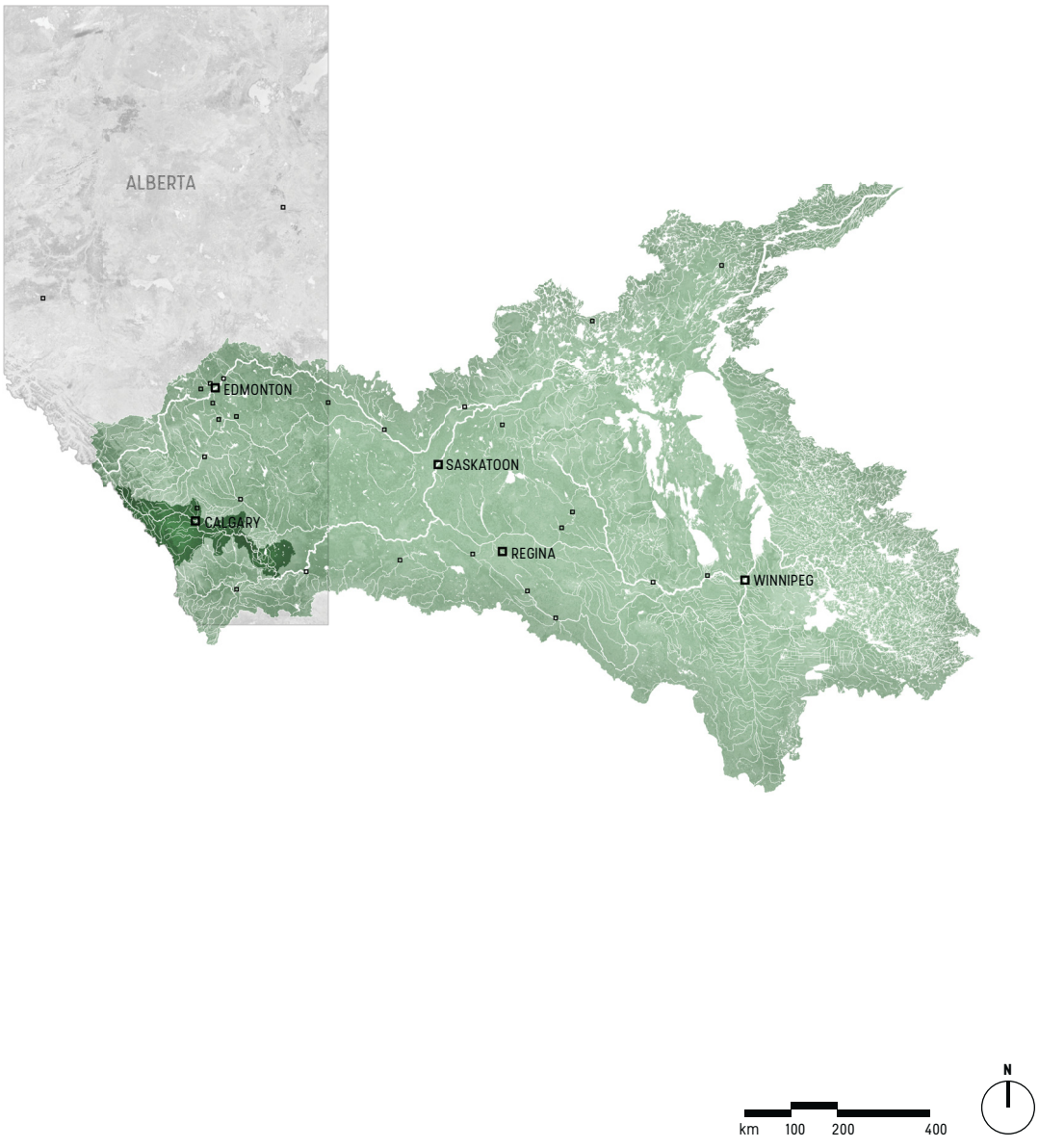
Map showing the five major watershed regions of Canada and the Nelson River watershed; data from Commission for Environmental Cooperation, *Lakes and Rivers 2009*; ESRI, *Provinces and Territories of Canada*, *World Continents*, *World Imagery*; and Natural Resources Canada, *Major River Basin*, *Ocean Drainage Areas*.

Nelson River Watershed

Zooming in on the Nelson River watershed, the second map shows prairie cities in relation to rivers. Every major city in this region is situated along a river, reflecting the importance of ecological systems in determining patterns of settlement. In the otherwise vast and windswept landscape of the prairies, river valleys provided shelter, fertile ground, and easy access to water.[70] Calgary is located within the Bow River watershed on the western edge of the prairies. As Beverly A. Sandalack and Andrei Nicolai write, "the situation of Fort Calgary at the confluence of the Bow and Elbow rivers acknowledged the importance of the water supply, and also started the city's relationship with these rivers."[71]

70. Beverly A. Sandalack and Andrei Nicolai, *The Calgary Project: Urban Form, Urban Life* (Calgary, AB: University of Calgary Press, 2006), 5-6.

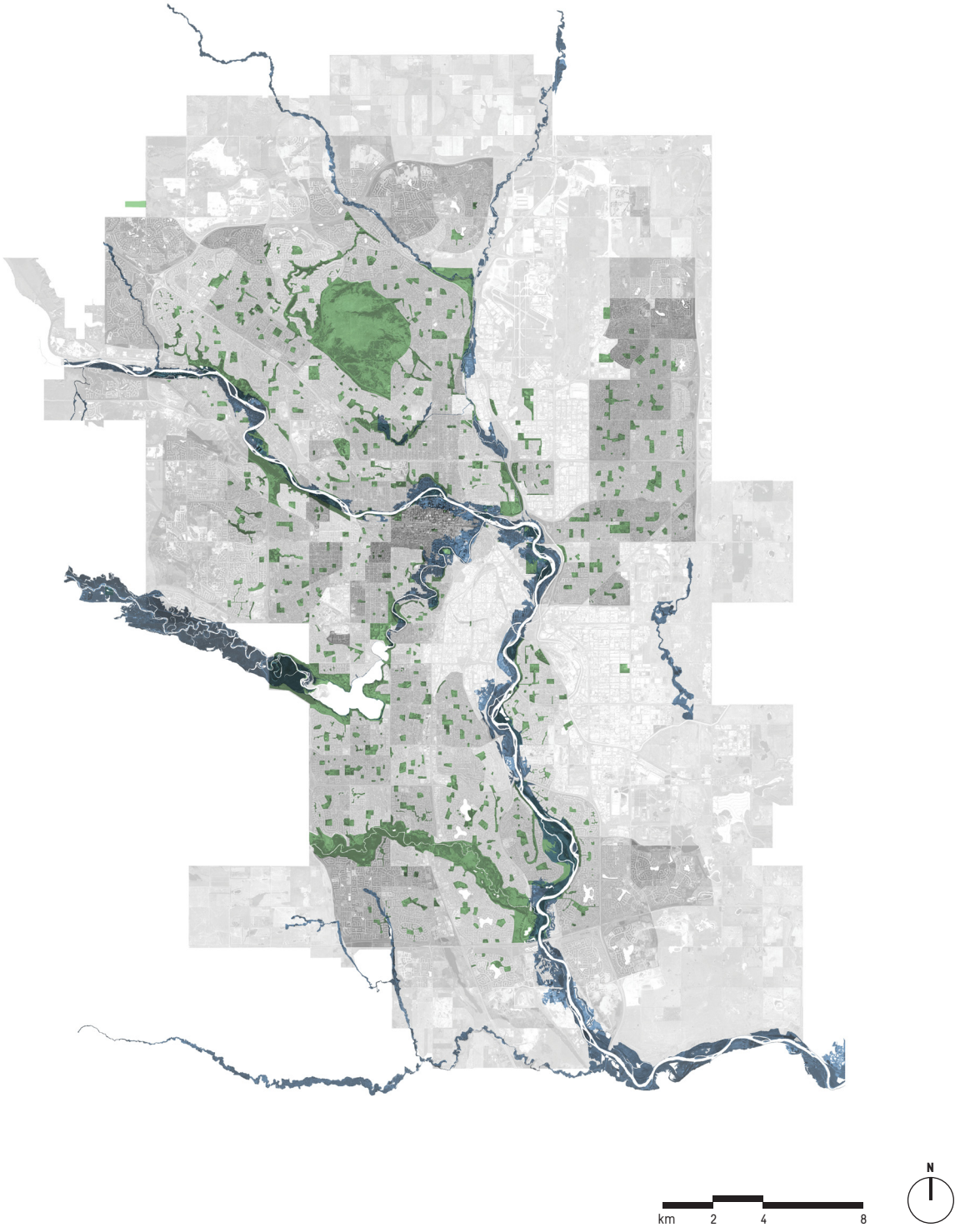
71. Ibid., 5.



Map showing the Nelson River and Bow River watersheds and the province of Alberta; data from ESRI, *Major Canadian Cities*, *Provinces and Territories of Canada*, *World Imagery*; and Natural Resources Canada, *Drainage Areas (WSC SDA)*, *Drainage Network – Nelson*, *Major River Basin*.

City Boundaries

While the characteristics of the landscape were so integral in establishing early urban form, they have now been relegated to a position as *other than* the city itself. The third map narrows in on Calgary, layering population density, parks, and riparian areas as a means of understanding the influence of the landscape on urban development. Parks are distributed throughout the city but tend to follow geographic features such as riverbanks, escarpments, and hills. There is a noticeable absence of parks in the city center where population density is most concentrated. These scattered patches of grass highlight our tendency to think of natural areas as isolated pockets of the city. The pervasive nature of the river disrupts this notion in favor of a more inclusive understanding.



Map of the city of Calgary showing the relationship between population density, parks, and riparian areas; data from City of Calgary, *City Boundary*, *Census by Community 2016*, *Hydrology*, *Riparian Areas – Variable Width*; and ESRI, *North America Parks*, *World Imagery*.

This series of maps intends to describe a way of understanding the river as a dynamic force moving through the landscape, vital in shaping the history and identity of our cities. In this narrative, the river is not just the river (as it is typically understood). The river is the mountains. It is the foothills and the prairies, the lakes and the oceans. The river is the place we live, the way we dwell. Which brings me back to the thesis question:

How can cities develop an inclusive relationship to and within ecological systems?

An important observation to be made is that ecological boundaries bear little resemblance to the administrative boundaries we use to define territory. I think these ecological boundaries should be given greater importance when it comes to designing in cities. In Calgary, flood hazard areas are administrative boundaries used to determine where and what can be built in terms of varying degrees of risk. In contrast, riparian areas are ecological boundaries used to describe varying degrees of influence that land and water have on one another. When responding to seasonal flooding, it is of obvious importance to manage risk in order to minimize damage and ensure personal safety. However, I would argue that it is more important to consider how our actions influence, and are influenced by, the ecosystems in which we interact. Perhaps flood hazard areas should look more like riparian areas. To reframe this statement:

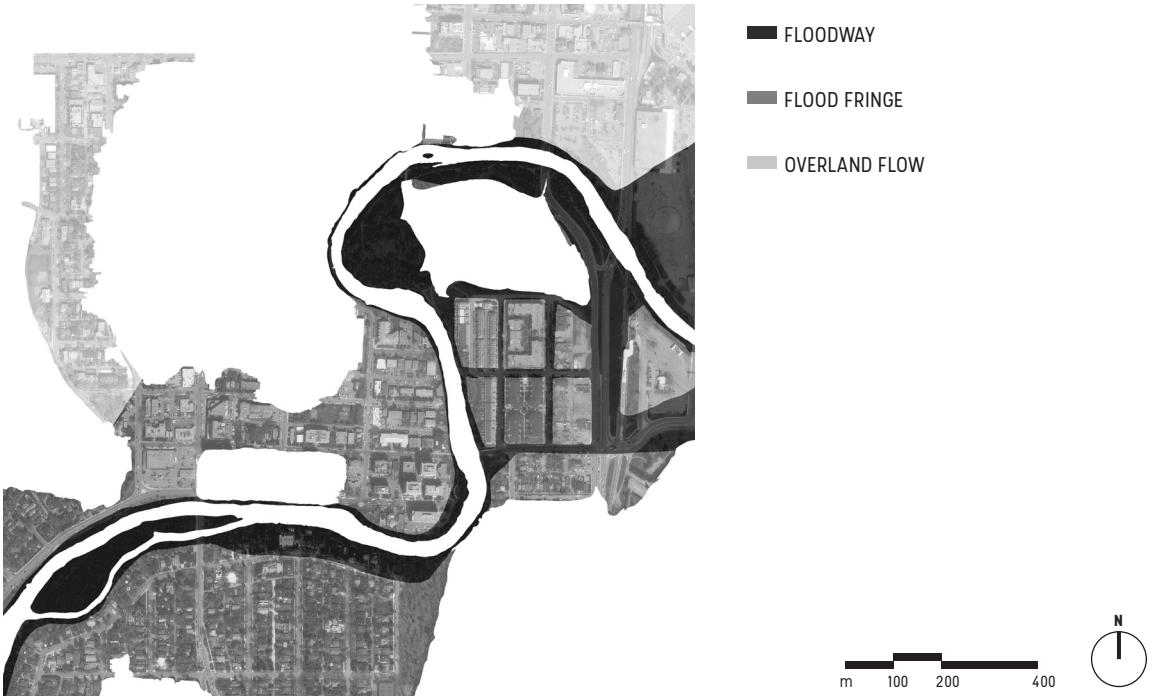
Administrative boundaries should reflect the varying degrees of influence that human inhabitation and ecological systems have on one another.

Flood Hazard Areas

According to Alberta Environment and Parks:

> Flood hazard mapping delineates areas that would be inundated during the 100-year design flood under encroached conditions... created to increase public safety and awareness of flood hazards, and be used as a planning tool by all levels of government and the public to mitigate future flood damages.[72]

- Floodway: The portion of the flood hazard area where flows are deepest, fastest and most destructive. The floodway typically includes the main channel of a stream and a portion of the adjacent overbank area. New development is discouraged in the floodway.
- Flood Fringe: The portion of the flood hazard area outside of the floodway. Water in the flood fringe is generally shallower and flows more slowly than in the floodway. New development in the flood fringe may be permitted in some communities and should be flood-proofed.
- Overland Flow: Areas of overland flow are part of the flood hazard area outside of the floodway, and are typically considered special areas of the flood fringe.[73]



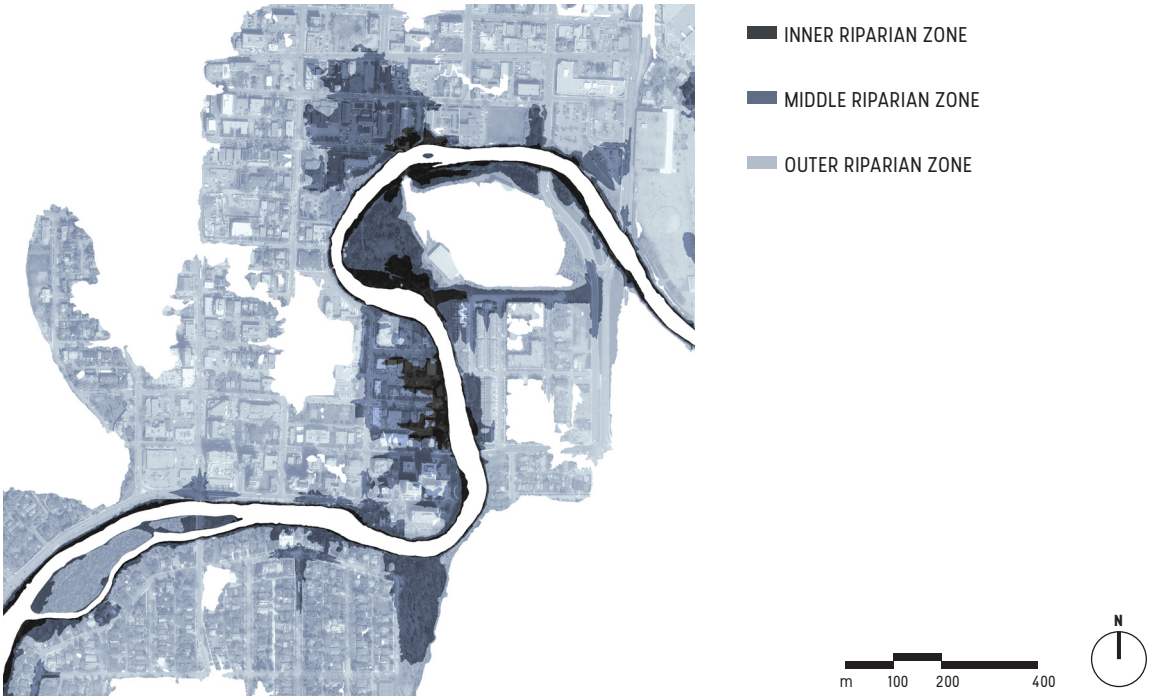
Flood hazard areas along the Elbow River; data from City of Calgary, *Bylaw Flood Hazard (100 Year)*; and ESRI, *World Imagery*.

72. Alberta Environment and Parks, "Digital Flood Hazard Mapping," accessed July 15, 2017, http://aep.alberta.ca/forms-maps-services/maps/resource-data-product-catalogue/hydrological.aspx.
73. Alberta Environment and Parks, "Flood Hazard Mapping," accessed July 15, 2017, http://aep.alberta.ca/water/programs-and-services/flood-hazard-identification-program/flood-hazard-mapping.aspx.

Riparian Areas

According to the City of Calgary:

> Riparian areas are transitional areas between upland and aquatic ecosystems. They have variable width and extent both above and below ground. These lands are influenced by and/or exert an influence on associated water bodies, which includes alluvial aquifers and floodplains, when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes.[74]
>
> - Inner Riparian Zone: This area directly adjacent to the stream is virtually certain to be riparian.
> - Middle Riparian Zone: This zone contains areas with strong potential to contain riparian conditions although in some cases riparian conditions may not arise.
> - Outer Riparian Zone: This area is riparian if conditions are right, but in other cases will not show riparian characteristics, although it still functions as an important interface between riparian areas and the surrounding uplands.[75]



Riparian areas along the Elbow River; data from City of Calgary, *Riparian Areas – Variable Width*; and ESRI, *World Imagery*.

74. O2 Planning and Design, "Riparian Areas Mapping Project – Phase 1 Technical Report" (report prepared for the City of Calgary, October 25, 2013): 34, accessed July 15, 2017, http://www.calgary.ca/_layouts/cocis/DirectDownload.aspx?target=http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Riparian_Areas_Mapping_Technical_Report.pdf.
75. Ibid, ii.

Typological Analysis

The architectural manifestation of the thesis position is not so much a method of construction but a physical and social infrastructure that allows ecological processes to happen while managing their associated risks. Bob Freitag et al. explain that "it is more constructive to think of floods as a natural process of rivers that provides both risk and opportunity."[76] This cultural shift in thinking begins with changing the way we speak about flooding. In the second phase of the design process, I used a typological survey of flood management infrastructure to develop a vocabulary of potential strategies. There are many possible variations to each, and the purpose of this exercise was not to generate a complete list but to create a framework for identifying which strategies support my position.

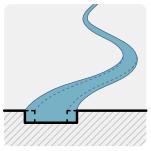
76. Bob Freitag et al., *Floodplain Management: A New Approach for a New Era* (Washington: Island Press, 2009), 19.

INSTEAD OF...

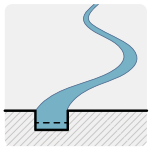
PREVENTING

MODIFYING

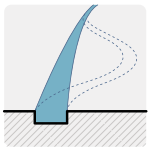
WIDEN



DEEPEN



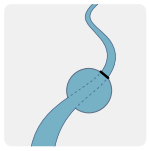
STRAIGHTEN



BYPASS

REGULATING

ON-STREAM

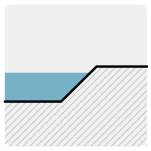


OFF-STREAM

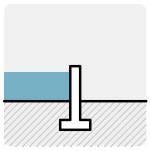
PROTECTING

EMBANKMENT

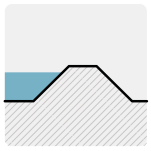
REVETMENT



FLOOD WALL



LEVEE



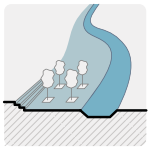
HOW ABOUT...?

ALLOWING

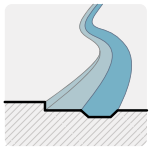
ACCOMMODATING

PARK

PLAZA

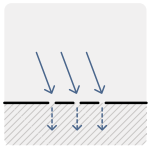


PROMENADE

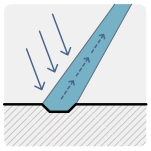


ABSORBING

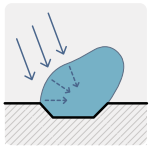
SURFACE



SWALE



BASIN



ACCEPTING

STILTED

FLOATING

SACRIFICIAL

RAISED

AMPHIBIOUS

WATERPROOF

Infrastructure typology diagrams explaining different design strategies for flood risk management. Based on Environment Agency, "Fluvial Design Guide;" Bob Freitag et al., *Floodplain Management*; Sofie Pelsmakers, "Living with Water;" and Martin Prominski et al., *River.Space.Design*.

Preventing tends towards stopping floods from happening or keeping them from reaching certain areas.

- *Modifying* focuses on altering the river to increase its capacity or change its course by widening, deepening, straightening, or bypassing the main channel.

- *Regulating* focuses on reducing downstream flood intensity by stopping the flow of water that has already entered the channel through on-stream or off-stream reservoirs and dams.

- *Protecting* focuses on creating reinforcements or barriers to keep floodwaters away from particular areas. Strategies include embankments, revetments, floodwalls, and levees.

Allowing tends towards letting floods happen while managing their risks.

- *Accommodating* focuses on creating public spaces such as parks, plazas, and promenades that are able to flood without sustaining significant damage.

- *Absorbing* focuses on reducing downstream flood intensity by slowing (but not stopping) the release of stormwater runoff into the channel using systems that incorporate permeable surfaces, drainage swales, and retention basins.

- *Accepting* focuses on creating structures that avoid damage from inundation by floodwaters. Strategies include stilted, raised, floating, amphibious, sacrificial, and waterproof buildings.

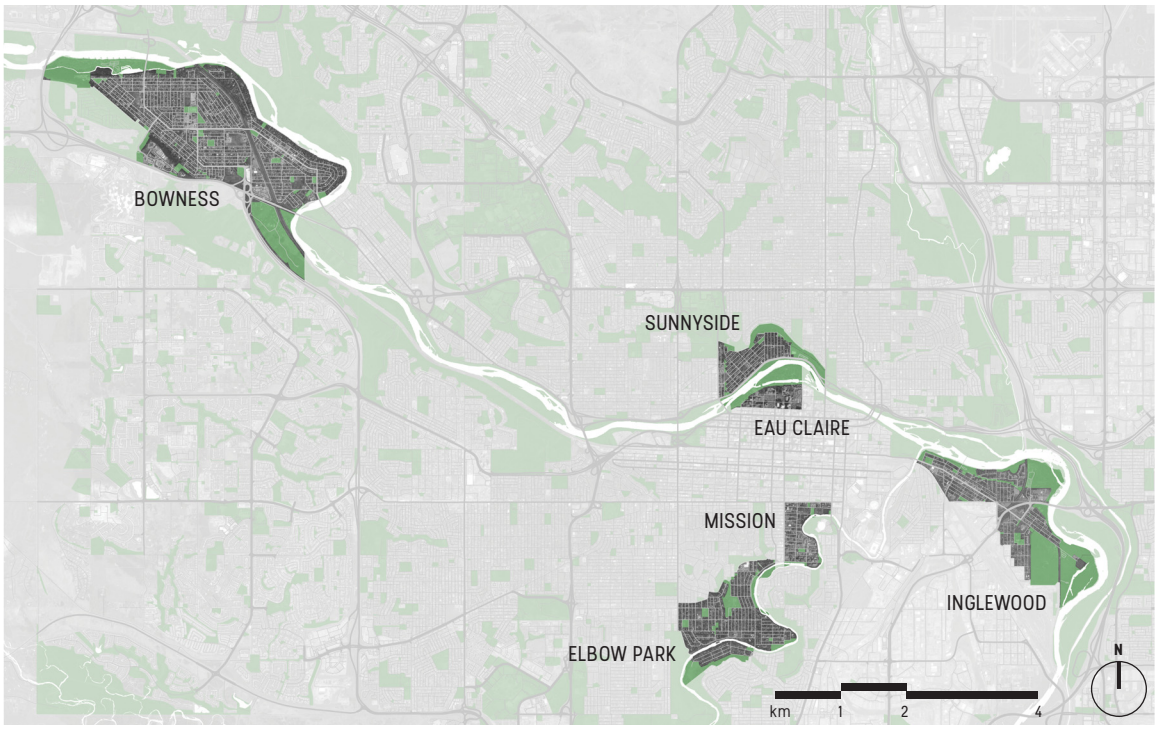
These categories are not intended to be hard-and-fast rules. Rather than taking an all-or-nothing stance, I advocate for a more nuanced application, arising from a specific understanding of site conditions. Any design intervention should begin by identifying which allowing strategies can be implemented in a manner appropriate to the context. Preventing strategies may be considered only in cases where they support an allowing strategy. For example, it may be appropriate to use a levee system as an outlet structure for a constructed wetland that incorporates swales and basins. This approach supports the thesis position because wetlands

can provide enjoyable public spaces and improve water quality and biodiversity while moderating downstream flooding. Similarly, a revetment may be necessary to stabilize a riverbank in order to create a promenade that encourages public gathering while accommodating floodwaters. It is important to note however that an allowing strategy on its own may not be sufficient in engaging its context. For example, raising a house on stilts keeps its inhabitants dry, but often reduces accessibility and creates unpleasant spaces beneath the house that isolate it from its context. Therefore, the professional expertise of the architect, in collaboration with community members, planners, and engineers, is integral to the discussion.

Systematic Site Selection

It may be easier to imagine wiping the slate clean, and re-designing cities to allow floods to happen without having to deal with the messy realities of existing infrastructure. But I think it is important to acknowledge what we have already built because the impact of human inhabitation on the landscape cannot be reversed or ignored. In the third phase of design research, I focused on an existing urban context through a systematic approach to site selection. From a list of communities potentially impacted by flooding, I identified six possible sites for the development of a design response.[77] Framing the principles that would be common to all sites, I classified each community by riverfront access, development pattern, and population density.

77. City of Calgary, "Communities Potentially Impacted by River Flooding," accessed July 15, 2017, http://www.calgary.ca/_layouts/cocis/DirectDownload.aspx?target=http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Flood-Info-Documents/Floodplain_CITY_8x10_2012.pdf.



Site selection map showing six of the flood-affected residential communities in Calgary; data from City of Calgary, *Census by Community 2016*, *Hydrology*, *Land Use Polygons*; ESRI, *World Imagery*; and Open Street Map, *Calgary – Roads*.

COMMUNITY	RIVERFRONT ACCESS	DEVELOPMENT PATTERN	POPULATION DENSITY
BOWNESS	private	parallel	low
SUNNYSIDE	public	parallel	high
EAU CLAIRE	public	imposed	high
INGLEWOOD	public	parallel	low
ELBOW PARK	private	imposed	low
MISSION	private	imposed	high

Site selection matrix classifying each community by riverfront access (private/public), development pattern (imposed/parallel) and population density (high/low).

Design Principles

1) Connect existing pathways and public spaces within the city.

The first category for site selection was riverfront access: is the area along the banks of the river privately restricted or publicly accessible? Communities such as Sunnyside and Eau Claire have continuous riverfront access with mixed-use pathways that connect public spaces throughout the city. I narrowed my scope to communities with private access.

2) Respond to the natural dynamics of the river.

The second category was development pattern: is the arrangement of streets imposed by the grid, or does it follow the contours of the landscape parallel to the riverbank? Communities such as Inglewood and Bowness have a parallel development pattern, which would make it easier to implement strategies that respond to water level fluctuations. I focused on sites with an imposed grid pattern to see how it could be adapted.

3) Create an urban landscape that is permeable to water.

The third category for selecting a site was population density: does the area consist mainly of multi-family residences or single-family houses? In low-density areas such as Elbow Park, the landscape is more permeable to water because there is a higher prevalence of yards and parks with grass instead of pavement. I looked instead at high-density sites, which tend to be less permeable.

Meeting all three criteria, Mission was identified as a community with private riverfront ownership, imposed grid development pattern, and high population density, making it an ideal testing ground for the thesis response.

Mission

The urban development of prairie cities was highly influenced by the Dominion Land Survey, a grid that was used to divide Western Canada into square-mile townships in the late 19th century. With the establishment of Fort Calgary in 1885, the superimposition of the grid on the irregular landscape carved out by the rivers became ingrained in urban form.[78] The area just upstream along the Elbow River was settled by a French Catholic Mission called Notre Dame de la Paix. The community was incorporated as the village of Rouleauville in 1899 and annexed by the growing city of Calgary in 1907. Many of the single-family houses built in the following decade are still standing today in the community now known as Mission.[79] Since Mission is located in an area where the river takes a sharp turn, it faces a high potential for flooding.

The period between the beginning of World War I and the end of World War II was characterized by slow population growth and harsh economic conditions.[80] Residential development in Calgary was mostly limited to infill until 1947, when oil was discovered near Leduc, Alberta.[81] Thus began a time of prosperity and rapid expansion that had a significant impact on Calgary's urban form.[82] In Mission, many single-family homes were replaced by apartments.[83] These buildings often have at-grade entrances and below-grade units, making them particularly susceptible to flood risk.

The first flood hazard maps were produced in the 1970s, bringing an increased awareness of the possible extent of flooding to many residential communities.[84] However, these maps did not significantly alter patterns of development. After a

78. Sandalack and Nicolai, *The Calgary Project*, 6-9.

79 City of Calgary, "MyProperty" (online database), accessed July 15, 2017, https://maps.calgary.ca/MyProperty.

80. Sandalack and Nicolai, *The Calgary Project*, 55.

81. Ibid.

82. Ibid., 77.

83 City of Calgary, "MyProperty."

84. Alberta Environment and Parks, "Flood Hazard Identification Program," accessed July 15, 2017, http://aep.alberta.ca/water/programs-and-services/flood-hazard-identification-program/default.aspx.

period of thirty years in which only one major flood occurred,[85] the 2013 flood caused major and unexpected damage, particularly in Mission.[86] A mandatory 72-hour evacuation was issued, and many people were unable to move back into their homes for weeks or even months after water levels subsided. Planning bylaws have since been updated to prevent construction in the floodway and require that the first floor and services of new construction in the flood fringe are built above the designated flood level.[87]

It is intriguing to note that Mission's administrative boundary is defined by the grid to the North and West, but by the riverbank to the South and East. Further research could circle back to the mapping exercise to investigate how the development of Mission was influenced by its relationship to the river. In *The Calgary Project*, Sandalack and Nicolai provide an excellent precedent, using a methodology that integrates spatial and historical information to map changes in urban form that occurred over several phases of development.[88] I am particularly interested in how maps influence public perceptions about how ecological systems function. For example, flood hazard maps may have created or at least reinforced the perception that floods are a) very unlikely and b) inherently dangerous. Many experts are beginning to realize that neither is the case.[89] Could maps be developed to better communicate this understanding to a non-specialized audience?

With an aging stock of single-family houses and apartment buildings, coupled with the pressures of flood mitigation and urbanization, Mission is primed for redevelopment. We could continue to build to meet existing standards, but I think this is an ideal opportunity to open up a wider discussion about our role within ecological systems at a time of rapid global change. So instead of modifying the

85. Calgary Public Library, "Flooding in Calgary: 1883-2013," *Calgary Flood Story*, accessed July 15, 2017, http://floodstory.com.

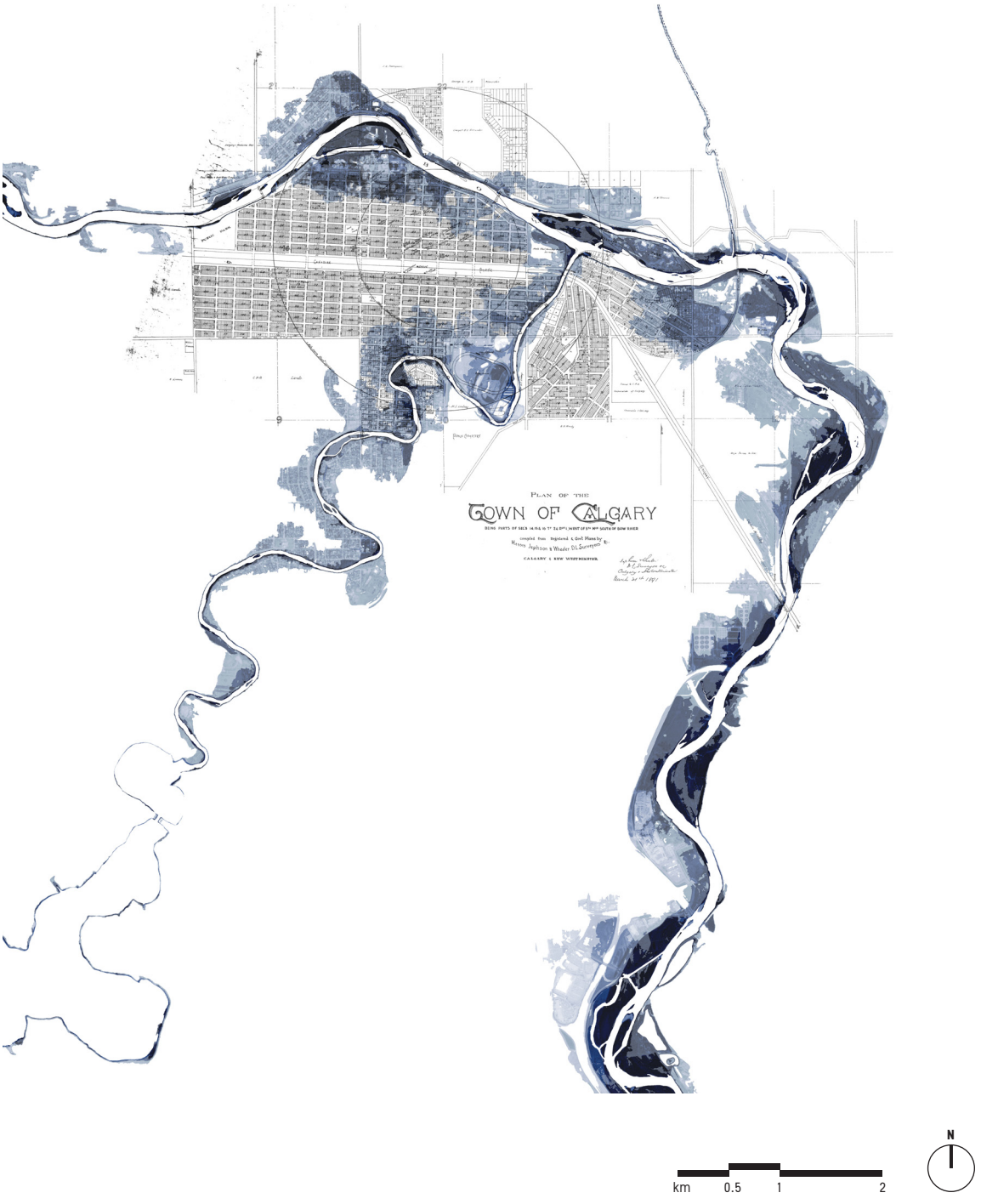
86. Erik Volmers, "Mission: A Work in Progress, but a Miraculous Recovery," *Calgary Herald*, June 20, 2014, accessed July 15, 2017, http://www.calgaryherald.com/life/mission+work+progress+miraculous+recovery/9955303/story.html.

87. City of Calgary, "Building Design in the Flood Fringe," *Land Use Bylaw 1P2007*, 60, accessed July 15, 2017, http://lub.calgary.ca.

88. Sandalack and Nicolai, *The Calgary Project*, 194-201.

89. Freitag et al., *Floodplain Management*, 1-17.

river, regulating it, or protecting ourselves from it, what if we accommodate its natural tendencies, absorb its impact, and accept that buildings on floodplains can and will flood? Perhaps we can use the necessity of flood risk mitigation to weave a new narrative that embraces the river as an integral part of the city fabric.



Map showing riparian areas juxtaposed against lot boundaries from an 1891 historic plan of Calgary; data from City of Calgary, *Riparian Areas – Variable Width*; ESRI, *World Imagery*; and Richard J. Jephson, *Plan of the Town of Calgary*.

CHAPTER 5: THE RIVER IS THE SOLUTION

> 'Floods' is the word they use, but in fact [the river] is not flooding; it is remembering. Remembering where it used to be. All water has a perfect memory and is forever trying to get to where it was. Writers are like that: remembering where we were, what valley we ran through, what the banks were like, the light that was there and the route back to our original place... And a rush of imagination is our 'flooding.'[90]

If we design infrastructure to manage risk, rather than eliminate flooding, we begin to change the narrative of nature versus culture to one of mutual inclusion. Having framed the position, strategies, and goals for the thesis, I used the case study of Mission to develop an architectural response. I designed at three interconnected scales to demonstrate an understanding of the river as part of the urban landscape by allowing floods to happen. This chapter explains the thesis response at the urban, site, and building scales, which correspond to accommodating, absorbing, and accepting strategies, respectively. The investigation led to many insights as well as further questions.

90. Toni Morrison, "The Site of Memory," in *Inventing the Truth: The Art and Craft of Memoir*, ed. William Zinsser (Boston: Houghton Mifflin, 1995), 99.

SPRING

SUMMER

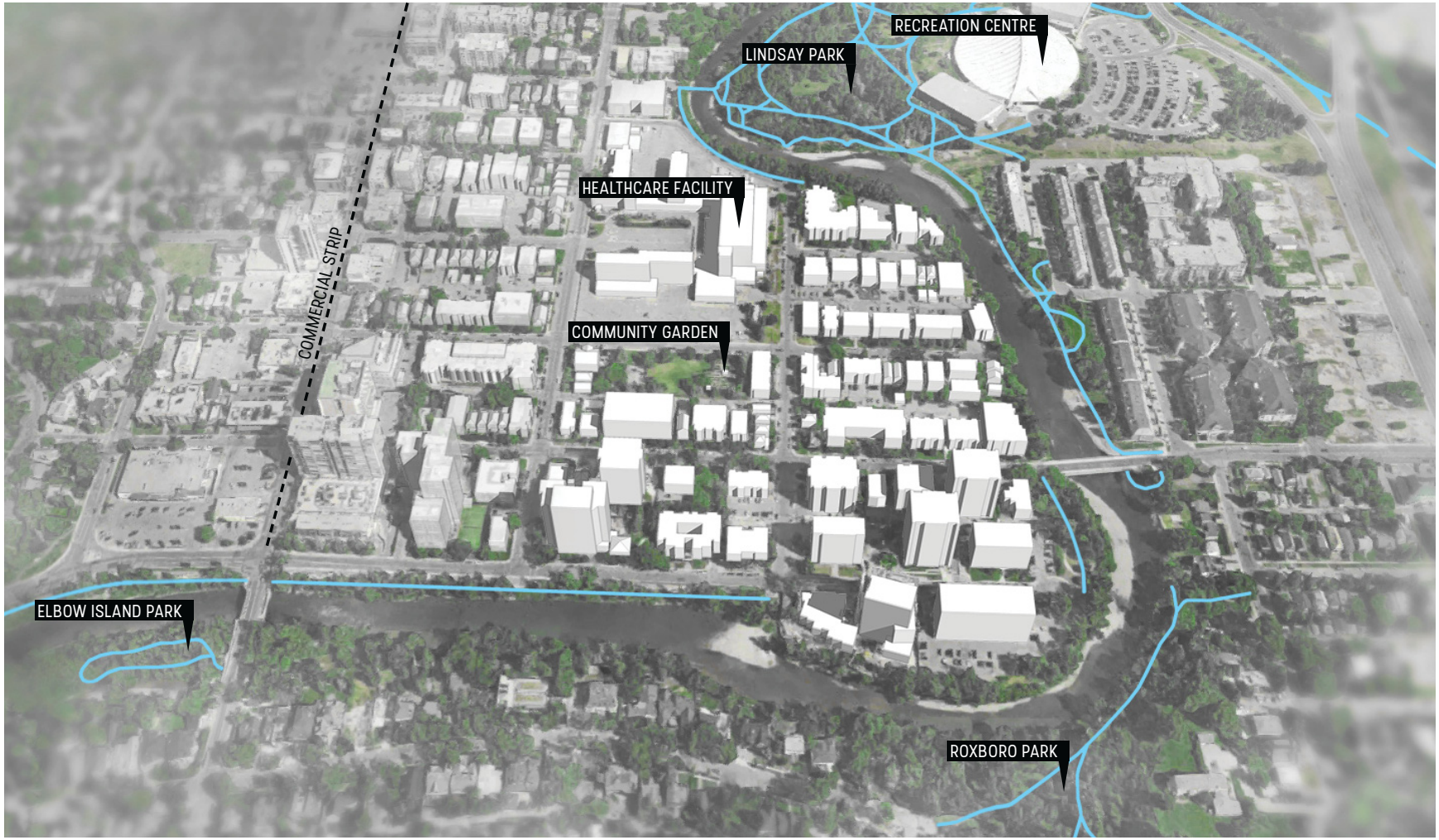
AUTUMN

WINTER

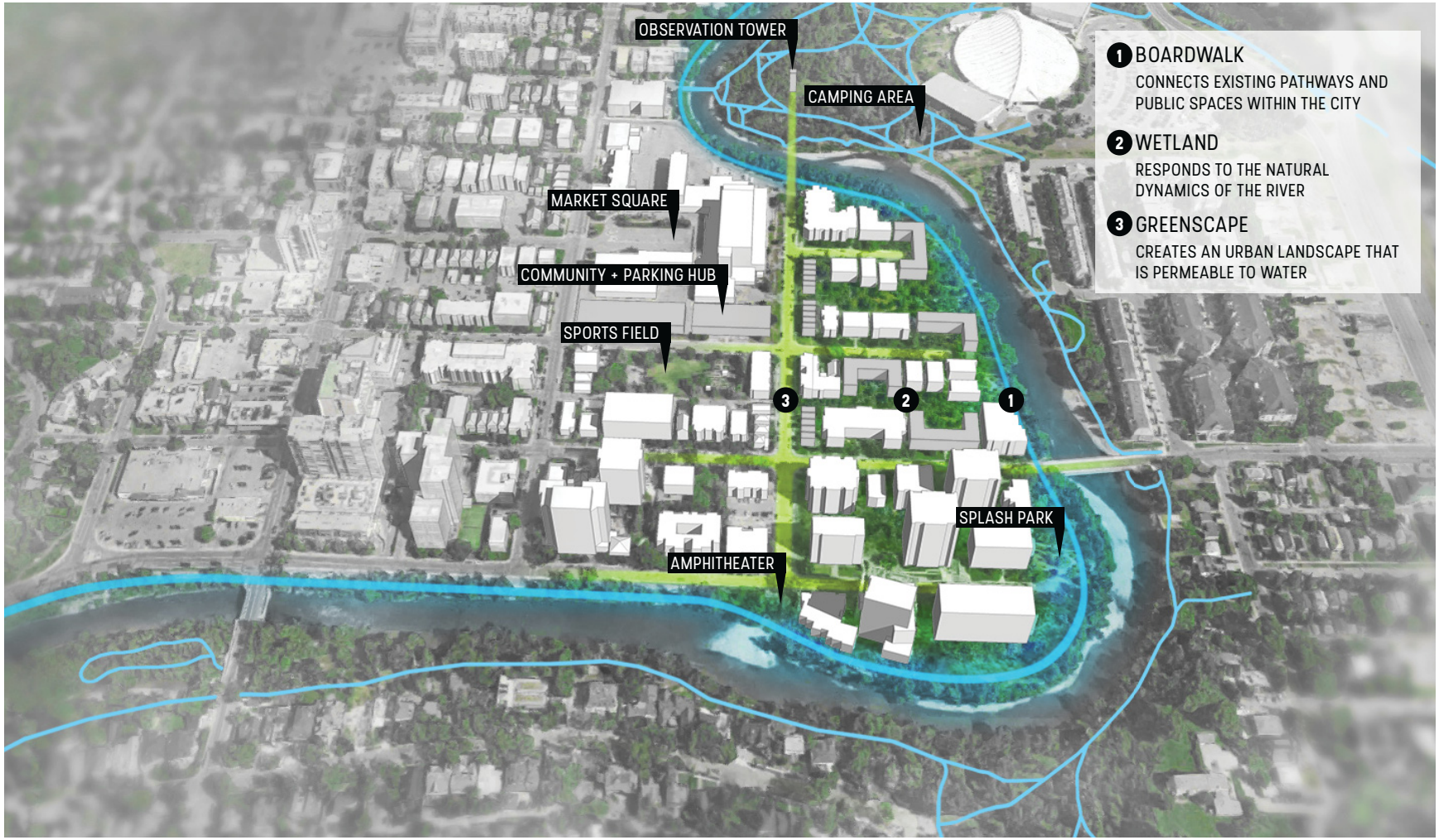
Early conceptual collages exploring the adaptation of indoor and outdoor public spaces in response to seasonal activities and water level fluctuations.

Accommodating

The response at the urban scale addresses the three design goals using accommodating strategies, which focus on creating public spaces that are able to flood without sustaining significant damage. Firstly, a boardwalk promenade connects the fragmented path network, reclaiming the privatized riverfront as part of the public realm. Secondly, water is brought into the street grid, turning the laneway spaces into wetlands to respond to the natural dynamics of the river. Thirdly, where hard surfaces are necessary for transportation, the greenscape merges with the existing roads to create a permeable landscape. Public plazas within this proposed network include a splash park and market square. Residential parking is moved off-site to a community hub, encouraging people to walk, bike or use public transit instead of driving. The greenscape bridges across the river to the adjacent park, where an observation tower provides opportunities for birdwatching and can be used as a signaling device in the event of a flood.



Existing context at the urban scale; data from Google Maps, *Mission*; and City of Calgary, *Digital Aerial Survey*.

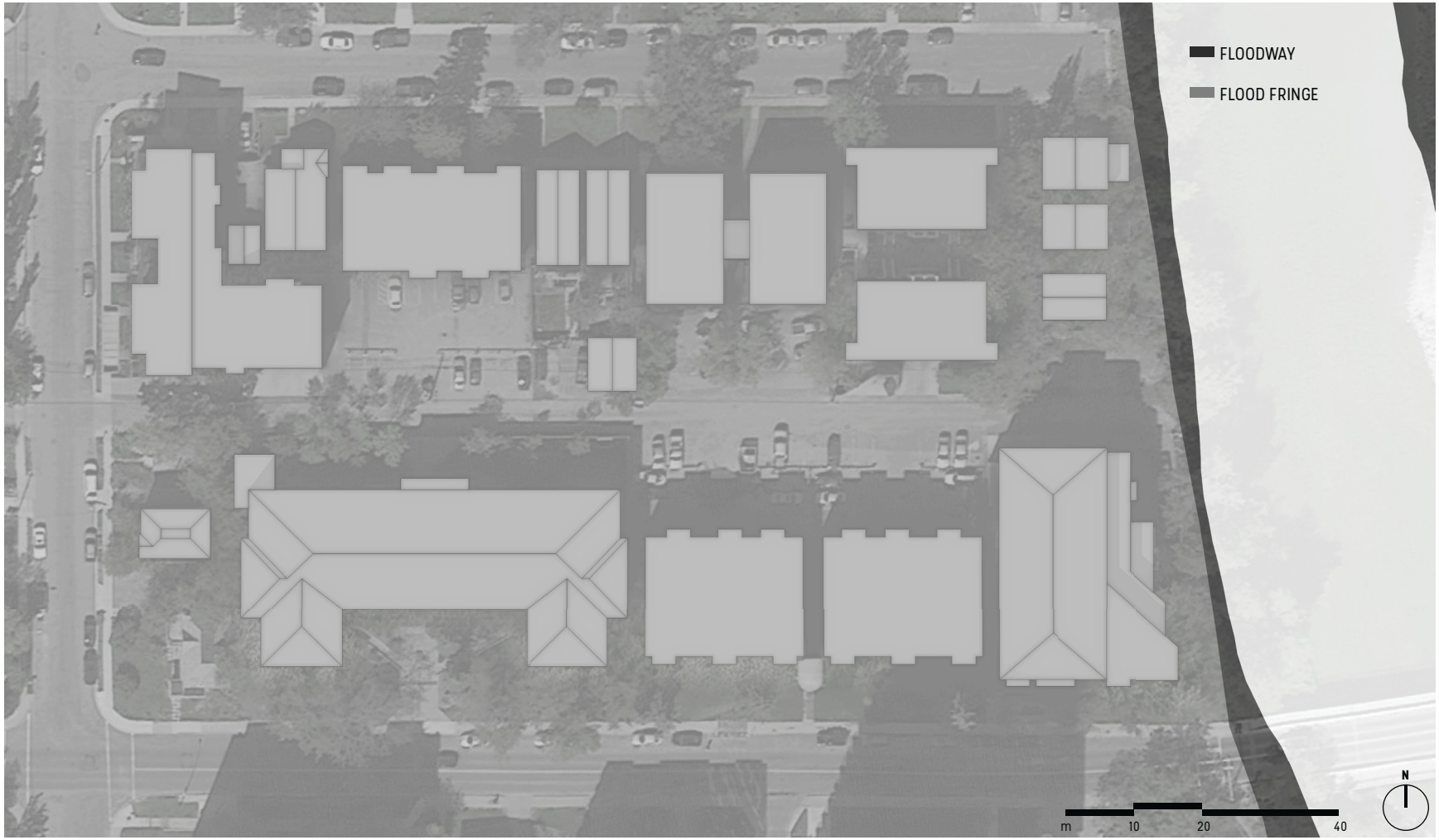


Design response at the urban scale; data from Google Maps, *Mission*; and City of Calgary, *Digital Aerial Survey*.

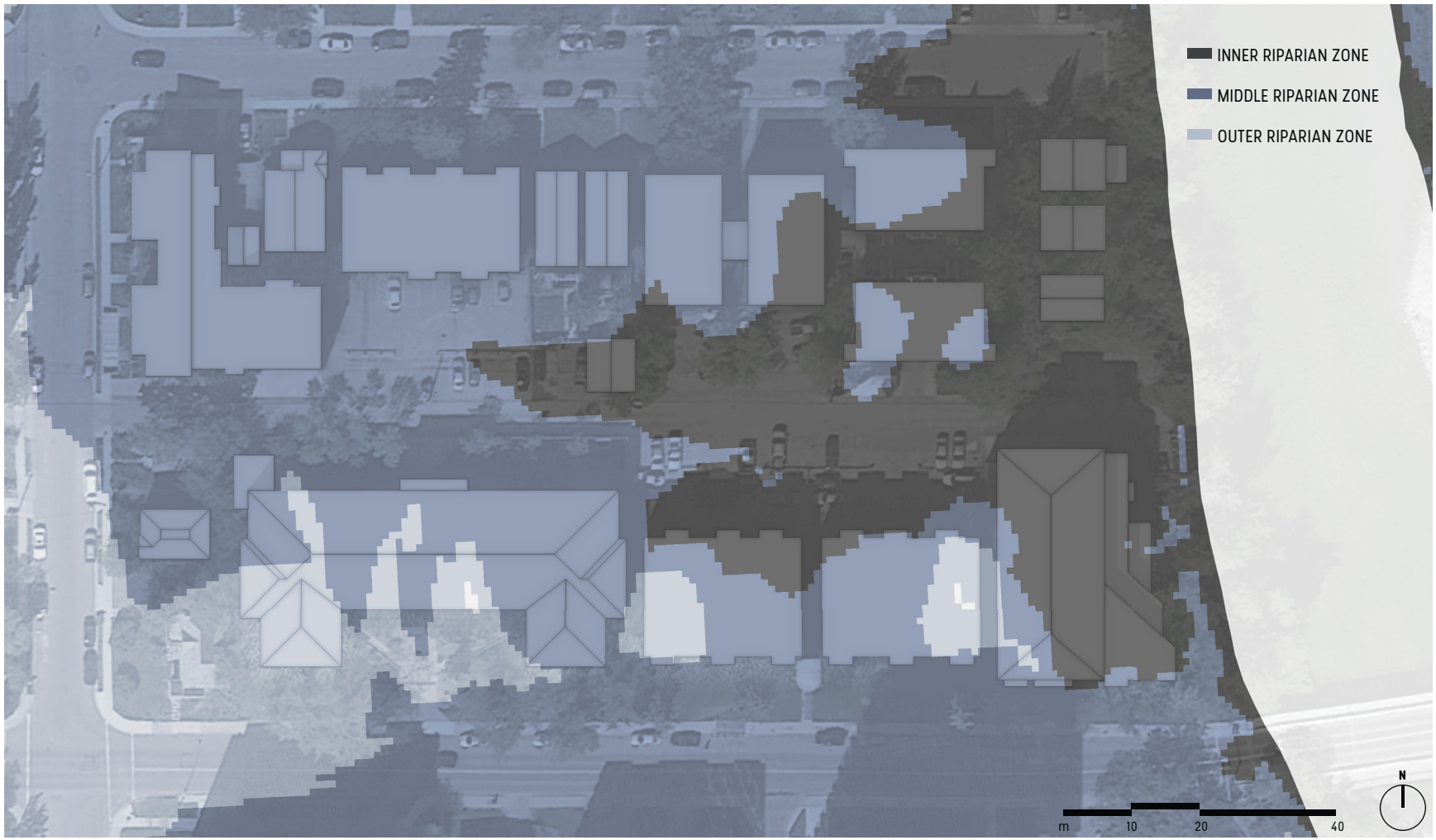
Absorbing

The site response focuses on the wetland to implement strategies for absorbing stormwater, reducing downstream flood intensity by slowing the release of runoff into the river channel. I narrowed my scope to one city block that has a range of single family houses and apartment buildings. The first thing I noticed when studying the existing context was that it is extensively paved, making it highly impermeable to water. The current flood hazard boundaries do not reveal much information about the influence of water on the site, except that all of the existing buildings are in the flood fringe zone. By overlaying riparian boundaries, I observed that the inner riparian zone already infiltrates the laneway to some extent. Working from the existing conditions, I imagined peeling back layers of earth to reveal an underlying infrastructure that functions as an ecological system: filtering water, encouraging biodiversity, providing spaces for gathering, circulation, and shelter, all in an interconnected topographic landscape. Riparian areas reflect varying degrees of permeability, with those areas showing the most riparian characteristics being the most permeable to water. However, it was not necessary to precisely mimic the riparian boundaries because these lines are simply static representations of a dynamic system. The design intervention considers edge erosion and water level fluctuations to demonstrate an understanding of change over time.

Existing site plan showing areas of permeability; data from Google Earth, *25 Avenue SW & 1 Street SW*; and City of Calgary, *Digital Aerial Survey*.

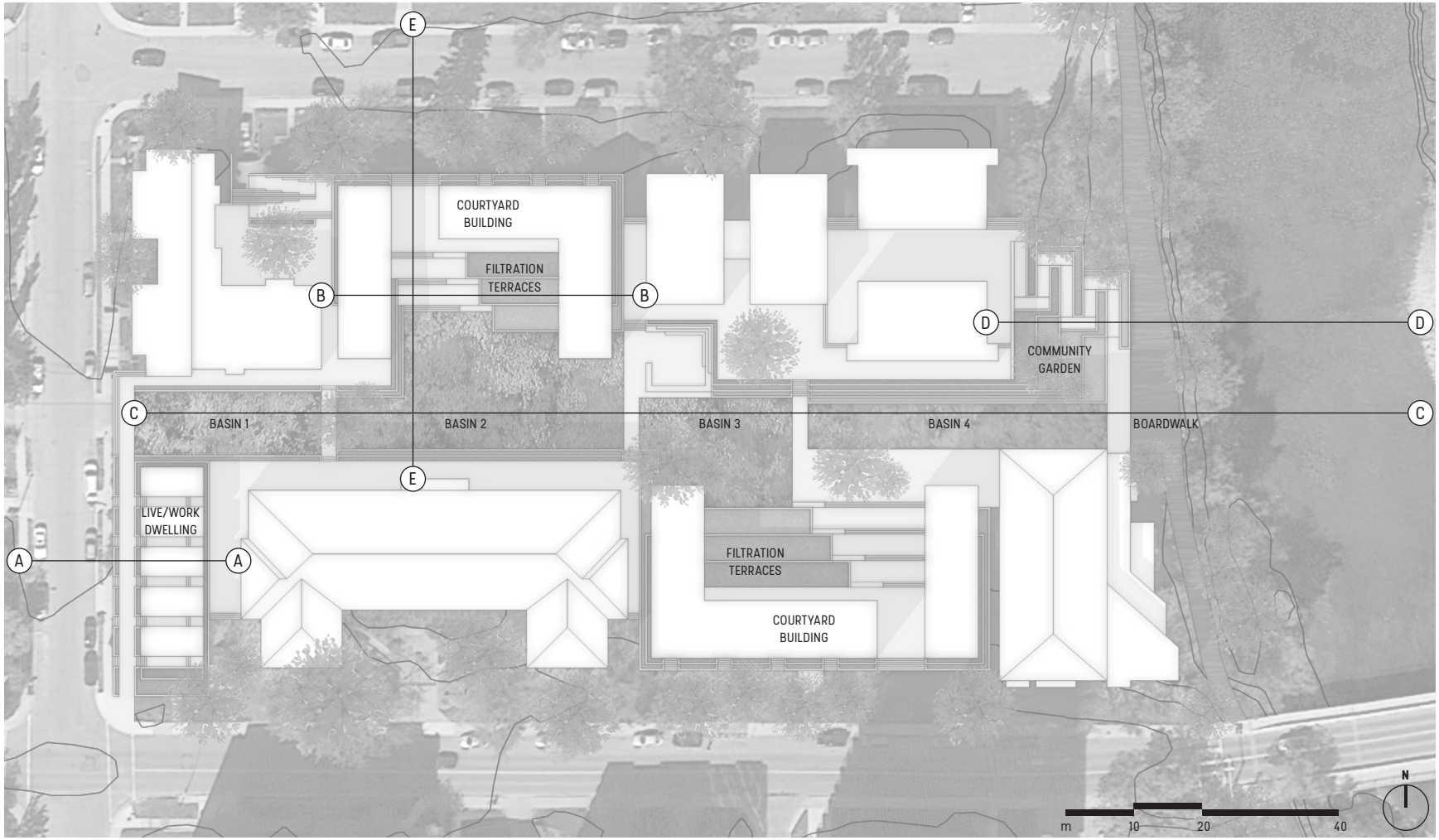


Existing site plan with overlay showing flood hazard boundaries; data from City of Calgary, *Bylaw Flood Hazard (100 Year)*.

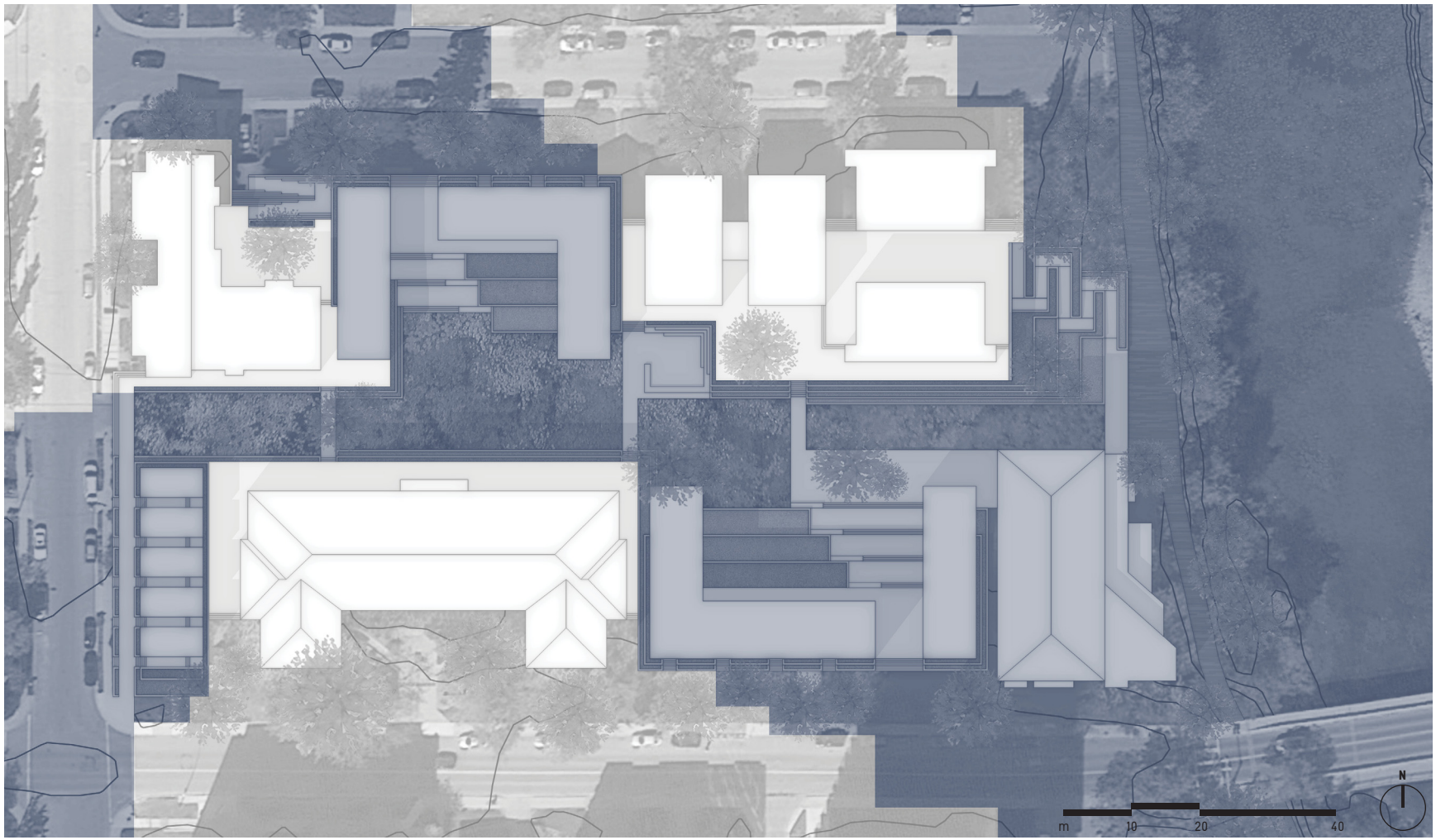


Existing site plan with overlay showing riparian boundaries; data from City of Calgary, *Riparian Areas – Variable Width*.

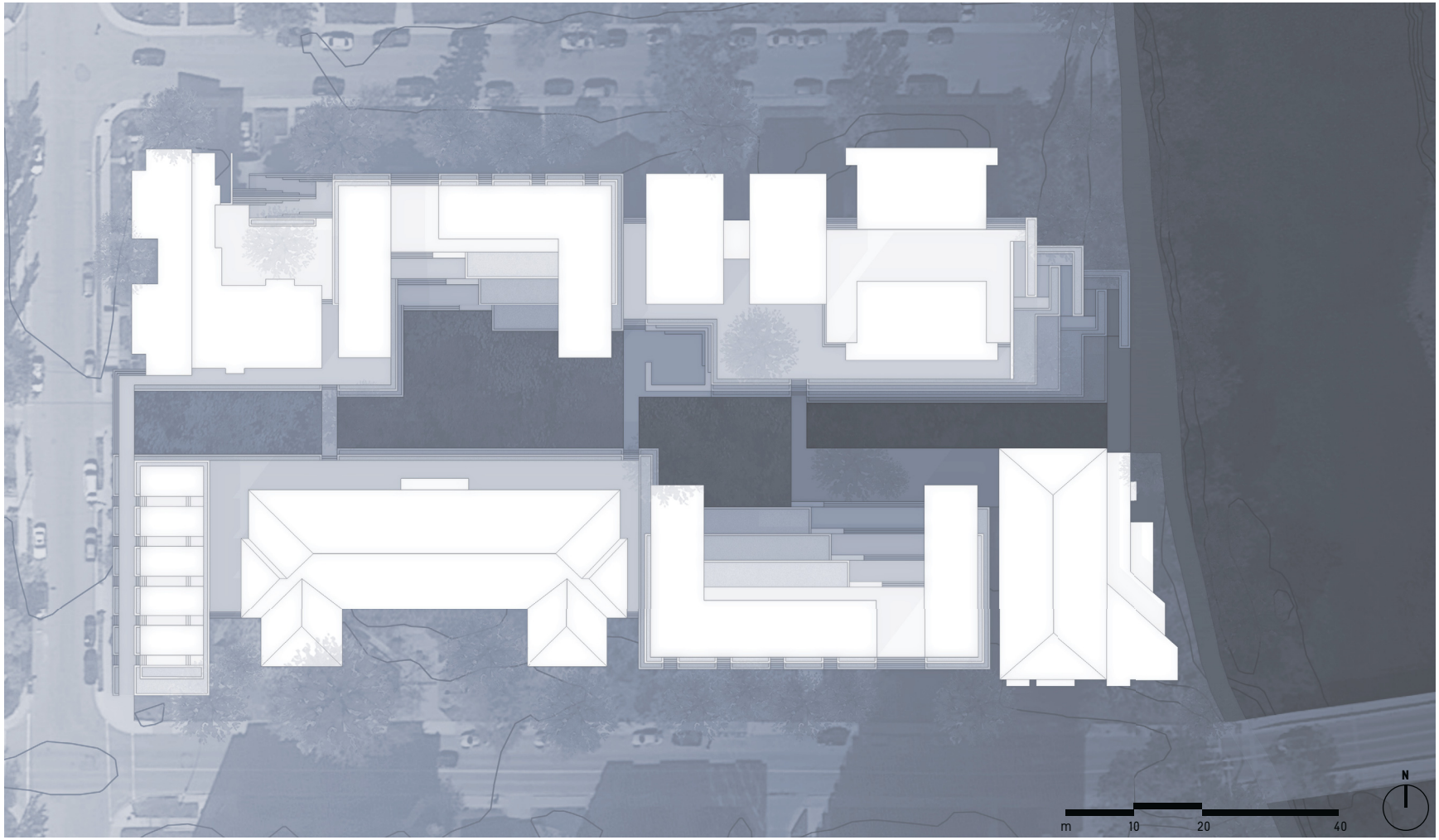
Proposed site plan showing areas of permeability; data from Google Earth, *25 Avenue SW & 1 Street SW*; and City of Calgary, *Digital Aerial Survey*.



Proposed site plan with overlay showing major design elements and callouts for integrated section (A-D) and building section (E).

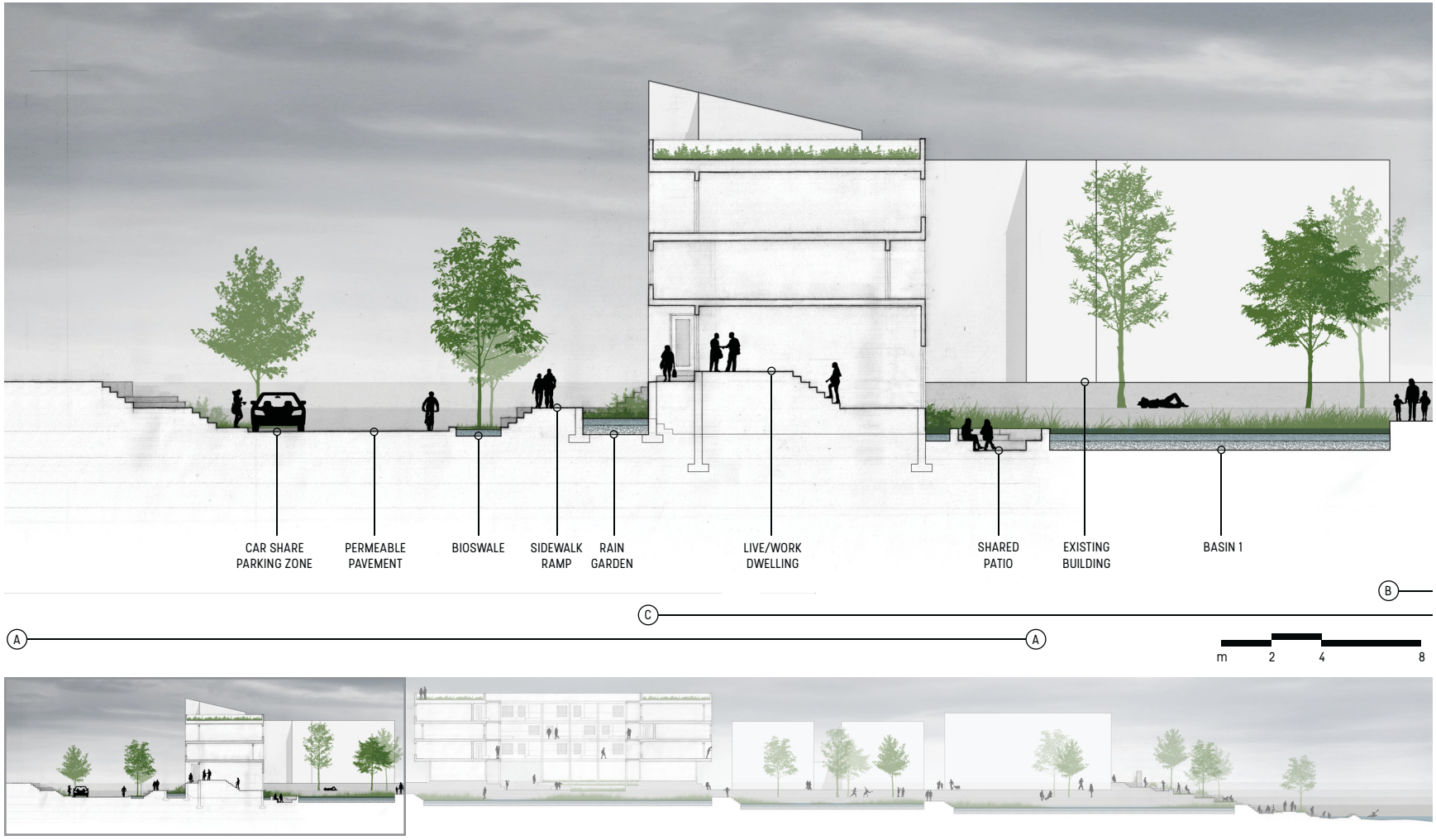


Proposed site plan with overlay showing edge erosion for future system expansion.

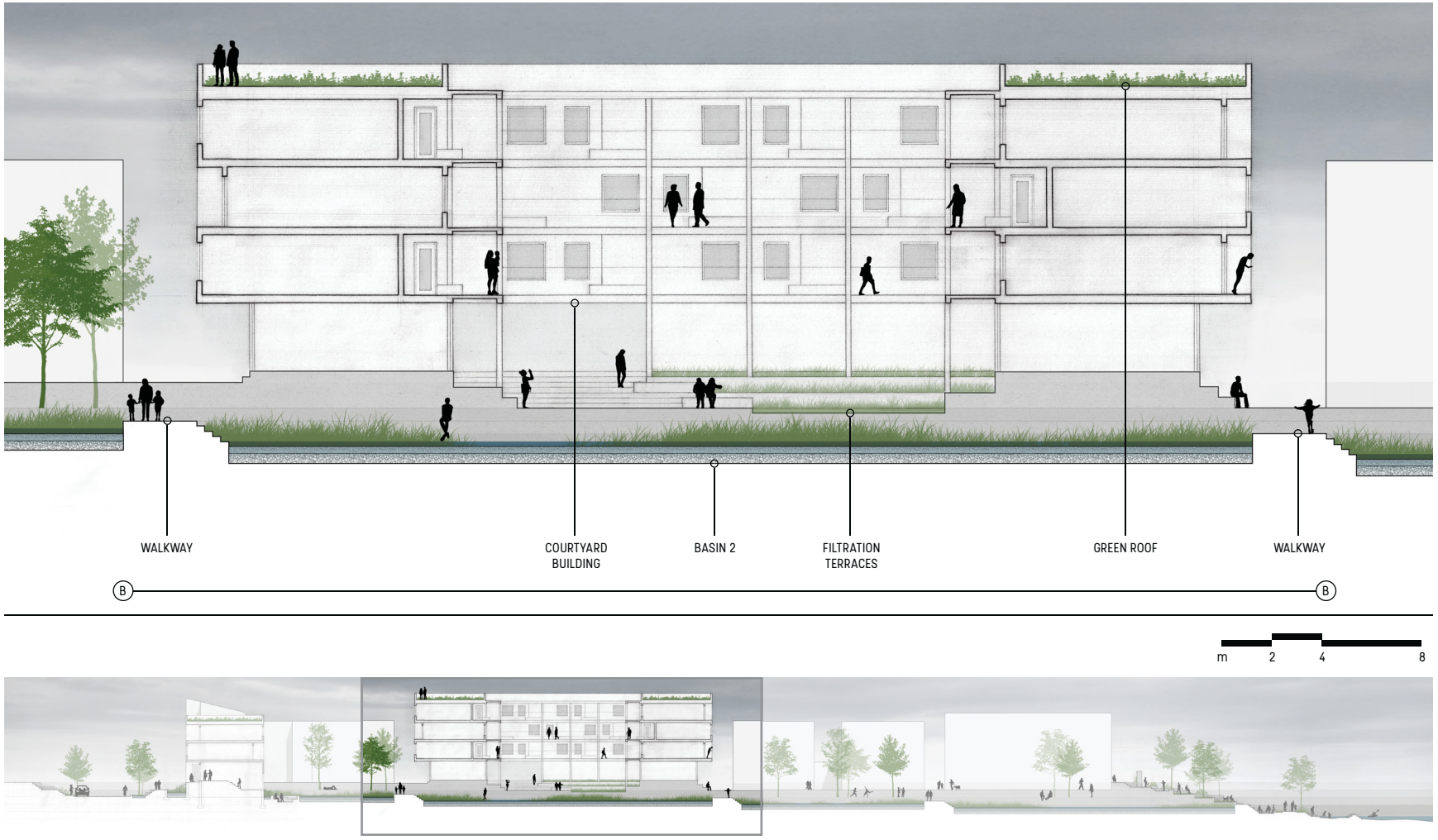


Proposed site plan with overlay showing water level fluctuations over time.

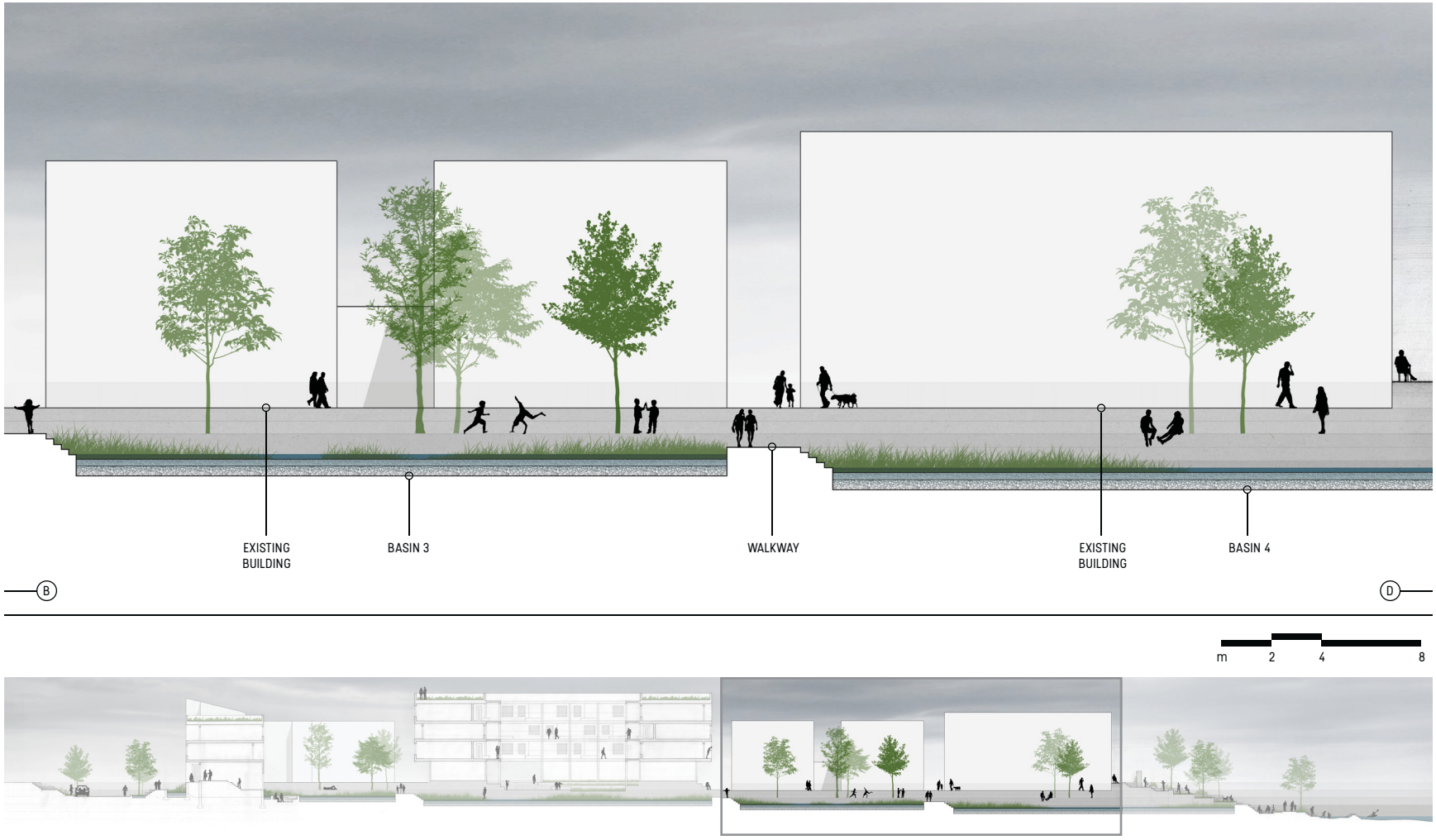
The integrated section stitches together four overlapping site sections to create an inhabitable ground plane. The basic approach is to leave existing buildings in place, but step the laneway down approximately two meters across the entire site. New buildings are raised up above the 100-year flood line. In Section A, the greenscape uses permeable paving surfaces to allow groundwater infiltration and provide car-share parking. Bioswales bring stormwater from other parts of the city into the wetland. The ground steps up to a ramped sidewalk and rain garden, then to a live/work dwelling, and then back down to a shared patio space. In Section B, the courtyard building uses a green roof to collect stormwater. Terraced gardens filter greywater from the building before releasing it into the wetland. Each terrace would have different soil characteristics and plantings corresponding to the sequential steps of the filtration process. In Section C, the four basins of the wetland have walkways allowing people to move between different parts of the system. The boardwalk incorporates a levee as an outlet structure for the wetland. In Section D, a community garden harvests water for growing food. Barbecue areas provide opportunities for gathering along the riverbank. Finally, a small wading pool slows down the current for children to play and for rafts and kayaks to launch.



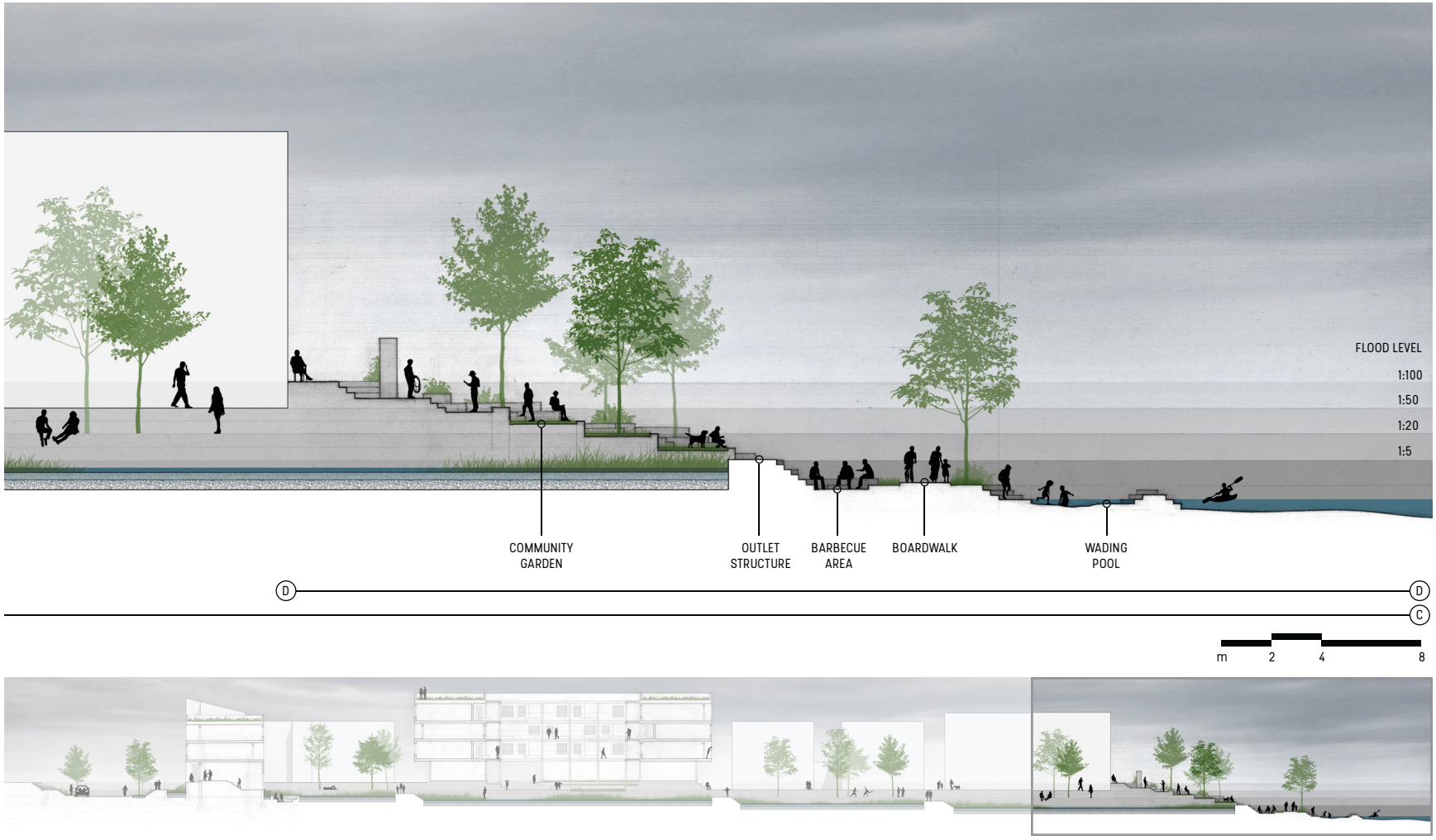
Integrated section (A-D) showing architectural response at the site scale (1 of 4); data from City of Calgary, *Digital Area Survey*, *Inundation Data*.



Integrated section (A-D) showing architectural response at the site scale (2 of 4).



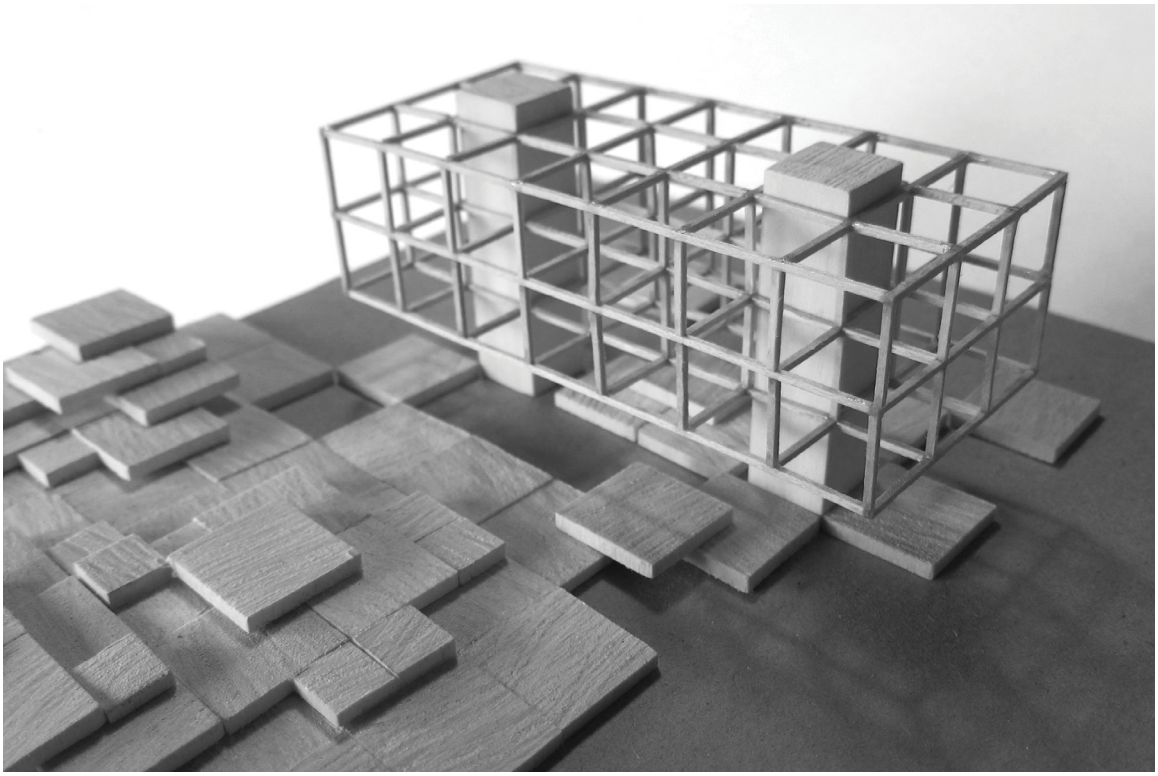
Integrated section (A-D) showing architectural response at the site scale (3 of 4).



Integrated section (A-D) showing architectural response at the site scale (4 of 4).

Accepting

At the building scale, the design response uses a hybrid accepting strategy combining raised foundations and stilts to avoid damage from inundation by floodwaters. The foundations manage the slope up to the 100-year flood line in a cut-and-fill process, where earth removed to create the wetland is used as fill during construction. This stereotomic approach allows water to enter the site while keeping interior spaces dry. The ground floor is dedicated to social gathering spaces such as a community kitchen and library. Stilts lift the private dwelling units above the ground floor so that they are not damaged by a flood greater than the predicted 1:100 event. This tectonic structure creates an open-air circulation corridor with common areas and recessed entrances, allowing units to receive natural light from both sides. It also reduces the energy requirements of the building because it provides solar shading during the summer and it does not need to be heated during the winter. The dwelling units are arranged around a central courtyard, mediating the boundary between building and site.



Early conceptual model exploring the relationship between landscape and building through stereotomic and tectonic elements.

Building section (E) showing architectural response to street and wetland conditions.

Building section (E) showing architectural response to high water levels during a 100-year flood.

CHAPTER 6: CONCLUSION

The implications of flooding in an ecological paradigm challenge the infrastructure upon which our society is built. Over the next few decades, it will be crucial for cities to develop and implement a strategic vision for the future. The thesis response was used to demonstrate an understanding of the river as an inclusive entity by integrating strategies for accommodating, absorbing, and accepting floods in a specific urban context. Reflecting on the outcomes of this process has provided several key insights and possibilities for future research.

Challenging limits

Boundaries are necessary because they give us frameworks for understanding complex and ever-changing systems. But we should think of these boundaries as thresholds rather than limits, by allowing movement rather than preventing it. For example, when designing at the building scale, I needed to expand my scope beyond the exterior walls, using the courtyard to facilitate the movement of water across the threshold between building and site. Future studies could challenge the building envelope itself. What if walls created a gradient between inside and outside through different levels of permeability? This exploration could lead to a different understanding of the private dwelling unit and its role within ecological systems. In developing the site strategy, I approached the edge of the city block that I had established as a working boundary. I realized that the rectangular block was not an appropriate expression of the riparian ecosystem within which I was designing because the block imposed an artificial barrier preventing the system from expanding. Further investigation would explore how the block could be reconfigured to allow movement across this threshold.

Society through technology

Infrastructure is often valued only for its ability to function as intended. If it does what it is supposed to do, why change it? Maybe we need to redefine the terms of what constitutes successful infrastructure. Throughout my investigation, I consciously looked for opportunities to align technical and social requirements.

At the building scale, I used stilts to lift the dwelling units above floodwaters and form an open-air circulation corridor with shared balconies. At the site scale, I used terraced basins to moderate the flow of water through the wetland and create walkways for circulation between buildings. At the urban scale, I used plazas to adapt to rising water levels and provide spaces for recreational activity. The common theme is that infrastructure serves a wider social function as a public amenity beyond environmental or technological concerns. Designing infrastructure in this way might help to change beliefs and actions that contribute to environmental disruption because people may start to see greater value in living responsibly within ecological systems.

Finding common ground

The thesis response also explored how infrastructure gives form to less tangible notions of land ownership. I argue that our tendency to define land as individually-owned territory perpetuates the Not in My Back Yard mentality that makes it difficult to respond to environmental challenges on a community level. At the building scale, I placed private dwelling units on the upper floors, leaving the ground floor open for community gathering spaces. At the site scale, I articulated the space between buildings as an inhabitable ground plane rather than a collection of parcels, drawing new lines to connect each building to its wider context. At the urban scale, I proposed a boardwalk to release the privatized riverfront into the public realm. These strategies demonstrate the potential in redefining the urban landscape as part of the river through alternative ownership models such as community land trusts. I may not have found the right answer, but I hope to open up a discussion about different ways of negotiating the boundary between private and public that do not exclude land from ecological responsibility.

All land is wet land

As designers, we tend to focus on keeping water out: stopping it from entering buildings, moving it away from foundations, and directing it into underground pipes. But on closer inspection, we find that water is all around us all the time, and the very systems we use to try and keep water out may be compounding problems

elsewhere. For example, when stormwater falls on an impermeable surface such as asphalt, it moves quickly into the sewer system and then into the main river channel, increasing the intensity of flooding downstream. If we shifted our focus to letting water in, considering the entire urban landscape as a continuous watershed, we could develop different methods for planning and building in cities. For example, we might think of riparian zones as degrees of permeability. Any new construction would be required to incorporate systems that accommodate, absorb, and accept a certain amount of water appropriate for its particular zone. These requirements would not necessarily exclude existing policies; building above the 100-year flood level is an approach that many cities have already implemented to accept the possibility of flooding. But bylaws should be expanded to include absorbing and accommodating strategies as well. In addition to changing the way we think about new construction, we should also look for underutilized spaces that already exist within the urban landscape that could be adapted to become more permeable. With the trend towards decreased dependence on cars in dense urban areas, laneways and parking lots could represent a growing opportunity in this regard. The result of this reorganization of building practices would be an urban form that evolves to align more closely with the natural systems in which it participates.

Although I have used flooding as an example, in a broader sense this thesis is all about boundaries, and how they mediate the relationship between natural and built environments. We have become so accustomed to the lines drawn on the urban landscape that we rarely question how they might be preventing us from moving forward in an era of rapid global change. I think we need to start to define new boundaries that better meet our collective interests and reflect the varying degrees of influence that human inhabitation and ecological systems have on one another. I have begun to explore the implications of this thesis at the building, site, and urban scales. What it means for the future of our cities, provinces, and even countries are questions that still need to be asked. I imagine an infrastructure of dwelling that defines natural processes less by their hazards and more by their opportunities in overcoming the dualistic boundaries of nature and culture. The river is not the problem; it is the solution.

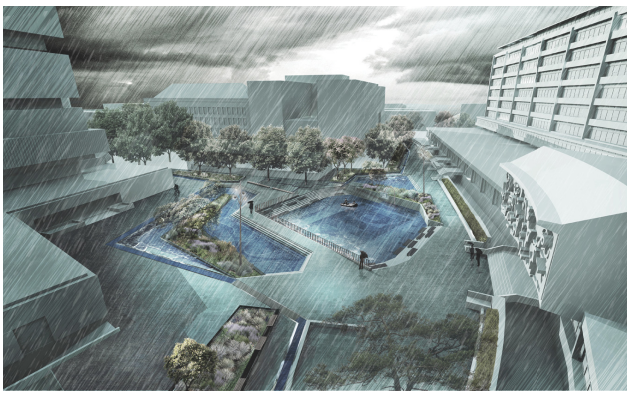
APPENDIX: CASE STUDIES

1. ALLOWING FLOODS TO HAPPEN

Room for the River
Nijmegen, Netherlands
H+N+S

2. PERMEABLE URBAN LANDSCAPES

Arkadien Winnenden
Stuttgart, Germany
Ramboll Studio Dreiseitl



3. INFRASTRUCTURE AS AMENITY

Waterplein
Rotterdam, Netherlands
De Urbanisten

4. BUILDING-INTEGRATED SYSTEMS

Sidwell Friends School
Washington, DC
KieranTimberlake

5. ALTERNATIVE OWNERSHIP MODELS

Quinta Monroy
Iquique, Chile
Elemental

6. THE RIVER IS THE SOLUTION

- Challenging limits
- Society through technology
- Finding common ground
- All land is wet land

Image sources:

1. Letty Reimerink, "A Dutch City Makes Room for its River – and a New Identity," *Citiscope*.
2. "Arkadien Winnenden," *Landezine*.
3. "Waterplein / Rotterdam Netherlands / De Urbanisten," *World Landscape Architecture*.
4. Sarah Wesseler, "AD Interviews: Kieran Timberlake," *ArchDaily*.
5. "Quinta Monroy / Elemental," *ArchDaily*.

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