School of Cities
UNIVERSITY OF TORONTO

Place Identity: Urban Water and the Anthropocene

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PREFACE

As a civil engineer by background and training, the journey back into academia has been invigorating. After 5 years of land development consulting, graduate school has given me countless learning outcomes and emergent lines of inquiry. This project seeks to integrate some of this new knowledge and critical thinking. I hope this work demonstrates one pathway to re-engage (civil) engineers in city building and re-imagine the purview of engineering practice.

Having lived in Calgary for more than 20 years, this city shaped me into who I am today. For that, I am grateful to learn more about my home city and add richness to its urban identity. As ideas about resilience continue to permeate the public consciousness—especially given COVID-19's impacts on cities—I hope this work sparks creativity and new conversations about what a resilient and equitable post-pandemic future might look like.

ACKNOWLEDGEMENTS

I am deeply grateful for this enrichment experience as a Graduate Fellow with the School of Cities to develop and pursue a project that I am proud of. My success is owed to the kind guidance and support of many. I wish to extend my gratitude to Marieme Lo, Katherine Danks, Matti Siemiatycki, Rebecca McMillan, and many others at the School of Cities. Their care, effort, and guidance have been invaluable. I also need to recognize my home department, Civil and Mineral Engineering, for their part in my academic journey. The professors and my colleagues there have inspired and shaped the theoretical foundations and lines of inquiry that make a project like this possible. Finally, a big thanks to Jack, Goji, Daniela, Kamel, Joe, Sofia, Christine, and Alex for their encouragement, patience, and humour.

EXECUTIVE SUMMARY

This project is about urban identity, water in cities and resilience. It is the end deliverable for my fellowship with the School of Cities. I explore the connections among place identity (how infrastructure enables meaning-making in cities), the Anthropocene (the emergence of hybrid built-natural infrastructure), and urban water (simply water in cities) to explore the severe flooding in Calgary, Alberta. As a case study of the June 2013 floods, I review the region's urban profile, salient watercourses, flooding history, a timeline of events, the response and impacts, flood mitigations, and narratives about the river, floodplain and resilience. While I offer that the different types of resilience—persistence, adaptation, and transformation—belong to different points along a response-recovery curve, resilience in practice suggests that persistence is common and transformation is rare. Employing four different spatial scales to represent the neighbourhood, community, regional, and metropolitan levels, I analyze four data sets to produce a spatial analysis of flooding impacts and a narrative analysis of Calgary's socio-hydrological fabric. I suggest that uncritical trade-offs and power-blindness are key challenges and offer a politics of resilience as an antidote. This work reveals three main takeaways. First, the production of resilience across the urban landscape should account for *who, what, when, where, and why*. Second, resilience should be reflected in policy and strategic documents across the municipal scale and integrate into the broader vertical and lateral governance frameworks. Third, resilience should be critically questioned and not assumed to be a positive outcome. It should reflect a city's tolerance for disruption and worldview about change.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADA	Aggregate dissemination area
CMA	Census metropolitan area
CSD	Census subdivision
FED	Federal electoral district
GOA	Government of Alberta

1. INTRODUCTION

Cities and urban regions are a continuous dialogue about the built form, environment, and human agency. These dialogues mediate spatial outcomes, experiences of place, and capabilities to respond to shocks and stresses. This report and project is the culmination of my Graduate Fellowship with the School of Cities at the University of Toronto. Drawing on resilience literature, I explore the interlinkages between how cities manage water and establish a sense of place in a world that has become a design space (Allenby and Chester, 2018). To that end, I look to the City of Calgary ("the City" or "Calgary") as a case study. Specifically, I consider the ongoing post-disaster response to the severe flooding of June 2013 and investigate narratives about the rivers, floodplain and resilience.

As a desktop study, this project attempts to reconcile academic discourse with real-world outcomes and seeks to instantiate a politics of resilience (Meerow and Newell, 2019). By fusing human equity considerations to the practice of urban resilience, this work adds nuance and a critical lens to the critique that resilience is power-blind (Davoudi, 2012). The structure is five-fold. Section 2 contains critical terms and concepts. Section 3 describes the methods while Section 4 summarizes the 2013 Calgary Floods as a case study. Section 5 is a discussion and Section 6 is a closure.

2. BACKGROUND

This section develops three key terms—place identity, the Anthropocene, and resilience—as a foundation for the remainder of the report. Urban water is understood simply as water within the city.

2.1 Place Identity

Infrastructure is the basic constitution and foundation of society (Star, 1999; Graham and Marvin, 2001; Kaika, 2005; Mcfarlane and Rutherford, 2008; Ferguson and Harman, 2015; Gao *et al.*, 2015; Howe *et al.*, 2016; Cao *et al.*, 2017; Dalgaard *et al.*, 2018; Nunzio, 2018; Shepard, 2019). As a continuous dialogue among the built form, the environment, human systems and people (Hay, 2016a; *The Co-Cities Protocol*, no date), infrastructure enables meaning-making across space and time. This is the entry point for the concept of place identity: the transformation of *space* into *place* through meaning-making. From place making to place capital to place character, the discourse on place reflects two different scales: the individual (Cuba and Hummon, 1993; Lewicka, 2008; Knez *et al.*, 2018) and the collective or urban (PPS, 2007; Green, 2010; Kent, 2011, 2015; Manenti, 2011). Putting things together, this means that infrastructure supports distinctive and unique narratives at the urban scale. This is how place identity is interpreted in the project. Section 4.7 identifies some of the narratives for Calgary's rivers and floodplain.

2.2 Anthropocene

The Anthropocene describes global, planetary change that is driven by human agency. Originating in earth systems science (Steffen *et al.*, 2011, 2015; Gaffney and Steffen, 2017) and migrating into geography (Ziegler, 2019; Ziegler and Kaplan, 2019), it has now permeating engineering literature as well (Allenby and Chester, 2018; Chester, Markolf and Allenby, 2019). Broadly, the literature is about the feedback loop between human impacts on the environment and global environmental change. For this project, the Anthropocene signifies how infrastructure is being reconceptualized (Allenby and Chester, 2018). Not only does it blur the distinction between the built and natural environment, it suggests that natural capital assets (Helm, 2019)—such as rivers, floodplains, and watersheds—are in fact infrastructure. Section 4.6 explores flood mitigation that seeks to manage the watershed as infrastructure.

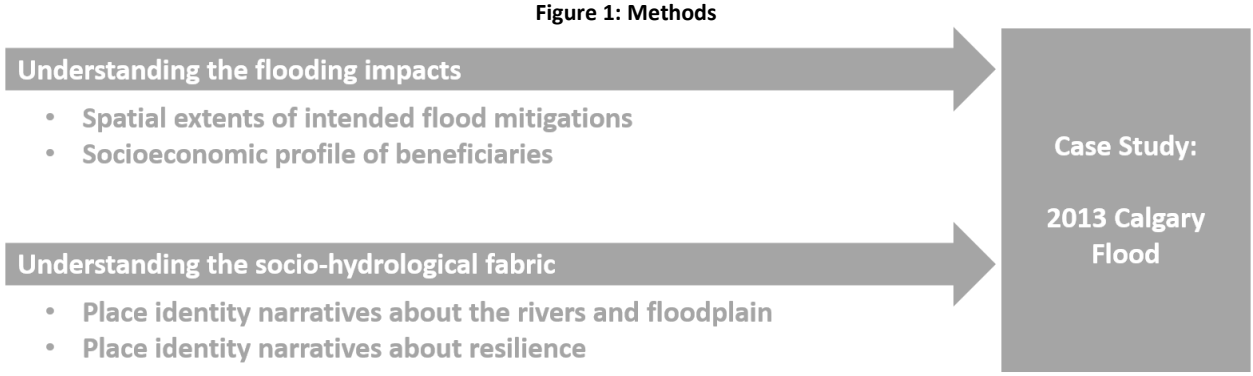
2.3 Resilience

The academic literature suggests (at least) two ways for understanding resilience. The first is a hierarchy structure where persistence, adaptation and transformation are successive levels of resilience (Holling, 1973; Gunderson and Holling, 2002; Folke, 2006; Folke *et al.*, 2010; Davoudi, 2012, 2018; Allen *et al.*, 2014; Meerow, Newell and Stults, 2016; Meerow and Newell, 2019). The second is sequential and time-based. Here, operational resilience (Hay, 2016a) follows the incident sequence model (Hay, 2016b) where persistence, adaptation, and transformation exist at different points along a response-recovery curve. Towards a politics of resilience, this paper adopts the framework by Meerow and Newell (2019) by asking *who, what, when, where, and why* urban resilience (re-)produces the place identity narratives of Calgary's river and floodplain. Section 4.7 identifies some of the narratives about resilience.

3. METHODS

This project adopts a two-track approach. The first track is about understanding the flooding impacts. This includes describing the spatial extents of the proposed flood mitigations and characterizing the socioeconomic profile of those who directly benefit. The second track is about understanding the socio-hydrological fabric by analyzing the place identity narratives about the rivers, floodplain and resilience. Both tracks are summarized in Figure 1. Section 3.1 reviews the data in this project while Sections 3.2 and 3.3 summarize the spatial and narrative analysis.

Figure 1: Methods



3.1 Data

As a desktop study, this project relies on two main types of secondary data. First is the quantitative data. This is spatial or numeric data from the City of Calgary's Open Data Portal and Statistics Canada. This data describes the spatial extents of flooding and characterizes the socioeconomic fabric of the City and the census metropolitan area (CMA). Second is the qualitative data. This is semantic data drawn from City of Calgary documents, Government of Alberta (GOA) publications, consultant reports, news, studies and any other pertinent and credible literature.

The two data types are resolved into four data sets. The first set is flooding data from the City of Calgary (City of Calgary, 2016c, 2018c, 2018a, 2018b, 2018e). The second set is Statistics Canada Data (Statistics Canada, 2017a, 2017y, 2017x, 2017r, 2017s, 2017j, 2017v, 2017k, 2017t, 2017l, 2017n, 2017c, 2017d, 2017e, 2017f, 2017g, 2017h, 2017o, 2017b) that describes the socioeconomic profile at multiple scales (Statistics Canada, 2017i, 2017u, 2017q, 2017p, 2017w) (also see Table 1). The third and fourth sets are semantic data about Calgary's rivers, floodplain and resilience. See Appendix A for further details.

3.2 Spatial Analysis

The spatial analysis reconciles the quantitative data from the City of Calgary and Statistics Canada using QGIS v3.8.3-Zanzibar (QGIS.org, 2019) and has three main components. First, the 1:200-year flood event (representative of desired level of flood mitigation – see Section 4.6), is mapped across the socioeconomic profile for the four spatial scales shown in Table 1.

Table 1: Spatial Scales

Scale	Abbreviation	Description
Aggregate dissemination area	ADA	Representative of the 'neighborhood' scale
Federal electoral district	FED	Representative of the 'community' scale
Census subdivision	CSD	Representative of the 'regional' scale
Census metropolitan area	CMA	Representative of the 'metropolitan' scale

Second, the three pairs of socioeconomic variables in Table 2 are used to characterize the socioeconomic profile. Each pair consists of a baseline variable and a vulnerability variable. The financial capacity variables consist of average income and the low-income index. These approximate the access to resources for responding to a disaster such as flooding. In other words, higher average income suggests that residents are better equipped to cope and bounce back. Conversely, high values for the low-income index means a high fraction of residents who experience financial vulnerability, suggesting less capacity for absorbing disruption. The physical ability variables consist of average age and the children & elderly index. These approximate how easy it would be for emergency egress and evacuation. The logic is that the youngest and oldest need additional support to evacuate and assumes that ages 16 through 64 are able-bodied. The social character variables consist of population density and the visible minority index. Population density approximates the typology of the built form. Higher densities correlate with interstitial (high-rise) communities that pose unique emergency preparedness considerations. The visible minority index approximates social diversity.

Table 2: Socioeconomic Variables

	Baseline Variable	Vulnerability Variable
Financial capacity	Average income	Low-income index
Physical ability	Average age	Children & elderly index
Social character	Population density	Visible minority index

Third, a visual inspection of flooding extents identifies the beneficiaries of flood mitigation at each scale. Then, the socioeconomic profiles at those scales can be further investigated to better understand who benefits. Appendix F contains a combined drawing set produced as a record of the spatial analysis.

3.3 Narrative Analysis

Narrative analysis is one method for drawing out the common reference that informs stories and society (Garcia Rodriguez, 2016). This paper and project, however, adopt a simplified version of narrative analysis. Here, the goal is simply to collect and coalesce sentiments and statements about Calgary's rivers, floodplain and resilience to counterpose real-world outcomes in flood mitigation. A comparison can then be used to inform a politics of resilience to verify if the prevailing narratives align with decision-making and policy.

4. CASE STUDY: 2013 CALGARY FLOOD

This project adopts the 2013 Floods in Calgary as a case study to understand how urban water relates to a sense of place and informs a politics of resilience (Meerow and Newell, 2019). Sections 4.1, 4.2, and 4.3 introduce the region's urban profile, the main watercourses, and flooding history as background information while Sections 4.4, 4.5, and 4.6 describe the timeline of events, response to and impacts of flooding, and flood mitigations. Section 4.7 summarizes narratives about the rivers, floodplain, and resilience.

4.1 Urban Profile

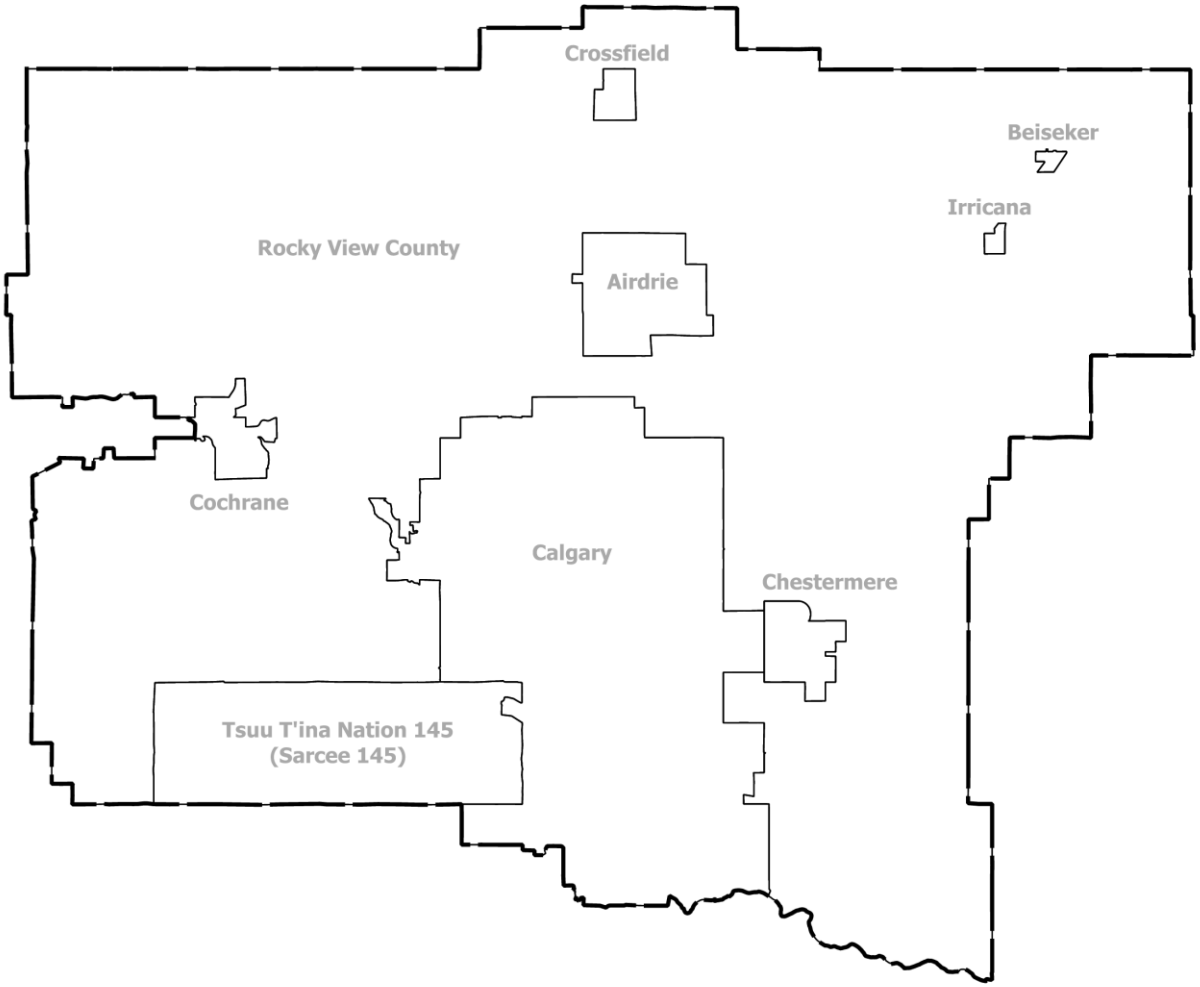
The City of Calgary is the major urban hub in Southern Alberta, founded at the confluence of the Bow and Elbow Rivers in 1875 (City of Calgary, no date). According to the 2016 Census Profile, Calgary had a population of 1,239,220 and a land mass of 825.56 km^2 for a population density of 1501.1 p/km^2 (Statistics Canada, 2017m). It forms the urban heart of the broader CMA, which also includes: Tsuu T'ina First Nation; MD of Rocky View County; Village of Beiseker; Town of Cochrane, Town of Crossfield, and Town of Irricana; City of Airdrie, and City of Chestermere. All nine CSDs in the CMA are shown in Figure 2 (page 5) (also see Drawing A3 in Appendix F).

4.2 Bow and Elbow Rivers

The City's hydrological landscape contains eight salient water features. One is an irrigation canal (Western Headworks Canal), one is a reservoir (Glenmore Reservoir), and four are creeks (Nose Creek, West Nose Creek, Fish Creek, and Pine Creek). The two remaining, the Bow and Elbow Rivers, are the focus of this case study. Broadly, each belongs to its own distinct watershed (City of Calgary, 2017e, p. 23). Drawing A4 from Appendix F, which is reproduced as Figure 3 (page 6), illustrates these water features. The dark blue represents the normal water level and the light blue is the 1:200-year flood event, which coincides with the level of protection that the City of Calgary is pursuing (see Section 4.6 for more).

There is substantial development in both the Bow and Elbow River floodplains (see Table 9 in Appendix B). Within the respective floodplains, 52% and 56% have remained as parks and open space, which notably includes Prince's Island Park, Saint Patrick's Island, Stanley Park, and Lindsay Park (City of Calgary, 2017e, pp. 24, 26, 28). Urban development occupies about 15% and 38% in the Bow and Elbow River Floodplains, respectively (City of Calgary, 2017e, pp. 24, 26, 28). Included are the residential neighbourhoods of Bowness, Hillhurst, Sunnyside, Eau Claire, East Village, Inglewood, Elbow Park, Roxboro, Erlton, and Mission. Commercial districts include Downtown, Deerfoot Meadows, and the Calgary Stampede grounds. Major infrastructure works such as Calgary's three wastewater treatment plants, the Glenmore Reservoir (which is also a water treatment plant), railways, railyards, and highways are also located in the floodplain.

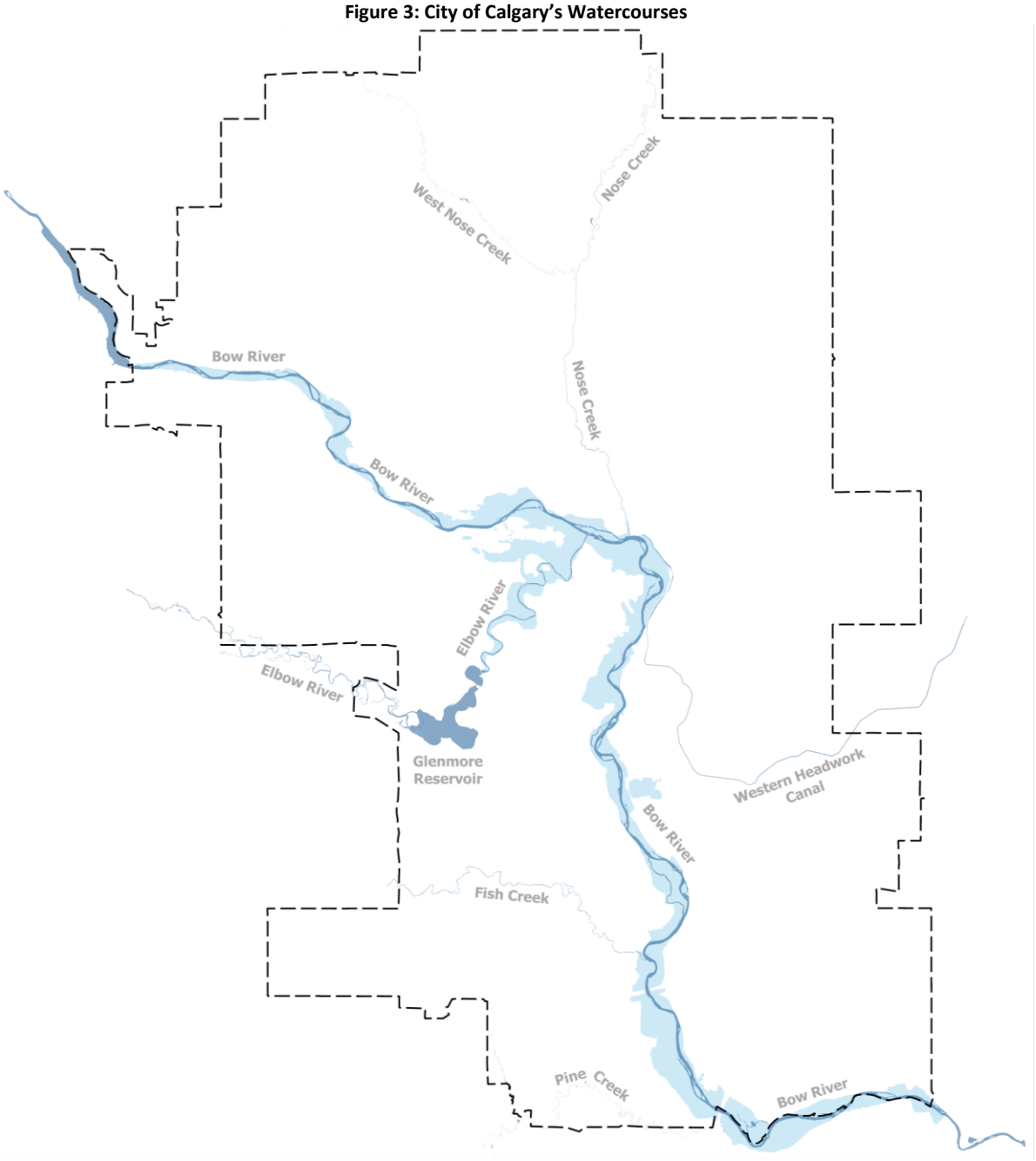
Figure 2: Calgary Census Metropolitan Area



4.3 Brief History of Flooding

Founded at the confluence of the Bow and Elbow Rivers, Calgary is prone to and has an extensive history of flooding. In addition to the June 2013 flood, other major floods were recorded in 1879, 1883, 1884, 1897,1902, 1915, 1923, 1929, and 1932, 1950 (CBC News, 2013c; CPL, 2014c). 2005 was a significant year for rainfall (CPL, 2014b), where both the Bow and Elbow Rivers had flow rates multiple times higher than normal: 300 m^3/s and 700 m^3/s, respectively (City of Calgary, 2020d). The flooding in 2005 impacted over 2000 Calgarians and 40,000 homes sustained water damage (CBC News, 2006; City of Calgary, 2020d). There was extensive damage to Fish Creek Park and infrastructure including roads, pathways, bridges, parks and open space, worth about $75 million in damages altogether (CPL, 2014b; City of Calgary, 2020d). Private residents and businesses further claimed more than $14 million in flood compensation (CBC News, 2006). One significant outcome of the 2005 floods was the formation of an Emergency Operations Centre that convened city administration and external agencies to better respond to natural disasters (CPL, 2014b). Unfortunately, the 2013 floods were worse.

Figure 3: City of Calgary's Watercourses



4.4 Timeline of Events

The "most destructive flood" (CPL, 2014a) in Alberta history took place in June 2013. The flood's severity was due to multiple conditions upstream of Calgary that coincided (CBC News, 2013d). Heavy rain melted snow that was on top of already-saturated or still-frozen ground (meaning the ground was not porous to absorb the water); runoff quickly concentrated on the steep and rocky mountain terrain to flow towards the City (AESRD, 2013; CBC News, 2013d; City of Calgary, 2020i). This was a 1:100-year flood event (City of Calgary, 2020e), with peak flowrates on the Bow River (2400 m^3/s) and Elbow River (1240 m^3/s) at eight and twelve times their normal rates (CPL, 2014a) (see Appendix C for more about flow rates). Flooding and evacuations were widespread, with significant damage to Downtown, parks and open space,

and other infrastructure. Figure 4 (page 7) summarizes a timeline of flooding for the City of Calgary from 19 June 2013 when the initial rains fell in Southern Alberta to 28 November 2013 when the Calgary Zoo was reopened. Note that this timeline has been truncated for this project; impacts and repairs continued for years after and mitigation efforts are ongoing today.

Figure 4: 2013 Calgary Floods, Timeline of Events (CBC News, 2013b; AWPS, 2013; The Canadian Press, 2013; Calgary Stampede, 2013; CBC News, 2013a, 2013d; Calgary Herald, 2013b; Cryderman and Tait, 2013; Gilligan, 2013b; Government of Canada, 2013; Huffington Post Alberta, 2014; CPL, 2014a)

4.5 Response and Impacts

The response efforts were robust. Calgary's 311 service[1] received over 100,000 calls during the crisis (CPL, 2014a). The City's Mayor, Naheed Nenshi, used Twitter to keep citizens informed and updated throughout the disaster (CPL, 2014a). Eight emergency response centres were set up (CPL, 2014a). Downtown offices were closed on Friday 21 June 2013 and all schools were closed on Monday 24 June 2013 (CBC News, 2013b, 2013a). The Canadian Armed Forces provided 1300 troops, 8 helicopters, 1 military airplane, trucks and other vehicles to support the disaster and recovery response (Government of Canada, 2013). Overall, at least 75,000 people were evacuated, impacting about 35,000 homes and businesses (CBC News, 2013a; Page, 2018).

Temporary flood barriers were constructed at critical locations and the water level at the Glenmore Reservoir was strategically lowered so it had greater storage capacity (while still maintaining the capability to treat drinking water) (City of Calgary, 2020i, 2020d). This mitigated flooding impacts along the Elbow River downstream of the reservoir. Calgary Transit suspended routes into Downtown, since all routes into the core were flooded, making downtown "inaccessible for days" (CPL, 2014a; City of Calgary, 2020d). The GOA would later revise the floodplain maps as well (CPL, 2014a). Overland and groundwater flooding and storm and sanitary sewer backups created significant damage to Downtown, neighborhoods, and other areas. At the peak of flooding, 32 communities were flooded. Figure 5 (page 9) illustrates the evacuated communities in pink with the flood extents from 22 June 2013 (approximately a 1:100-year flood event).

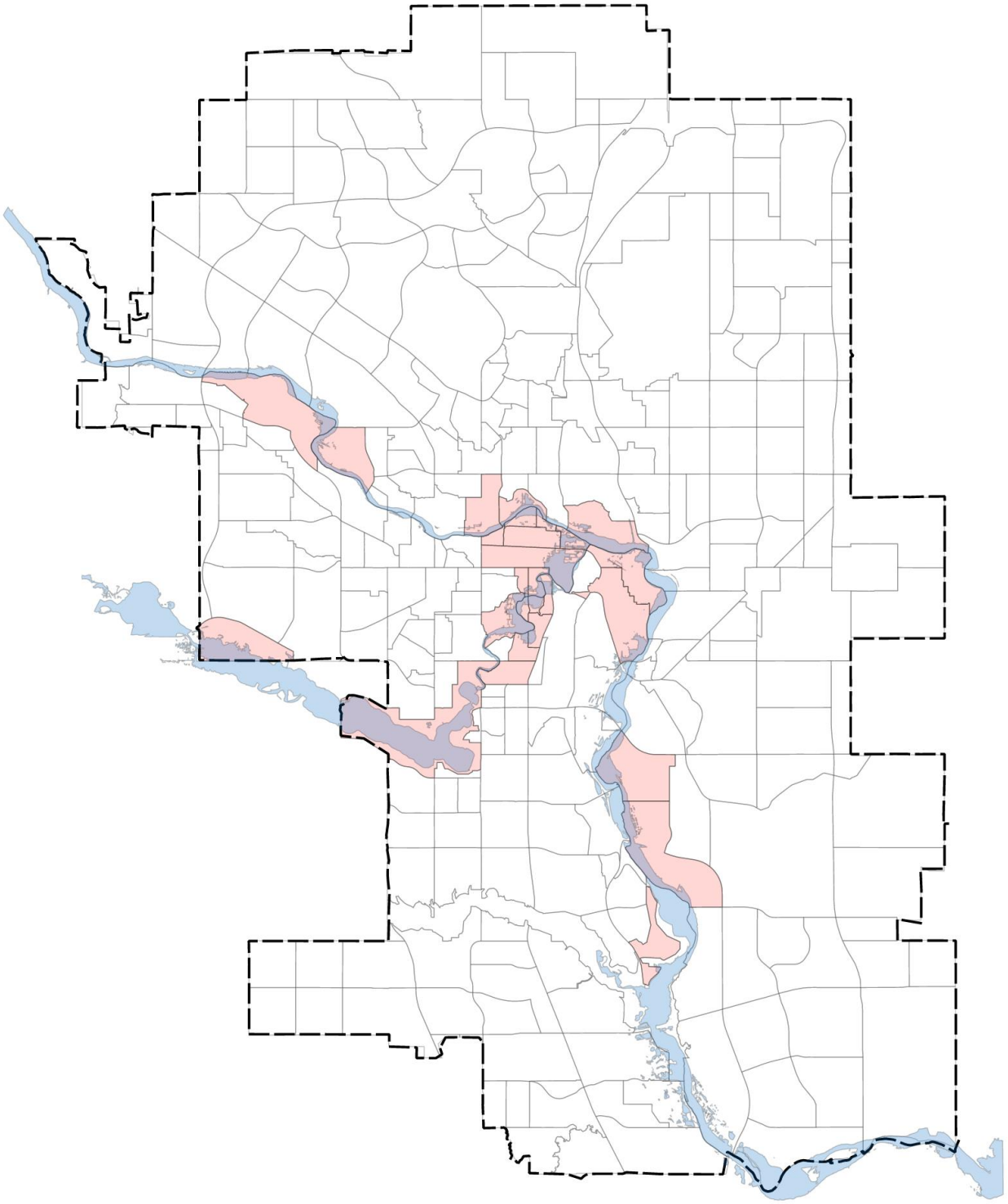
The Downtown was submerged and without power for several days, as the flooding damaged a power substation (Cryderman and Tait, 2013; CPL, 2014a; City of Calgary, 2020i). The Scotiabank Saddledome[2] sustained water damage up to the tenth row of seats, destroying the stage and dressing rooms (CBC News, 2013b). Debris accumulated on the Calgary Stampede grounds and water damaged buildings, electrical and mechanical systems, and other utilities (Calgary Stampede, 2013). There was extensive damage to parks, open space and the Calgary Zoo (Calgary Herald, 2013a; Gilligan, 2013a; Young, 2013; Page, 2018).

Roads and other transport infrastructure were washed out and damaged. For example, the C-Train[3] rail tracks around Erlton Station were lifted by the flood waters and unusable (Martin, 2013). Repairs were expedited and transit operations restored in time for the Calgary Stampede (which opened on Thursday 4 July 2020 for "sneak-a-peak") (Calgary Stampede, 2013). About 40 km of City pathways, many along the river valleys, were washed out or destroyed completely (Page, 2018).

Overall, this was among the costliest disasters in Canadian history with insurable damages estimated at $1.7 billion (CPL, 2014a). Damages to City infrastructure and property are estimated at over $400 million (Page, 2018; City of Calgary, 2020d). Damages to City parks (including Prince's Island Park and Bowness Park) are estimated at $55 million (Page, 2018). The emergency response and recovery efforts cost about $55 million and $323 million, respectively (City of Calgary, 2020d).

[1] The phone line for city information and non-emergency support
[2] Calgary's multi-purpose indoor sports arena and concert venue
[3] Calgary's light rail transit system

Figure 5: Evacuated Neighborhoods in Calgary (AWPS, 2013; Elliott, 2013; City of Calgary, 2016a)



4.6 Flood Mitigations

Given the historic flood levels and widespread impacts and damage, recovery and protection commitments by decision-makers to were prompt (Calgary Herald, 2013b, 2014; Government of Canada, 2013). While the June 2013 floods are characterized as a 1:100-year flood event (see Appendix C for more about flow rates), the City of Calgary's Flood Mitigation Measures Assessment championed flood

mitigations for the 1:200-year flood event (City of Calgary, 2016b, p. 5). These mitigations, a shared responsibility among citizens and the three levels of government (municipal, provincial, and federal), would span three scales: property, community and watershed (City of Calgary, 2016b). The mitigations could be non-structural (ie. policy at the property-scale) or structural (ie. built infrastructure at the community- and watershed-scale).

For the property-scale, mitigations address building codes, bylaws, land use regulations, flood mapping, flood awareness education and other policy changes (City of Calgary, 2016b, p. 9; Lo, 2020). Substantive changes include restricting greenfield development and sensitive uses within the floodplain, strategic acquisition of properties or buildings, early warning and forecast systems, emergency preparedness protocols, and creating interactive and educational flood risk and awareness maps (City of Calgary, 2016b; Bowen, 2017, p. 9; City of Calgary, 2018f, p. 11, 2019, p. 11, 2020d, 2020q, p. 11).

For the community-scale, flood mitigation is made up of barriers, in-stream works, and other utility enhancements along both rivers (City of Calgary, 2016b). For the Bow River, flood barriers were identified for six areas, including Downtown, Sunnyside-Hillhurst, Bowness, Heritage Drive, Inglewood and the Bonnybrook Wastewater Treatment Plant (City of Calgary, 2016b, p. 8, 2020l). Four of these six are underway (City of Calgary, 2020f, 2020n, 2020b, 2020a). For in-stream works, a bank stabilization program has been completed and two gravel bar dredging projects are forthcoming (City of Calgary, 2016b, 2020c, 2020m). Finally, a suite of storm and sanitary sewer improvements are being pursued (City of Calgary, 2020c). This includes pump stations and lift stations, separating drainage infrastructure, outfall improvements, and utility relocations (City of Calgary, 2020j, 2020o, 2020r, 2020a, 2020k).

For the Elbow River, the main community-scale mitigation is an upgrade to the dam gates at the Glenmore Reservoir (City of Calgary, 2020l). After a comprehensive review of other mitigation approaches, the City committed $82 million in 2014 (CBC News, 2014; WaterSMART and Alberta Innovates, 2014). Construction commenced in the spring of 2017 (Perri, 2017; City of Calgary, 2018d) and the upgrade was completed in May 2020 (Dippel, 2020). A pedestrian and cyclist pathway on top of the dam was opened to the public in September 2020 (Kaufmann, 2020). The reservoir's storage capacity has now doubled (City of Calgary, 2018d; Lo, 2020, p. 1) and absorbs up to 20% of the 2013 flood risk (Lo, 2020, p. 3). For in-stream works, two gravel bar projects are anticipated (City of Calgary, 2020c).

While the watershed-scale mitigations are the most impactful, they are also the most costly and complex. These mitigations are large-scale; they alter the behaviour of the watershed upstream of the City and take the form of reservoirs. For the Bow River, an interim solution is operational while a permanent mitigation is pursued. During the 2013 floods, the Ghost Reservoir (upstream of Calgary) was used to retain water and lessen the flood impacts downstream. Following several reports and recommendations (AMEC, 2014; Expert Management Panel on River Flood Mitigation, 2014), modified operations on the Ghost Reservoir have continued following successful pilot projects (TransAlta, 2014, 2016). A five-year agreement between TransAlta (the power company that operates the Ghost Reservoir) and the GOA was arranged in 2016 with intentions to extend beyond 2021 (TransAlta, 2016; City of Calgary, 2020l). A permanent reservoir for the Bow River, which requires both provincial and federal involvement, is still in the early stages and a location has not been determined (City of Calgary, 2016b; Government of Alberta, 2020a). Currently, the GOA is completing the conceptual assessment for three options (Government of Alberta, 2017a, 2018a, 2020a; Wood, 2020).

The watershed-scale mitigations for the Elbow River contrast the restrained progress on the Bow River. A 2013 report by engineering services consultant Stantec Consulting Ltd. identified three options: the Springbank Reservoir, McLean Creek, and Elbow-to-Bow Diversion (Stantec Consulting Ltd., 2013). After multiple studies and reports (AMEC, 2014, 2015; Expert Management Panel on River Flood Mitigation, 2014; WaterSMART and Alberta Innovates, 2014; Deltares, 2015; IBI Group, 2015c, 2015b, 2015a), the GOA announced in December 2016 to proceed with the Springbank Reservoir, which is located about 18 km upstream of the City (Government of Alberta, 2015, 2016; City of Calgary, 2020l). After completing further studies, updates, open houses, and other environmental compliance (Government of Alberta, 2017c, 2017b; IBI Group, 2017; Government of Alberta, 2018b; Stantec Consulting Ltd., 2018; Government of Alberta, 2019b), the Springbank Reservoir is ready for construction pending regulatory approvals as of Spring 2020 (Government of Alberta, 2020b). A summary of flood mitigations is given in Table 14 in Appendix D.

4.7 River, Floodplain and Resilience Narratives

Broadly speaking Calgarians hold the rivers and floodplain in high regard. Socially, they offer green and blue spaces for leisure and recreation. This includes parks and other open spaces for picnics, walking and cycling; clean water for boating, floating, rafting, canoeing, and fly fishing; and a healthy river ecosystem that connects Calgarians to urban wildlife. The leisure and recreation activities translate into economic benefits, especially given the Bow River's world-class, international reputation for fly fishing and water sports (Government of Alberta, 2019a, p. 4). Both the social and economic dimensions are supported by Calgary's strict adherence the environment, wastewater treatment, and maintenance of ecosystem health.

Given the closeness of social, economic, and environmental narratives, it is no surprise that Calgarians take pride in the rivers and floodplain. They coincide with meaning-making, as "83% of Calgarians say that river areas are important to them personally" (Ipsos Public Affairs, 2016; City of Calgary, 2017e, p. 1). This is the most significant narrative. It demonstrates how Calgarians derive value from the rivers and floodplain. Notably, the underlying assumption is that all Calgarians have equal and abundant benefit and access that supports a "first-class lifestyle" (Calgary River Valleys, 2012; City of Calgary, 2017e).

This importance is further reflected in decision-making. There is long-term planning for the rivers and floodplain. Further, the rivers and floodplain are critical to the sustainability goals of Calgary's Municipal Development Plan (City of Calgary, 2009). In addition to the recreational functions stated above, the rivers and floodplain are valued for development. Particularly, the City's origins at the confluence of the Bow and Elbow Rivers is being re-imagined by the Rivers District Revitalization of East Village and Victoria Park East (City of Calgary, 2007, 2017b; CMLC, 2019; City of Calgary, 2020p; Stephen, 2020). To protect against flooding, the City and developers adopt the view that watershed infrastructure can be managed and transformed for human consumption, that the floodplain is hybrid built-natural infrastructure. See Table 10 and Table 11 in Appendix B for more details about these narratives.

Resilience has become much more important to city building efforts since 2013. Resilience against urban flooding has became "a top priority" (City of Calgary, 2020h, p. 3). Among the three types of resilience, the City's approach reflects persistence and adaptation. Persistence is foremost, as resilience is defined as "the capacity to endure and recover from disruptive events" (City of Calgary, 2017e, p. 5). Adaptation is secondary and specific to urban flooding: "there will always be a need to prepare, respond and adapt to floods" (City of Calgary, 2020l). Persistence and adaptation are reflected in narratives about

development within the floodplain. The City notes that the costs to relocate *all* development out of the floodplain is "extraordinarily high (over $2 Billion)" (City of Calgary, 2017c, p. 12), suggesting persistence. However, they further pursue strategic buyouts of properties to "reduce future flood damages" (City of Calgary, 2017c, p. 12), suggesting adaptation. These narratives contrast the ones about new development in the floodplain, which suggest resilience as transformation of the watershed as hybrid built-natural infrastructure.

In combination, the views about resilience and infrastructure exemplify inconsistencies about the role of people in building resilience. On the one hand, resilience is framed as an activity and process for a more equitable society. City documents (City of Calgary, 2016b, 2017d) suggest that all Calgarians have a stake and role in building resilience. On the other hand, the knowledge capital and resilience capability is rarefied. The City looks to industry and subject matter experts for advice and subsequently brokers the agenda about flood resilience, engaging with those it deems necessary (City of Calgary, 2017d, pp. 2, 10). In other words, citizens and the broader public experience the first-hand impacts of flooding yet should necessarily lean on expert advice and City leadership in times of crisis *by design*. This suggests that the share of public ownership about resilience is actually much smaller in practice. See Table 15 and Table 16 in Appendix D for more details about these narratives.

5. DISCUSSION

One critique of urban resilience is that it is power-blind (Davoudi, 2012). In other words, it is employed as a normative instrument for reaching improved (more resilient) urban outcomes with little consideration for human equity. The following discussion demonstrates that resilience is not neutral, that it is unequally spatialized across urban landscapes. Section 5.1 is a synthesis of the spatial and narrative analysis that supports a politics of resilience described in Section 5.2. Finally, takeaways are given in Section 5.3.

5.1 Spatial and Narrative Analysis

The spatial analysis reconciles the spatial benefits of flood mitigation with the socioeconomic profile at four different scales (Table 1). Appendix F contains a combined drawing set produced as a record of this analysis for the six variables described in Table 2. When comparing across scales, conclusions are weak and necessarily generalized since the CMA and CSD scales are so large they obscure local character and context. What does come through, however, is that the City of Calgary is either representative of the metropolitan region (age characteristics) or exhibits qualities typical of urban centres (richer, denser, more socially diverse). Thus, targeted flood mitigations for the City benefits the region overall, broadly speaking.

A more nuanced understanding of resilience is revealed by comparing the baseline and vulnerability variables at the ADA scale for the areas most impacted. A visual and semantic assessment of the drawing set (Appendix F) and flood mitigations (Section 4.6) leads to the critical ADAs listed in Table 3. Table 4 summarizes their socioeconomic profile. In terms of financial capacity, the critical ADAs have at least the average income of Calgarians, but are more (Bowness, Downtown) or less (Glenmore Reservoir area) income vulnerable than the City overall. This is analogous for physical ability. The critical ADAs are at least as old as the average Calgarian but are more (Bowness, Glenmore Reservoir area) or less (Downtown) age vulnerable. For social character, all critical ADAs are as dense as the Calgary average but less socially diverse. This demonstrates that the socioeconomic profile is spatially uneven. For example, higher average income suggests "less" need for resilience, but older average age and higher density suggest the opposite.

When vulnerability is considered, there is further fragmentation. For example, the Glenmore Reservoir area has the least income vulnerability, most age vulnerability, and least social diversity. The resilience trade-offs quickly become wicked. See Appendix E for more details about the spatial analysis and interpretation of drawings.

Table 3: Critical Aggregate Dissemination Areas

	ADA Number
Bowness	050, 052, 061
Downtown	095, 095, 098, 102, 104, 106, 107, 109
Glenmore Reservoir area	118, 125, 128

Table 4: Socioeconomic Profile for Calgary, Bowness, Downtown, and Glenmore Reservoir Area

	Average Income ($)	Income Vulnerability	Average Age (Years)	Age Vulnerability	Population Density (p/km^2)	Social Diversity
Calgary Average	44,000	0.4	37.6	0.64	1501.1	0.4
Bowness	44,500	0.64	43.1	0.72	1804.2	0.19
Downtown	48,500	0.65	38.8	0.39	6962.5	0.36
Glenmore Reservoir area	51,000	0.32	46.2	0.88	1682.1	0.17

Broadly, the narrative analysis suggests three main themes. First, the rivers and floodplains are natural capital assets for all Calgarians to utilize and enjoy. Second, resilience is important to Calgary's overall city building efforts and is practiced as persistence or adaptation. Third, resilience is rarefied for decision-makers and subject matter experts at the expense of the everyday person. Combining the spatial and narrative analysis supports the critique that the production of flood resilience is unequal and power-blind. Indeed, fulfilling all the 1:200-year flood event mitigations would protect the City and wider region, but the benefits diverge and fragment across the urban landscape by socioeconomic profile.

Based on the three pairs of variables adopted in this project (Table 2), the production of urban resilience is then an exercise in trade-offs. Should resilience be prioritized for Downtown since it has high income vulnerability and high social diversity? Or should resilience be prioritized for the Glenmore Reservoir area, which has high age vulnerability? Beyond these trade-offs, the upgraded dam gates have immediate value for the Glenmore Reservoir area. But both watershed-scale mitigations for the Bow and Elbow Rivers are still underway, which means Bowness and Downtown remain vulnerable. Indeed, it is rational to link resilience to the level and extent of flooding (ie. based on topology and storm event). This approach to resilience remains power-blind, however, as it broadly overlooks the local need and human equity considerations associated with the socioeconomic profile of flood impacted areas.

5.2 Politics of Resilience

To inform a politics of resilience about flood mitigation, this section builds upon the uncritical trade-offs and power-blindness highlighted above. Specifically, it emulates the approach by Meerow and Newell (2019) by asking *who, what, when, where, and why*. Asking these questions can support and clarify the intentions behind pursuing different types of resilience (persistence, adaptation, or transformation). Further, these questions are a mirror and litmus test for validating if policy and decision-making aligns with the prevailing narratives about the rivers, floodplain, and resilience in the first place. Insight to these questions are given in Table 5.

Table 5: The Politics of Resilience

Who	**Who determines what is desirable?** All levels of government and industry decide the outcomes of resilience. Citizens engagement, while a consideration in the resilience building process, does not drive the production of urban resilience. **Whose resilience is prioritized?** People and development (whether existing or proposed) within the floodplain benefit from improved resilience up to the 1:200-year flood event. The spatialization of resilience is driven by topology rather than socioeconomic profile, local need and human equity. **Who is included (and excluded)?** Decision-making power resides with government and industry. Citizens play a passive role in deciding the outcomes of resilience.
What	**What are we being resilient to?** Water damage in terms of river and stormwater flooding and disruption to the daily lives of people and businesses within the floodplain. **What is included in the urban system?** The rivers, floodplain and watersheds within and upstream of the City in addition to the urban built environment within City limits . **Is the focus on generic or specific resilience?** The focus is specific to flood mitigation.
When	**Does the resilience respond to shocks or stresses?** The resilience responds to shocks on the watershed infrastructure and urban built environment. **Is the focus on long or short-term resilience?** The focus is on resilience up to the 1:200-year flood event, which has a 0.5% chance of occurring in a given year. **Is the focus on resilience for present or future generations?** The investment in resilience benefits both present and future generations up to the 1:200-year flood event. However, the major capital expenditures may become a liability for future generations, eroding the future resilience.
Where	**What are the spatial boundaries?** Mitigations occur in 3 scales: property, community, and watershed. Ultimately, the City seeks to manage the watershed as infrastructure. This extends Calgary's flood resilience boundaries beyond it's political borders, as the Springbank Reservoir, Ghost Reservoir and future Bow River Reservoir all belong to municipalities outside of the City of Calgary. **Is the resilience of some areas prioritized over others?** Resilience is prioritized based on flooding extents of the 1:200-year flood event. This is driven necessarily by topology and does not reflect socioeconomic need of people or development living or operating in the floodplain. Flood mitigation infrastructure within the City is underway or complete. The net effect is prioritized resilience along the Elbow River. **Does building resilience in some areas affect resilience elsewhere?** The specific focus on flood resilience diverts resources from other areas of the City that remain underinvested.
Why	**What is the goal and underlying motivation for building urban resilience?** The underlying motivation is to persist in the floodplain (and adapt as possible). The rivers and floodplain as natural capital assets that Calgarians enjoy as recreation (fishing, boating, parks and open space) or development (Rivers District) are protected.

5.3 Takeaways

To move towards a world that is more resilient and equitable, three key takeaways are clear. First, resilience in practice should think critically about *who, what, when, where, and why*. These questions can guide dialogues on how resilience is spatialized and bring more voices and stakeholders into the fold of decision-making. By raising these questions, it may be possible to rectify the citizen engagement process by making wicked trade-offs more legible. This is one pathway to inoculate the power-blindness critique and co-create urban resilience.

Second, resilience is necessarily spatial so policy should be nested. Rather than standalone reports and strategies solely focused on resilience, policy should permeate the breadth and depth of strategic municipal documents. They should also extend vertically across levels of government and laterally across jurisdictions. This is one way to address the slow progress towards the new reservoirs for the Bow and Elbow Rivers.

Finally, pause and reflection should be accorded to whether the pursuit of resilience is a net positive or net negative. This is about questioning resilience as a normative instrument. I would argue that a reasonable urban practitioner would reasonably foresee future consequences and damage to people and development within the floodplain from urban flooding. In this case study, the City of Calgary estimated that it would cost about $2 billion to relocate development (City of Calgary, 2017c, p. 12). The pursuit of other mitigation options suggests that the disruption to the socioeconomic fabric is unpalatable. However, if insurable costs for the 2013 flood alone amounted to $1.7 billion (CPL, 2014a), one instance of a flood similar to the one in 2013 (prior to the completion of the two remaining reservoirs) would have more than justified this relocation cost. In other words, should resilience be about persisting in the floodplain, adapting to the floodplain, or transforming (away from) the floodplain? The answers to these questions ultimately reflect a city's tolerance for disruption and worldview about change.

6. CLOSURE

The narratives we tell about the places and cities we live in are linked to their resilience. In this project, I adopted the 2013 floods in the City of Calgary as a case study to understand the connections among place identity, the Anthropocene, and urban water. By combining a spatial analysis of flooding impacts with a narrative analysis to understand Calgary's socio-hydrological fabric at four different scales (neighbourhood, community, regional, and metropolitan), I demonstrate the trade-offs and power-blindness in the practice of resilience. An antidote to these challenges is to instantiate a politics of resilience (Meerow and Newell, 2019). In turn, three takeaways become legible. First, resilience should think critically about *who, what, when, where, and why*. Second, resilience as a policy should be spatialized and nested laterally and vertically among governance scales. Third, resilience as a normative instrument should be afforded pause to question if it aligns with a city's tolerance for disruption and worldview about change.

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APPENDIX A: OPEN DATA

Table 6: Open Data – City of Calgary, Flooding Data

Description	Reference
Flood extents on June 22, 2013	(City of Calgary, 2018c)
1:100 Flood Map	(City of Calgary, 2018a)
1:200 Flood Map	(City of Calgary, 2018b)
Regulatory Flood Map	(City of Calgary, 2018e)
Hydrology	(City of Calgary, 2016c)

Table 7: Open Data – Statistics Canada, Census Profile, 2016 Census

Scale	Spatial Extents	Reference
Aggregate dissemination area	City of Calgary	(Statistics Canada, 2017a, 2017b, 2017c, 2017d, 2017e, 2017f, 2017g, 2017h)
Federal electoral district	City of Calgary	(Statistics Canada, 2017o)
Census subdivision	City of Calgary	(Statistics Canada, 2017l)
Census subdivision	Calgary Metropolitan Area	(Statistics Canada, 2017x, 2017r, 2017s, 2017j, 2017v, 2017k, 2017t, 2017y)
Census metropolitan area	Calgary Metropolitan Area	(Statistics Canada, 2017n)

Table 8: Open Data – Statistics Canada, Cartographic Boundary Files

Scale	Year	Reference
Aggregate dissemination area	2016	(Statistics Canada, 2017i)
Federal electoral district	2013	(Statistics Canada, 2017u)
Census subdivision	2016	(Statistics Canada, 2017q)
Census metropolitan area	2016	(Statistics Canada, 2017p)
Provinces, territories	2016	(Statistics Canada, 2017w)

APPENDIX B: BOW AND ELBOW RIVERS

Table 9: Development in the Bow and Elbow River Watersheds (City of Calgary, 2017e, pp. 24, 26, 28)

	Bow River Watershed	Elbow River Watershed
Parks and Open Space	Bowness Park, Bowmont Park, Edworthy Park, Shouldice Park, Prince's Island Park, Saint Patrick's Island, Pearce Estate Park, the Inglewood Bird Sanctuary, Beaverdam Flats, Sue Higgins Park, Carburn Park, and Fish Creek Provincial Park	Griffith Woods, The Weaselhead, Sandy Beach Park, The Calgary Golf and Country Club, Stanley Park, and Lindsay Park
Residential and Commercial	**Residential**. Bowness, Hillhurst, Sunnyside, Eau Claire, East Village, Inglewood, Bridgeland, Riverbend, Quarry Park, and Cranston. **Commercial**. Downtown core, Deerfoot Meadows	**Residential**. Elbow Park, Roxboro, Erlton. **Mixed use**. Mission. **Commercial**. Calgary Stampede grounds
Infrastructure	Wastewater treatment plants (Bonnybrook, Pine Creek, and Fish Creek), railways, railyards, highways	Glenmore reservoir, Glenmore Water Treatment Plant.

Table 10: River and Floodplain Narrative Summary

Takeaway	Quote
Rivers coincide with meaning-making	"83% of Calgarians say that river areas are important to them personally" (Ipsos Public Affairs, 2016; City of Calgary, 2017e, p. 1)
The floodplain is watershed infrastructure that can be managed	"Riparian areas are the foundation of a new approach to integrated watershed management" (City of Calgary, 2017e, p. 8)
The City conceptualizes the floodplain as hybrid built-natural infrastructure	"By integrating natural and built infrastructure, water managers reduce their reliance on the latter, while at the same time realizing a host of riparian benefits, including: flood risk management; clean, safe water; biodiversity; economic benefits; quality of life; and education and stewardship" (City of Calgary, 2017e, pp. 9–10)
The rivers and floodplain are important to decision-makers	"to protect and restore riparian landscapes within Calgary" (City of Calgary, 2017e, p. 1)
All Calgarians benefit and derive value from the rivers and floodplain	"Responsible planning and management of riparian areas will benefit Calgarians by providing cleaner water and improved drainage that supports recovery after climactic events, including flood and drought" (City of Calgary, 2017e, p. 7)
All Calgarians benefit and derive value from the rivers and floodplain	"Current and future Calgarians will benefit from improved community safety, as these drainage features can be designed as emergency valves for extreme rainfall events. Other benefits include access to nature and increased ability to recover from climatic events, including food and drought. As more riparian areas are protected from development, The City could lower its maintenance costs by having less engineered drainage infrastructure" (City of Calgary, 2017e, p. 15)
All Calgarians benefit and derive value from the rivers and floodplain	"As more riparian areas are restored to health, current and future Calgarians will benefit from improved water quality in our waterways, improved drainage and improved public safety due to increased ability to recover from climatic events, including food and drought. Healthy banks are also more aesthetically pleasing, require less engineered bank infrastructure and provide critical habitat and corridors for plant, animal and fish populations" (City of Calgary, 2017e, p. 18)
All Calgarians benefit and derive value from the rivers and floodplain	"Current and future Calgarians will benefit from a greater connection to Calgary's rivers and creeks. Other watershed groups working within the area of riparian protection and restoration will also benefit through increased watershed literacy among citizens, increased support for their work and specific opportunities to partner with The City." (City of Calgary, 2017e, p. 20)
Watershed management aligns with the Calgary Municipal Development Plan goal of "Greening the City" (City of Calgary, 2009)	Figure 5 "Alignment of Riparian Action Program with Riparian Strategy" (City of Calgary, 2017e, p. 13)

The City's origins at the confluence of the Bow and Elbow Rivers is being re-imagined by the Rivers District Revitalization (City of Calgary, 2020p)	"Calgary's historical roots are at the confluence of the Bow and the Elbow Rives, a naturally occurring ford that has been the centre of life and activity in this region for millennia" (City of Calgary, 2017e, p. 9)
The rivers are highly prized, which translates into pronounced community pride in the river valleys	"Calgary River Valleys is a strong and effective voice for Calgary's most valued natural resource, its river valleys" (Calgary River Valleys, 2012, p. i)
There are multiple stakeholders for the preservation of the rivers, which is treated as a commons	"CRV brings together Calgary residents, community associations, Council members and staff from all levels of government to ensure the long-term health of Calgary's water resources" (Calgary River Valleys, 2012, p. i)
There is long-term planning for the river and water resources	"Calgary is wisely investing in river valley preservation now" (Calgary River Valleys, 2012, p. 4)
The Bow provides Calgary with clean drinking water that enables a "first-class lifestyle" (Calgary River Valleys, 2012, p. 9)	"The Bow River provides 60 % of Calgary's drinking water. That water supports health, commerce, tourism and a first-class lifestyle" (Calgary River Valleys, 2012, p. 9)
Calgary is serious about wastewater treatment and maintaining the health of the Bow River.	"The Bow River also flushes away a lot of waste that Calgarians would rather not keep close. Fortunately for the river and our downstream neighbours, Calgary has state-of-the-art wastewater treatment facilities." (Calgary River Valleys, 2012, p. 9)
The river valleys offer parks and other open spaces for picnics, walking and cycling that is accessible to all.	"Most Calgarians enjoy the Bow River and its tributaries through the many parks along the shores. These parks offer a nature getaway within everyone's reach. A picnic, a walk or a bicycle ride can take a person's mind of more hectic aspects of life." (Calgary River Valleys, 2012, p. 9)
The rivers provide recreational activities in the water, such as boating or floating (City of Calgary, 2020g).	"The Bow River also provides summer fun for responsible boaters. Many people enjoy an afternoon on the river right at their doorstep in a way other city dwellers around the world envy." (Calgary River Valleys, 2012, p. 9)
The healthy river ecosystems connect Calgarians to urban wildlife.	"Healthy riparian corridors throughout the city allow Calgarians to glimpse wildlife that would otherwise avoid populated areas." (Calgary River Valleys, 2012, p. 9)
The Bow River maintains a world-class, international reputation for fly fishing and water sports such as rafting and canoeing.	"Over the last 30 years, the Bow River (part of the South Saskatchewan River Basin) has grown in reputation to become a world-famous fly-fishing destination and popular area for rafting and canoeing. The Bow River, an iconic river with over a million people living next to it, draws local and international attention." (Government of Alberta, 2019a, p. 4)
The river has a significant economic impact.	"The direct economic contribution of the Bow River fishing community to City of Calgary businesses is in excess of $24.5M and by regional fishing related activities a total of $114m annually." (CRUA, 2016, p. 5)
Recreation and the river is important for locals and economic development.	"CRUA is of the opinion that improving boat access within the City of Calgary will contribute greatly to the fishing and paddling experience that visitors and local users have while in the city. An enjoyable experience will generate an increase in return visitors to the city. Local businesses will thrive and benefit from satisfied customer generating increased revenue." (CRUA, 2016, p. 5)
The river enables both social and economic value.	"River activities including canoeing, kayaking, rafting and fishing are popular recreation and leisure activities according to the 2013 Albert Recreation Survey" (City of Calgary, 2017a, p. 3)

Table 11: River and Floodplain Narrative Analysis

	Society	Economy	Environment	Equity	Pride	Development	Recreation
Rivers coincide with meaning-making					●		
The floodplain is watershed infrastructure that can be managed						●	
The City conceptualizes the floodplain as hybrid built-natural infrastructure						●	
The rivers and floodplain are important to decision-makers					●		
All Calgarians benefit and derive value from the rivers and floodplain				●	●		
Watershed management aligns with the Calgary Municipal Development Plan goal of "Greening the City" (City of Calgary, 2009)					●	●	
The City's origins at the confluence of the Bow and Elbow Rivers is being re-imagined by the Rivers District Revitalization (City of Calgary, 2020e)						●	
The rivers are highly prized, which translates into pronounced community pride in the river valleys					●		●
There are multiple stakeholders for the preservation of the rivers, which is treated as a commons				●	●		
There is long-term planning for the river and water resources					●	●	
The Bow provides Calgary with clean drinking water that enables a "first-class lifestyle" (Calgary River Valleys, 2012, p. 9)			●	●			
Calgary is serious about wastewater treatment and maintaining the health of the Bow River.			●	●			
The river valleys offer parks and other open spaces for picnics, walking and cycling that is accessible to all.	●			●			●
The rivers provide recreational activities in the water, such as boating or floating (City of Calgary, 2020c).	●						●
The healthy river ecosystems connect Calgarians to urban wildlife.	●		●				●
The Bow River maintains a world-class, international reputation for fly fishing and water sports such as rafting and canoeing.	●	●					●
The river has a significant economic impact.		●					
Recreation and the river is important for locals and economic development.		●					●
The river enables both social and economic value.	●	●					

APPENDIX C: 2013 CALGARY FLOOD

Table 12: Annual Return Periods – Flow Rates (City of Calgary, 2020e)

Return Period (years)	Probability of Occurrence in a Given Year (%)	Elbow River (m^3/s)		Bow River (m^3/s)	
		Above Glenmore Dam	Below Glenmore Dam	Above Elbow River	Below Elbow River
2	50	84.6	63.9	369	433
5	20	194	143	659	802
10	10	307	234	927	1160
20	5	454	275	1230	1500
50	2.0	708	494	1660	2150
100	1.0	954	803	2020	2820
500	0.2	1770	1690	2920	4610

Table 13: Flow Rates from the 2013 Calgary Flood (CPL, 2014a; City of Calgary, 2020e)

Return Period (years)	Elbow River (m^3/s)		Bow River (m^3/s)	
	Above Glenmore Dam	Below Glenmore Dam	Above Elbow River	Below Elbow River
100	1240	699	1840	2400

APPENDIX D: FLOOD MITIGATIONS AND RESILIENCE

Table 14: Summary of Flood Mitigations

Scale	Bow River	Elbow River
Property	**Policy initiatives**. Building codes, bylaws, land use regulations, flood mapping, flood awareness education and other policy changes. **Developments**. Restricting greenfield development and sensitive uses within the flood fringe, strategic acquisition of properties or buildings within the flood fringe, adopting warning and forecast systems, updating and practicing emergency preparedness, and creating interactive and educational flood risk and awareness maps.	
Community	**Flood barriers**. Downtown, Sunnyside-Hillhurst, Bowness, Heritage Drive, Inglewood and the Bonnybrook Wastewater Treatment Plant **In-stream works**. Riverbank stabilization, Centre Street Gravel Bar, Crowchild Trail NW gravel bar **Utilities**. Sunnyside sanitary and stormwater lift stations, Upper Plateau Separation, stormwater outfall improvements, Bonnybrook Wastewater Treatment Plant upgrades	**Flood barriers**. Upgrade to the dam gates at the Glenmore Reservoir. **In-stream works**. Riverbank stabilization, Mission island gravel bar, Scollen Bridge gravel bar.
Watershed	**Interim**. Modified operations at the Ghost Reservoir. **Forthcoming**. Permanent reservoir for the Bow River is in the conceptual assessment phase. Three locations are under consideration: Glenbow East, relocated Ghost Dam, Morley (Government of Alberta, 2020a)	**Forthcoming**. The Springbank Reservoir is ready for construction pending regulatory approvals as of Spring 2020.

Table 15: Flood Resilience Narrative Summary

Takeaway	Quote
The City adopts the persistence approach to resilience	"Resilience is the capacity to endure and recover from disruptive events" (City of Calgary, 2017e, p. 5)
The City understands that flood risk is dynamic and uncertain	"The 2013 flood event emphasized the need to address flood risk in Calgary, protect public safety and reduce future social, environmental, and economic flood damages to our city. This imperative drove the recommendation for The City to gain a better understanding of Calgary's flood risk and the changing dynamics of the floodplain, and develop evidence-based strategies to reduce flood risk" (City of Calgary, 2017c, p. 3)
The City conceptualizes the watershed as hybrid built-natural infrastructure that can be managed	"This aligns with concepts of integrated watershed management and integrated flood risk management, which aim to manage the watershed as a holistic system and create climate adaptable resilience." (City of Calgary, 2017c, p. 9)
The social and economic costs of relocating development out of the floodplain is too high and hence infeasible.	"Property ownership and development within Calgary's floodplain is diverse, spanning many land uses and demographics. The cost of buying out all properties at flood risk in Calgary and converting them to parkland is extraordinarily high (over $2 Billion) – far more costly than any other mitigation option assessed. Not all properties have to be bought out to reduce future flood damages. Buying out select properties, however, leaves many other properties still in need of protection. The financial and social implications of buying properties must be considered very carefully." (City of Calgary, 2017c, p. 12)

Everyone has a stake in flood resilience	"Protecting Calgary from flood risk is a shared responsibility of all orders of government and citizens" (City of Calgary, 2016b, p. 3)
The City looks to industry and subject matter experts for advice. At the same time, the City calls on the "whole community" to collaborate towards resilience.	"To guide the flood resiliency program, The City supported the formation of an independent Expert Management Panel to make recommendations on flood resiliency shortly after the 2013 flood. The City is now implementing the 27 recommendations from the 2014 Report from the Expert Management Panel on River Flood Mitigation (PFC2014-0512). Building flood resiliency takes the whole community working together. It requires long-term commitment and collaboration across the Corporation, with other orders of government, community partners, and citizens" (City of Calgary, 2017d, p. 2)
The City leads and brokers the agenda about flood resilience, engaging with those it deems necessary	"It is critical for The City to keep Calgarians informed, provide resources and engage with citizens when it comes to building flood resiliency. Since 2013, City staff has met regularly with citizens, community members, organizations, community action groups, flood task forces and media for engagement and to provide community-specific updates on flood mitigation and resilience strategies" (City of Calgary, 2017d, p. 10)
The City is invested in flood resilience for all Calgarians	"Building flood resilience remains a top priority for The City and recognizes the importance of reducing flood risk to its citizens" (City of Calgary, 2020h, p. 3)
The City adopts the persistence and adaptation approaches to resilience	"As a river city, there will always be a need to prepare, respond and adapt to floods." (City of Calgary, 2020l)

Table 16: Flood Resilience Narrative Analysis

	Type	Equity	Expertise	Development
The City adopts the persistence approach to resilience	•			
The City understands that flood risk is dynamic and uncertain				•
The City conceptualizes the watershed as hybrid built-natural infrastructure that can be managed			•	
The social and economic costs of relocating development out of the floodplain is too high and hence infeasible.				•
Everyone has a stake in flood resilience		•		
The City looks to industry and subject matter experts for advice. At the same time, the City calls on the "whole community" to collaborate towards resilience.		•	•	
The City leads and brokers the agenda about flood resilience, engaging with those it deems necessary			•	
The City is invested in flood resilience for all Calgarians		•		
The City adopts the persistence and adaptation approaches to resilience	•			

APPENDIX E: ANALYSIS

For ease of reference, the drawing titles for the Table 17 through Table 25 are given below:

- B1 – Total Population, Baseline Scenario, Average Income
- B2 – Total Population, Baseline Scenario, Average Age
- B3 – Total Population, Baseline Scenario, Population Density
- C1 – Total Population, Vulnerability Index, Low Income
- C2 – Total Population, Vulnerability Index, Children & Seniors
- C3 – Total Population, Vulnerability Index, Visible Minority
- D1 – Total Population, Calgary: Average Income and Low Income
- D2 – Total Population, Calgary: Average Age and Children & Seniors
- D3 – Total Population, Calgary: Population Density and Visible Minority

For the B and C drawings, the following information is ascertained from the drawings:

- CMA – the average value that characterizes the Calgary CMA
- CSD – the minimum, maximum and Calgary CSD values for the entire CMA region
- FED – the minimum, maximum and Calgary-Centre FED values for the Calgary CSD region
- ADA – the minimum, maximum, Bowness, Downtown, and Glenmore Reservoir area ADA values for the Calgary CSD region

For the D series drawings, the following information is ascertained from the drawings:

- Calgary CSD average value
- The ADA values for Bowness, Downtown, and the Glenmore Reservoir area

Table 17: Analysis and Interpretation – Drawing B1

Scale	• $30,000 to $60,000
CMA	• about $45,000 ($44,740)
CSD	• Min: Village of Beiseker – about $37,000 ($37,480) • Max: MD of Rockyview – about $51,000 ($51,340) • Calgary: about $44,000 ($44,336)
FED	• Min: Calgary Forest Lawn (deep east) – about $33,000 ($33,281) • Max: Calgary Centre – about $50,000 ($49,696) • Calgary Centre – about $50,000 ($49,696)
ADA	• Bowness – about $44,500 ○ 050: about $48,000 ($48,478) ○ 052: about $38,000 ($38,115) ○ 061: about $47,000 ($47,187) • Downtown – about $48,500 ○ 095: about $43,000 ($43,346) ○ 098: about $43,000 ($43,489) ○ 102: about $47,000 ($46,761) ○ 104: about $50,000 ($49,899) ○ 106: about $49,000 ($49,211) ○ 107: about $55,000 ($54,603) ○ 109: about $52,000 ($52,090) • Glenmore Reservoir area – about $51,000 ○ 118: about $50,000 ($49,680) ○ 125: about $53,000 ($53,438) ○ 128: about $50,000 ($49,845) • Min: 067 (Taradale, NE) – about $30,000 ($30,226) • Max: 060 (Aspen Woods, SW) $59,000 ($59,289)
Interpretation	• CMA, CSD. Flood mitigation benefits Calgary in context of the wider CMA region • FED. On average, Calgary Centre ($50,000) has more money to deal with flood impacts than the average Calgary ($44,000) • ADA. On average, Bowness ($44,500), Downtown ($48,500), and the Glenmore Reservoir area ($51,000) have at least as much money than the average Calgarian ($44,000) • Min. Some of the poorest ADA's in NE Calgary also remain unaffected by flood damage; but distance and poor connectivity to the downtown core impedes their access to the benefits of flood mitigation • Max. Conversely, some of the wealthiest ADA's in West Calgary remain unaffected by flood damage; but close proximity to the downtown core (via road and transit) means asymmetric access to the benefits flood mitigation

Table 18: Analysis and Interpretation – Drawing B2

Scale	• 25 years to 55 years
CMA	• 37.4 years
CSD	• Min: City of Airdrie – 33.2 years • Max: MD of Rockyview – 40.3 years • Calgary: 37.6 years
FED	• Min: Calgary Skyview (NE) – 33.5 years • Max: Calgary Confederation (Central North) – 40.1 years • Calgary Centre: 38.7 years
ADA	• Bowness – about 43.1 years ○ 050: 45.1 years ○ 052: 40.5 years ○ 061: 43.7 years • Downtown – about 38.8 years ○ 095: 43.9 years ○ 098: 35.6 years ○ 102: 37.4 years ○ 104: 37.4 years ○ 106: 39.1 years ○ 107: 39.6 years ○ 109: 38.6 years • Glenmore Reservoir area – about 46.2 years ○ 118: 42.5 years ○ 125: 47.0 years ○ 128: 49.2 years • Min: 157 (New Brighton, SE) – 29.5 years • Max: 128 (Pump Hill, Palliser, SW) – 49.2 years
Interpretation	• CMA, CSD. Calgarians (37.6 years) are on average as old as people in the metropolitan region (37.4 years). • FED. People in Calgary Centre (38.7 years) are slightly older than the average Calgarian (37.6 years). • ADA. The most flood impacted areas (Bowness, 43.1 years; Downtown, 38.8 years; Glenmore Reservoir area, 46.2 years) are at least as old as the average Calgarian (37.6 years) • Min. The youngest ADA (New Brighton, 29.5) is not impacted by flooding. • Max. The oldest ADA (Pump Hill, Palliser, 49.2 years) is directly impacted by flooding.

Table 19: Analysis and Interpretation – Drawing B3

Scale	• 0 p/km^2 to 15000 p/km^2
CMA	• 272.5 p/km^2
CSD	• Min: Tsuu T'ina Nation 145 (Sarcee 145) – 5.8 p/km^2 • Max: City of Calgary – 1501.1 p/km^2 • Calgary: 1501.1 p/km^2
FED	• Min: Calgary Shepard – 816.4 p/km^2 • Max: Calgary Centre – 2422.4 p/km^2 • Calgary Centre – 2422.4 p/km^2
ADA	• Bowness – about 1804.2 p/km^2 ○ 050: 1499.5 p/km^2 ○ 052: 2305.7 p/km^2 ○ 061: 1607.4 p/km^2 • Downtown – 6962.5 p/km^2 ○ 095: 3687.2 p/km^2 ○ 098: 10,288.9 p/km^2 ○ 102: 14,134.6 p/km^2 ○ 104: 9196.7 p/km^2 ○ 106: 605.2 p/km^2 ○ 107: 3369.6 p/km^2 ○ 109: 7455.1 p/km^2 • Glenmore Reservoir area – about 1682.1 p/km^2 ○ 118: 1430.0 p/km^2 ○ 125: 1476.7 p/km^2 ○ 128: 2139.6 p/km^2 • Min: 007 (Carrington, Livingston, NE & NW) – 7.6 p/km^2 – this is farmland • Max: 102 (Beltline, downtown) – 14,134.6 p/km^2
Interpretation	• CMA, CSD. The City of Calgary (1501.1 p/km^2) is much denser than the metropolitan area (272.5 p/km^2) • FED. Calgary Centre (2422.4 p/km^2) is denser than the City as a whole (1501.1 p/km^2) • ADA. The most flood impacted areas (Bowness, 1804.2 p/km^2; Downtown, 6962.5 p/km^2; Glenmore Reservoir area, 1682.1 p/km^2) are all denser than the City as a whole (1501.1 p/km^2). • Min. The lowest density ADA (Carrington, Livingston, 7.6 p/km^2) is far removed and not impacted by flooding • Max. The highest density ADA (Beltline, downtown, 14,134.6 p/km^2)is directly impacted by flooding

Table 20: Analysis and Interpretation – Drawing C1

Scale	• 0 to 1 (unitless)
CMA	• 0.38 (0.379299802)
CSD	• Min: Tsuu T'ina Nation 145 (4806804) – 0.00 • Max: Village of Beiseker (4806024) – 0.45 (0.445239212) • Calgary: 0.40 (0.396424408)
FED	• Min: Calgary Rocky Ridge (48010) – 0.27 (0.265977291) • Max: Calgary Forest Lawn (48006) – 0.61 (0.613378173) • Calgary Centre (48004): 0.55 (0.548056036)
ADA	• Bowness – about 0.46 ○ 050: 0.35 (0.350484415) ○ 052: 0.64 (0.644477589) ○ 061: 0.38 (0.376681615) • Downtown – about 0.65 ○ 095: 1.00 ○ 098: 0.84 (0.839640513) ○ 102: 0.63 (0.630986353) ○ 104: 0.62 (0.616307712) ○ 106: 0.54 (0.538254705) ○ 107: 0.40 (0.39615915) ○ 109: 0.52 (0.520026932) • Glenmore Reservoir area – about 0.32 ○ 118: 0.30 (0.304932734) ○ 125: 0.29 (0.290472008) ○ 128: 0.36 (0.35670354) • Min: 145 (Lake Bonavista, SE) – 0.14 (0.138252134) • Max: 095 (Eau Claire, Chinatown, East Village, downtown) – 1.00
Interpretation	• CMA, CSD. There income vulnerability is greater in the City of Calgary than the metropolitan region. • FED. Calgary Centre (0.55) is more income vulnerable than the average Calgarian (0.40) • ADA. The most flood impacted areas are either more (Bowness, 0.46; Downtown, 0.65) or less (Glenmore Reservoir area, 0.32) income vulnerable than the average Calgarian (0.40) • Min. The least income vulnerable (Lake Bonavista, 0.14) is not impacted by the flooding. • Max. The most income Vulnerable ADA (Eau Claire, Chinatown, East Village, downtown, 1.00) is directly impacted by the flooding.

Table 21: Analysis and Interpretation – Drawing C2

Scale	• 0 to 1 (unitless)
CMA	• 0.65 (0.65092787)
CSD	• Min: Town of Irricana (4806022) – 0.63 (0.630044929) • Max: Tsuu T'ina Nation 145 (4806804) – 0.76 (0.764507404) • Calgary: 0.64 (0.64488467)
FED	• Min: Calgary Centre (48004) – 0.47 (0.4742279) • Max: Calgary Heritage (48007) – 0.69 (0.693797835) • Calgary Centre (48004): 0.47 (0.4742279)
ADA	• Bowness – about 0.72 ○ 050: 0.83 (0.828959113) ○ 052: 0.60 (0.601105778) ○ 061: 0.72 (0.720660023) • Downtown – about 0.39 ○ 095: 0.56 (0.557087259) ○ 098: 0.35 (0.348572337) ○ 102: 0.31 (0.308981316) ○ 104: 0.24 (0.236122029) ○ 106: 0.45 (0.453842461) ○ 107: 0.50 (0.497490395) ○ 109: 0.29 (0.289337587) • Glenmore Reservoir area – about 0.88 ○ 118: 0.76 (0.757562401) ○ 125: 0.87 (0.872461116) ○ 128: 1.00 • Min: 104 (Beltline, downtown) – 0.24 (0.236122029) • Max: 128 (Pump Hill, Palliser, SW) – 1.00
Interpretation	• CMA, CSD. The age vulnerability is approximately the same for the Calgary CSD (0.64) and Calgary CMA (0.65). • FED. Calgary Centre (0.47) is less age vulnerable than the City of Calgary (0.64) as a whole. • ADA. The most impacted areas either less (Downtown, 0.39) or more (Bowness, 0.72; Glenmore Reservoir area, 0.88) age vulnerable than the City of Calgary as a whole (0.64). • Min. The least age vulnerable ADA (Beltline, downtown, 0.24) is directly impacted by the flooding. • Max. The most age vulnerable ADA (Pump Hill, Palliser, 1.00) is directly impacted by the flooding.

Table 22: Analysis and Interpretation – Drawing C3

Scale	• 0 to 1 (unitless)
CMA	• 0.38 (0.376607191)
CSD	• Min: Tsuu T'ina Nation 145 (4806804) – 0.02 (0.016976648) • Max: City of Calgary (4806016) – 0.40 (0.404444963) • Calgary: 0.40 (0.404444963)
FED	• Min: Calgary Midnapore (48008) – 0.25 (0.249317915) • Max: Calgary Skyview (48013) – 0.78 (0.776429817) • Calgary Centre (48004): 0.28 (0.283146748)
ADA	• Bowness – about 0.19 ○ 050: 0.25 (0.248236331) ○ 052: 0.13 (0.131866746) ○ 061: 0.18 (0.178107646) • Downtown – about 0.36 ○ 095: 0.56 (0.562934256) ○ 098: 0.64 (0.635938221) ○ 102: 0.34 (0.341958212) ○ 104: 0.34 (0.339839034) ○ 106: 0.20 (0.199974793) ○ 107: 0.17 (0.173284088) ○ 109: 0.28 (0.277366105) • Glenmore Reservoir area – about 0.17 ○ 118: 0.11 (0.111706349) ○ 125: 0.19 (0.187712731) ○ 128: 0.21 (0.211497354) • Min: 007 (Carrington, Livingston, NE & NW) – 0.07 (0.065895676) • Max: 059 (Saddle Ridge, NE) – 1.00
Interpretation	• CMA, CSD. The social vulnerability is comparable at the metropolitan (0.38) and City (0.40) scales. • FED. Calgary Centre (0.28) is less socially inequitable than Calgary as a whole (0.40) • ADA. The areas most impacted by flooding (Bowness, 0.19; Downtown, 0.36; Glenmore Reservoir area, 0.17) are less socially inequitable than Calgary as a whole (0.40). Downtown approaches the average social inequity • Min. The least socially diverse ADA (Carrington, Livingston, 0.07) is not impacted by flooding. • Max. The most socially diverse (inequitable) ADA (Saddle Ridge, 1.00) is not impacted by flooding.

Table 23: Analysis and Interpretation – Drawing D1

	Average income	Low income index
Scale	• $30,000 to $60,000	• 0 to 1 (unitless)
Calgary CSD	• about $44,000 ($44,336)	• 0.40 (0.396424408)
Bowness	About $44,500 • 050: about $48,000 ($48,478) • 052: about $38,000 ($38,115) • 061: about $47,000 ($47,187)	About 0.64 • 050: 0.35 (0.350484415) • 052: 0.64 (0.644477589) • 061: 0.38 (0.376681615)
Downtown	About $48,500 • 095: about $43,000 ($43,346) • 098: about $43,000 ($43,489) • 102: about $47,000 ($46,761) • 104: about $50,000 ($49,899) • 106: about $49,000 ($49,211) • 107: about $55,000 ($54,603) • 109: about $52,000 ($52,090)	About 0.65 • 095: 1.00 • 098: 0.84 (0.839640513) • 102: 0.63 (0.630986353) • 104: 0.62 (0.616307712) • 106: 0.54 (0.538254705) • 107: 0.40 (0.39615915) • 109: 0.52 (0.520026932)
Glenmore Reservoir area	About $51,000 • 118: about $50,000 ($49,680) • 125: about $53,000 ($53,438) • 128: about $50,000 ($49,845)	About 0.32 • 118: 0.30 (0.304932734) • 125: 0.29 (0.290472008) • 128: 0.36 (0.35670354)
Interpretation	The most flood impacted areas (Bowness, about $44,500 and 0.64; Downtown, about $48,500 and 0.65; Glenmore Reservoir area, about $51,000 and 0.32) have as much or more money (resources) than the average Calgarian (about $44,000), but the income vulnerability is either higher or lower than Calgary as a whole (0.40)	

Table 24: Analysis and Interpretation – Drawing D2

	Average age	Children & seniors index
Scale	• 25 years to 55 years	• 0 to 1 (unitless)
Calgary CSD	• 37.6 years	• 0.64 (0.64488467)
Bowness	About 43.1 years • 050: 45.1 years • 052: 40.5 years • 061: 43.7 years	About 0.72 • 050: 0.83 (0.828959113) • 052: 0.60 (0.601105778) • 061: 0.72 (0.720660023)
Downtown	About 38.8 years • 095: 43.9 years • 098: 35.6 years • 102: 37.4 years • 104: 37.4 years • 106: 39.1 years • 107: 39.6 years • 109: 38.6 years	About 0.39 • 095: 0.56 (0.557087259) • 098: 0.35 (0.348572337) • 102: 0.31 (0.308981316) • 104: 0.24 (0.236122029) • 106: 0.45 (0.453842461) • 107: 0.50 (0.497490395) • 109: 0.29 (0.289337587)
Glenmore Reservoir area	About 46.2 years • 118: 42.5 years • 125: 47.0 years • 128: 49.2 years	About 0.88 • 118: 0.76 (0.757562401) • 125: 0.87 (0.872461116) • 128: 1.00
Interpretation	While the age (physical ability) of the most impacted areas (Bowness, 43.1 years; Downtown, 38.8 years; Glenmore Reservoir area, 46.2 years) are at least as old as the average Calgarian (37.6 years), the age vulnerability is either less (Downtown, 0.39) or more (Bowness, 0.72; Glenore Reservoir area, 0.88) than the city as a whole (0.64)	

Table 25: Analysis and Interpretation – Drawing D3

	Population density	Visible minority index
Scale	• 0 p/km^2 to 15000 p/km^2	• 0 to 1 (unitless)
Calgary CSD	• 1501.1 p/km^2	• 0.40 (0.404444963)
Bowness	About 1804.2 p/km^2 • 050: 1499.5 p/km^2 • 052: 2305.7 p/km^2 • 061: 1607.4 p/km^2	About 0.19 • 050: 0.25 (0.248236331) • 052: 0.13 (0.131866746) • 061: 0.18 (0.178107646)
Downtown	About 6962.5 p/km^2 • 095: 3687.2 p/km^2 • 098: 10,288.9 p/km^2 • 102: 14,134.6 p/km^2 • 104: 9196.7 p/km^2 • 106: 605.2 p/km^2 • 107: 3369.6 p/km^2 • 109: 7455.1 p/km^2	About 0.36 • 095: 0.56 (0.562934256) • 098: 0.64 (0.635938221) • 102: 0.34 (0.341958212) • 104: 0.34 (0.339839034) • 106: 0.20 (0.199974793) • 107: 0.17 (0.173284088) • 109: 0.28 (0.277366105)
Glenmore Reservoir area	About 1682.1 p/km^2 • 118: 1430.0 p/km^2 • 125: 1476.7 p/km^2 • 128: 2139.6 p/km^2	About 0.17 • 118: 0.11 (0.111706349) • 125: 0.19 (0.187712731) • 128: 0.21 (0.211497354)
Interpretation	The most flood impacted areas (Bowness, 1804.2 p/km^2, 0.19; Downtown, 6962.5 p/km^2, 0.36; Glenmore Reservoir area, 1682.1 p/km^2, 0.17) are at least as dense as Calgary as a whole (1501.1 p/km^2), but are less socially diverse than Calgary as a whole (0.40)	

APPENDIX F: DRAWINGS