SCARRING THE LANDSCAPE: DESIGNING FOR A FIRE PRONE REGION, KELOWNA, B.C.

by

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for the degree of Master of Architecture

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DALHOUSIE UNIVERSITY

SCHOOL OF ARCHITECTURE

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled “Scarring the Landscape: Designing for a Fire Prone Region, Kelowna, B.C.” by Michael Alexander Cook in partial fulfilment of the requirements for the degree of Master of Architecture.

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DEDICATION

To the men and women who put themselves in the path of danger to protect lives, homes and communities.

CONTENTS

ABSTRACT

This thesis explores architectural and design principles for fire-prone regions. A number of these principles are identified and developed in the design of a recreational infrastructure for Kelowna, British Columbia, at both the scale of the city and the building.

At the city scale, the project proposes the integration of a fuel break into the southern border of Kelowna, providing a corridor of defensible space between the city and an approaching fire. This fuel break, a landscape “scar”, is developed as a linear park that links points of interest along its 16 kilometre length.

One point of interest is selected as a building site for a community centre and lookout. The design principles for forest fire safety provide the necessary framework for the design decisions of siting and materials.

ACKNOWLEDGEMENTS

Thank you...

To Christine Macy and Richard Kroeker, for guiding me through this process and pushing me out of my comfort zone. Your knowledge and expertise have been an invaluable asset, and your patience and generosity of time have benefitted me greatly.

To both my parents, for your unwavering support over the last five years. I could not have done it without your constant encouragement and love.

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CHAPTER 1: INTRODUCTION

Thesis Question

How can an architectural strategy provide the framework for safe community and building design in fire prone regions?

Fire & Culture

> Praised be my lord for our brother fire, through whom thou givest us light in the darkness: and he is bright and pleasant and very mighty and strong. (Rossotti 2002, 33)

Fire, as defined by its physical properties, is a self-sustaining, high temperature oxidation reaction in which heat and light are released. As an abstract entity, fire is a symbol with roots that cover much of human experience, "evoking desire, passion, sexuality, romance, vitality, curiosity, knowledge, anger, punishment, evil, destruction, purity, domesticity and comfort" (Rossotti 2002, 5).

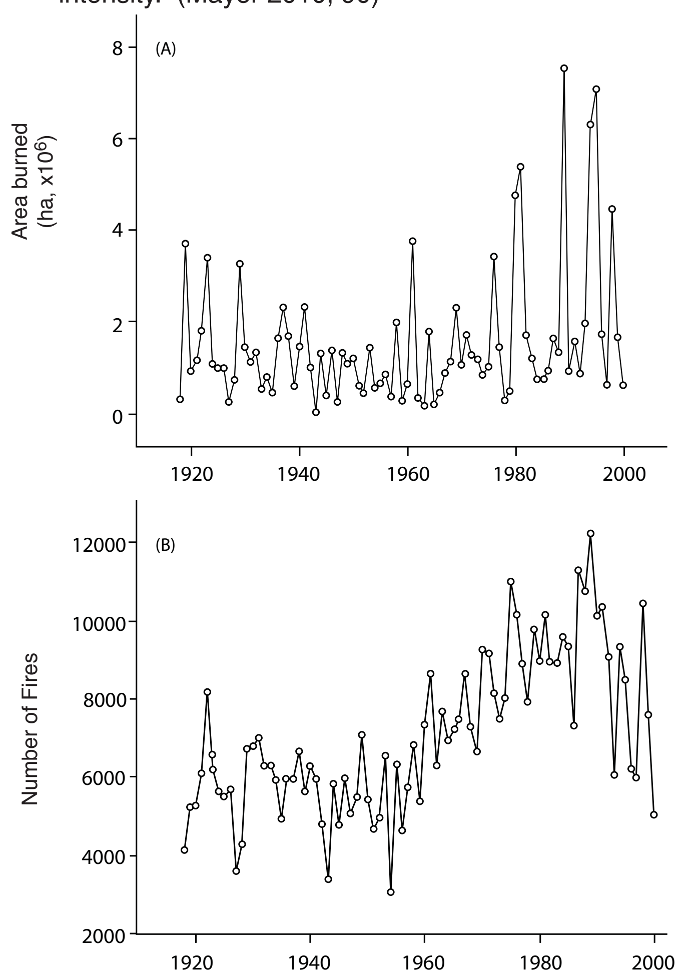
The taming of fire is described by Vitruvius as the foundation for human gatherings. "Therefore it was the discovery of fire that originally gave rise to the coming together of men, to the deliberative assembly, and to social intercourse" (Morgan 2005, 38). Birthed from natural forest fire conditions, primitive fire provided the necessary conditions for ancient society to develop. Eventually, fire became a controllable standard for land clearance, a sort of constructive destruction used to cultivate land for crops or other growth.


Wood Engraving from 1527, referencing Vitruvius' "taming of fire". From Rossotti, *Fire.*

Today in North America, we are more likely to view fire as a threat to lives, families and homes. Media coverage of fire often dwells on the physical and psychological damage fire inflicts on households and businesses, explaining in detail the bereavement, fear and material loss suffered in human life and property and lives. Yet significant advances in building science and emergency strategies have limited fire casualties in the built environment, and forestry officials have consistently attempted to limit the role of wildfires in forests.

The 20th century has seen a noticeable increase in both the number and size of forest fires, a trend continuing into the 21st century. As Canadians rethink the way we live and as climate change inevitably alters our weather patterns, the threat of forest fire will occupy a more prominent role in our national consciousness.

> In the past ten years, the number of worldwide weather related catastrophes has been on the rise. Not only are these occurring more frequently, they are also growing in intensity. (Mayer 2010, 90)



Area burned (A) and number of fires (B) in Canada, 1918-2000. Data collected from Pyne, *World Fire*

Fire Management Techniques

> But fire as urban catastrophe didn't require riots and wars. It demanded only that the city develop as it had, and that the fuels from suppressed fires build up until they could be released in a fury of natural rage. (Pyne 1995, 229)

Fire is a key process in nature that regulates the life cycle of wild lands. However, fire also bears negative connotations associated with fear and destruction. Forestry policies of the last century have been predicated on this fear and the implementation of these policies has contributed to increasingly destructive conflagrations. This mismanagement is evidenced in the well-intentioned Smokey Bear campaign of the US Forest Service, which advocated complete elimination of forest fires. "Fire suppression is surely required where human developments are threatened. But to focus on fearful outcomes reveals only part of the story about wild land fires" (Omi 2005, 1).

The policy of fire suppression resulted in a thick over-accumulation of forest growth in regions that have historically relied on fire as a catalyst for recycling nutrients. Removing "natural" fire from ecosystems only provided more fuel for the inevitable inferno.

> With or without its city, the landscape will burn. The issue is whether it burns in small chunks over centuries or in great catastrophes, whether from accident or error or malice, whether under controlled circumstances or in crisis. (Pyne 1995, 230)

In the late 20th century as forest fires became increasingly difficult to control, fire management techniques began to allow for a more inclusive role for fire, through prescribed fire as part of an integrated program of fuel management. "Ultimately, the solution involves creation of forests where fire can be prescribed safely as a management tool, including strategic placement of fuel breaks across the landscape" (Omi 2005, 43).

Forestry managers of the 21st century have the difficult task of keeping fire from encroaching on communities and homes, while also managing the public's perception of fire as a destructive force. When fire is no longer associated with destruction of homes and communities, it can be more readily re-introduced into ecosystems, and hopefully begin to regulate the over-abundance of fuel that misguided 20th century forest management policies created.

Below: *Elk Bath (2000)*. Photograph by John McColgan, from BLM Alaska Fire Service.

Herrington Manor Cabin (2009). Photograph by Timothy Jacobsen, from Marylandlife.

Romanticism of the Wild

> It was no longer necessary to pursue wild land fire into the backcountry. It had come to the cities and suburbs, or they had come to it. Cities moved out, fuels moved in, and fires glowed in the crack between. (Pyne 1995, 224)

North America was built on the dream of the frontier, taming the wilderness in the name of progress and wealth. Late in the 19th century, this ideal shifted towards sheltering the wild from that same progress. The collective American dream of a house in the suburbs with a white picket fence is shared almost equally by the dream of a house in the wilderness surrounded by thick forest. Many city-dwelling homeowners yearn for the solitude offered by this ideal. As a result, these families have begun escaping to the rural landscapes surrounded by wilderness. "The so-called rural renaissance was not, however, a revival of rural economies so much as repopulation of formerly rural landscapes by an exurban population" (Pyne 1995, 272). By continuing to build human developments deeper and deeper into remote hinterlands, community officials only increase the risk of catastrophe in what is now known as the "Urban-Interface Zone", where communities and forests meet.

> To aging fuels the new era adds houses, often outfitted with highly flammable roofs, and to the old cycle of ignitions it adds further sources from power lines, machinery, children and arsonists. Conflagrations that had formerly raged in the backcountry or along a tattered rural fringe now, by virtue of this instant geography, burn into suburbs. (Pyne 1995, 226)

As temperatures rise and communities continue to sprawl further into forested land, the threat of major conflagorations becames very real. Through concious design of our communities and buildings, we can limit the impact of this destructive force.

CHAPTER 2: DESIGNING FOR FIRE

Community Design Principles

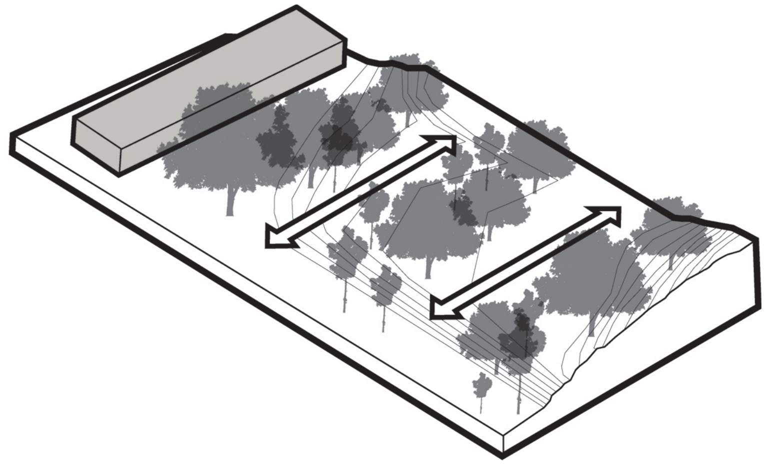
> To truly know our home places, we have to know not only how they flourish, but also how they break… Making the effort to envision – and prepare for – the plausible consequences of the unthinkable is a civic act, a necessary part of the work of placing ourselves. (Steffen 2008, 479)

When communities push into the edges of forested areas, there are some common sense solutions that reduce the risk of forest fires making their way into the community boundaries. Many of these strategies have been tested with varying degrees of success in California throughout the 20th century. The essential goal for community officials and forestry managers is to

> fashion an environment in which we can better control the fires we do not want and promote those we do. Changing the combustibility of the landscape should dampen the prospects for damaging conflagrations where they do not belong, while allowing for prescribed fires that will behave as they should. (Pyne 2004, 114)

Small Scale Solutions

Small scale solutions begin with city officials mandating more stringent building codes for areas of the community that are particularly at risk of interface fires. Specifically, firewalls between neighbouring high risk buildings can be mandated, and the proper spacing of buildings can be written into zoning by-laws. Also, requirements for road access and excess water collection are some common sense solutions that will inevitably save both lives and homes. “Communities and county regulators can adopt sensitive and sensible subdivision design criteria” (Omi 2005, 182).



Principle 1:
Strategic community planning using fuel breaks.

Fuel Breaks

A more radical solution at the city scale is the use of fuel breaks. Fuel breaks are strips of land “where flammable vegetation is converted or restructured (that is, by thinning of forest crowns) to provide safe access for fire fighters and to provide anchor points for firing operations on wild and prescribed fires” (Omi 2005, 43). These are an alternative to fire breaks, which are strips of land free of any vegetation.

Fire breaks tend to be implemented quickly, in times of emergency, while fuel breaks are cultivated and planned into landscape design. “Fuel breaks that support low growing plants are much more practical and aesthetically pleasing, as well as being less susceptible to erosion and easier to maintain” (Pyne 1997, 120).

One successful fuel break in the United States was the Ponderosa Way, a 800-mile-long fuel break that spanned across the western slope of the Sierra Nevada and was built in 1933. The goal of this fuel break was to separate the high level conifers of the Sierra Nevada with the lower level chaparral of Northern California.

Crew of CCC men building firebreak on the San Bernardino National Forest, California. 1933. Photograph by W.I. Hutchinson from *Forest History Society Photograph Collection.*

While it existed, it was a significant deterrent for fire moving into the chaparral and threatening nearby communities. Parts of the break are still in use, while other sections have grown over from lack of maintenance due to insufficient funding.

Author Stephen Pyne has written extensively concerning fuel breaks and ways of improving their success.

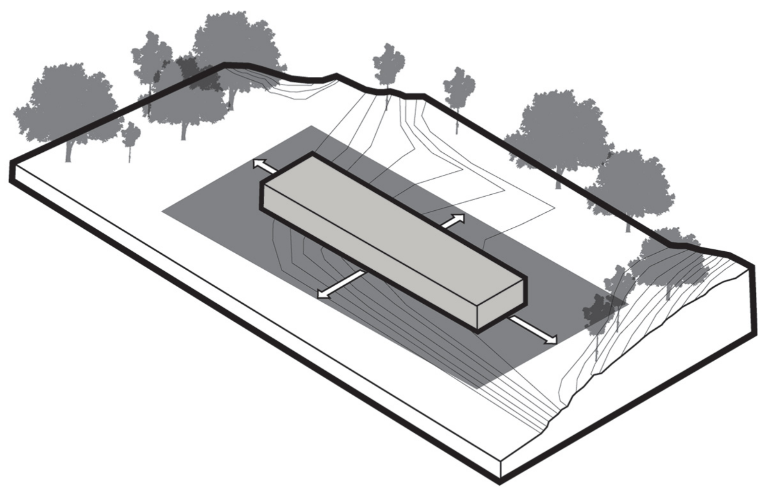
> There is no reason to nuke the woods; the purpose is not to stop fire cold, by paving a surrounding lagoon of asphalt, but to force the flames out of the canopy and onto ground and then, by offering only lightly textured combustibles, to tame the fire into something controllable. There will be fire; there will be a need for firefighters; there may well be some houses lost, the outcome of poor housekeeping or bad luck. But firefighters could stand against such flames, and the community would enjoy a reasonable degree of protection. (Pyne 2004, 125)

Although they offer a heightened degree of safety to a region, fuel breaks can result in a dramatic scarring of the landscape, and have many negative visual consequences in areas where they are necessary. Pyne however, offers a compromise, suggesting that "the greenbelts could well become recreational sites or wild land parks, suitable for picnics and nature walks" (125).

Building Principles

> Build a city out of forest materials and it will burn like a forest. The fire swept through a city remade in an exurban image. (Pyne 1995, 276)

A multitude of fire resistant design strategies are available to landowners in urban interface zones. While no technique is fire-proof, conscious design choices can significantly reduce the dangers facing a building in a fire-prone region.



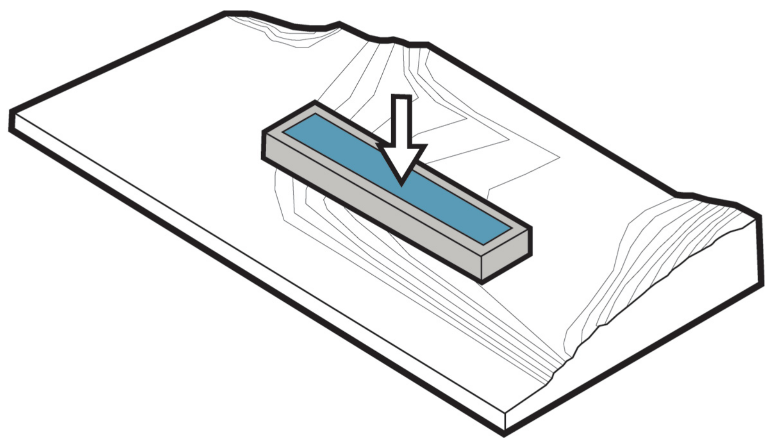
Principle 2:
Maintaining a defensible space or perimeter around the building.

Defensible Space

The most important concept in fire resistant design is defensible space. This is a space around a building that reduces the risk of fire ever touching the structure. Conduction burns structures when flame makes contact, and so a significant amount of space is required to separate the two. The space, optimally a thirty-foot ring around the building, should be cleared of flammable vegetation completely. "This range refers only to a tree-enveloping sheet of flame blasting its heat against a wooden structure. Radiant heat from smaller caches of fuel will shrink the zone of danger" (Pyne 2004, 122). The next thirty-feet should be thinned, providing adequate spacing of tree crowns to slow the progress of fire. This defensible space is the key to the protection of a building, but can have a significant impact on the aesthetics of surroundings, and thus is often ignored.

If for whatever reason vegetation is left near the building, any overhanging branches near the roof should at least be pruned, while woody fuel, leaf and pine needle deposits should be removed completely.

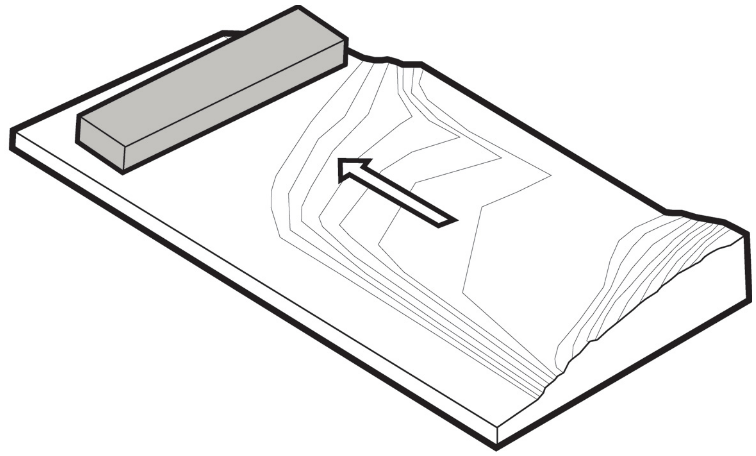
Principle 3:
Proper material choices on exterior surfaces and roofs.



Exterior Material Choices

More specific to the building itself, there are some key design choices that can be made on new buildings. Notably, the exterior material should be of fire-resistant materials such as concrete, straw bale, rammed earth or metal. Wood-shingled roofs are the leading cause of home loss in fire-prone regions, and should be replaced by concrete, asphalt shingles, or even water as alternatives.

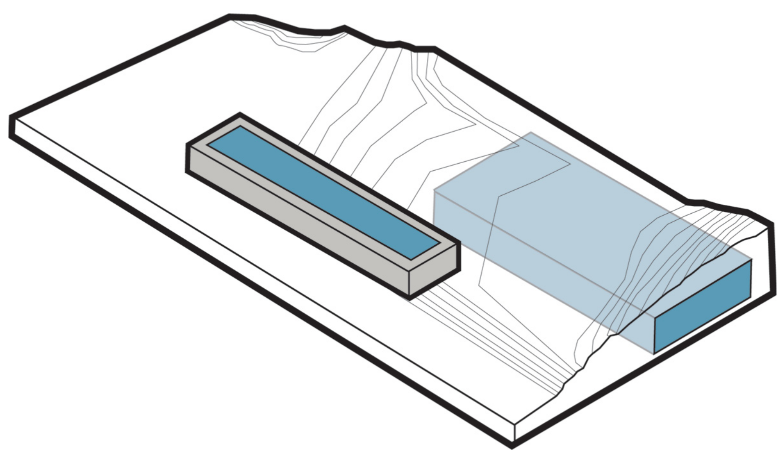
Principle 4:
Proper siting of the building, i.e. downslope.



Siting

The siting of a building can play a significant role in how fire approaches it. Fire acts differently depending on where the fuel is situated. “A surface fire travels up a bank more quickly than along or down it, because the flame warms a larger area of the slope above it than below it, or to either side of it” (Rossotti 2002, 194). Therefore, if the building is placed at the bottom of a hill with fuel removed all around it, it is in a much more defensible position than at the top of the hill with fire below.

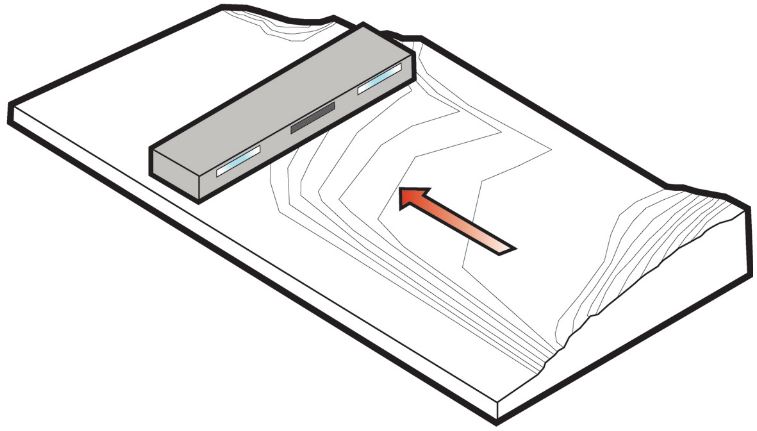
Principle 5:
Maintaining a collection of on-site water storage.



Water Storage

On-site water storage, collected through runoff or from grey water, will serve as a back up in the event that the integrity of municipal water supply is compromised.

Principle 6:
Strategic placement and defense of buildings weak points (windows and doors).



Above: Barton Myer's home, Santa Barbara, CA. Photographs from *3 Steel Houses.*

Weak Point Defence

Finally, it is important to evaluate the defence of the building's weak points, such as windows and doors. If a building's exterior has low flammability, additional precautions can be made by protecting the vulnerable structural openings. Architect Barton Myers addressed this by using insulated metal shutters that roll down to cover large glass openings in his own home, located in the fire prone hills of Southern California.

All of these measures work together to increase the likelihood of a structure surviving a forest fire.

> Protection is possible, but firefighting has at most a modest role. Post fire studies suggest that a non-wooden roof increases the chances of structural survival from 19 to 70 percent. Clearing flammable shrubs thirty feet around the structure improves the odds from 15 to 90 percent. If, in addition, a firefighter is present – which requires adequate water sources and road access – a house is 99 percent defensible even under extreme conditions. (Pyne 1995, 231)

Selection of Fire-Resistant Building Materials

Based on the principles above, further research was conducted regarding structural materials and their ability to withstand the typical heat ranges produced in a wildfire.

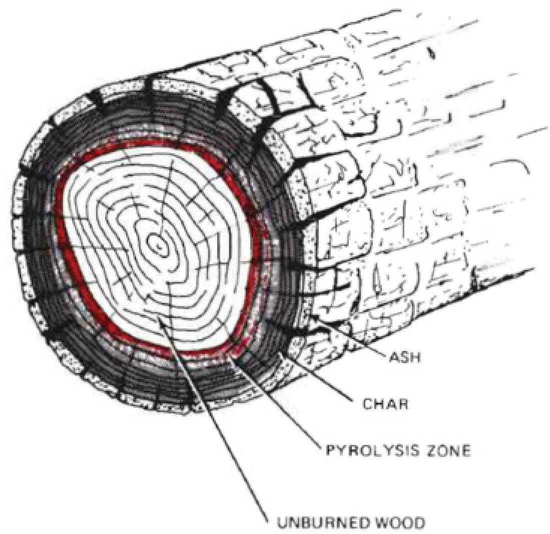
Concrete

Concrete is non-combustible and is, predictably, a reliable building material in areas prone to wildfires. It performs well as a thermal insulator in fire conditions, providing protection to steel reinforcing and interior spaces. Yet, concrete's performance in fire varies greatly depending on the type of aggregate used. Flint and gravel are aggregates that have been subjected to heat in their formation, and are thus less prone to damage from forest fires.

Concrete begins to display a reduction in compressive strength at approximately 100C. When heated above 600C, concrete maintains very little of its original strength, but fortunately such temperature is rarely maintained throughout the face of the concrete in a forest fire. Instead, with temperature fluctuating in intensity, hot spots will briefly occur in varying locations. The loss of strength in concrete is irreversible.

Timber

Timber structures are combustible and are therefore likely to ignite if in close contact with conditions found in forest fires. However, as the timber chars, the process provides a degree of protection for the interior of the beam or column. Once the surface of the structural member has been charred, further damage occurs at a reasonably slow and steady rate. The majority of timber found in the Kelowna region has a char rate of approximately .64 mm/min. The low conductivity of timber allows this slow charring process, and can easily be seen when a burned timber is shown in section.



Section of a burned tree from Countryman, *Heat: Its Role in Wildland Fire.*

However, once a temperature of approximately 200C is reached on a piece of timber, significant and irreversible effects will occur. These include discoloration, distortion and loss of weight, and the rate of these processes roughly doubles for each 10C rise above 200C. Also, timber begins to give off flammable gases at 150C, and will spontaneously ignite at temperatures around 200C. In wildfire conditions, the necessarily high ambient temperature and the heat of the approaching fire will likely combine to preheat and distort the timber. There is also evidence that when timbers protected with treatments are exposed to severe fire conditions, (e.g. temperatures above 800 C) they behave little better than untreated timbers. A more effective approach is to acknowledge in the design of structures that timber is a combustible material and that it will be progressively destroyed by fire once it is heated beyond 200C. Aside from its loss of structural stability at relatively low temperatures, timber also presents other hazards when burning, specifically the emission of smoke and carbon monoxide, both of which are highly toxic and carcinogenic.

Steel

Steel used in building construction is clearly non-combustible. However, when it is heated, it physically expands at a known rate while its strength decreases at a predictable rate. At 300C, steel begins to decrease rapidly in strength to about 50% at 550C and to 10% at 800C, recovering approximately 90% of its initial strength when cooled. Work-hardened steels, typically cold-worked bars or pre-stressed wire, deteriorate at a more rapid pace, losing 50% of their strength at about 400C. Upon cooling, this steel reverts back to its original unworked form, but there is considerable loss of strength.

Steel is also a useful material for use in the design of building shutters. Glazed surfaces are vulnerable to damage from flying debris and flame and the larger the glazed area, the greater the vulnerability. Shutters can provide a reasonable degree of impact resistance and protection against all but the most intense wildfire heat.

Rammed Earth

Rammed earth, made entirely from non-flammable materials, is extremely resistant to fire. CSIRO testing in Australia has resulted in a 300mm wall receiving 4-hour fire rating. Similar to poured concrete, rammed earth walls don't use block construction, so there are no weakened mortar joints.

> Fire tests to AS 1530.4 – 1985 on a 300mm-thick rammed earth wall with 6 percent cement gave 240/240/240 for structural adequacy, integrity and insulative capacity. This means the wall is still standing strong after four hours in a fire. (Sirewall)

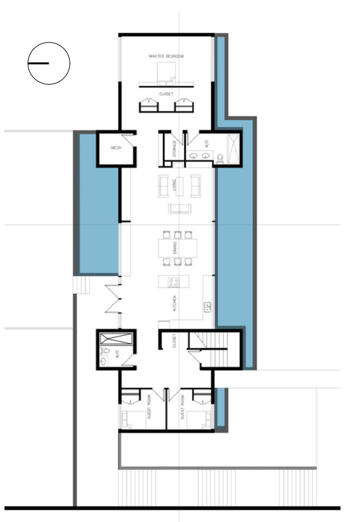
Material Implications

Based on this research, the selective use of steel structure paired with concrete and rammed earth walls will be explored in this thesis. The temperatures reached during most forest fires will exceed the limit of what steel is able to withstand directly. However, strategies employing the design principles discussed above (namely the design of “defensible space “and “weak point defence”) will be used to protect the structure from direct contact. These ideas will be explored further in the design section of the thesis.

Pilot Project Summary

The pilot project was an opportunity to explore the design implications of fire-resistant design in the framework of a single family home.

The building is sited in the South Mission region of Kelowna, an area that suffered significant losses in a large 2003 fire and continues to be at risk for fire. The challenge was to design a house that integrates all the principles in a meaningful way while responding to the unique site.

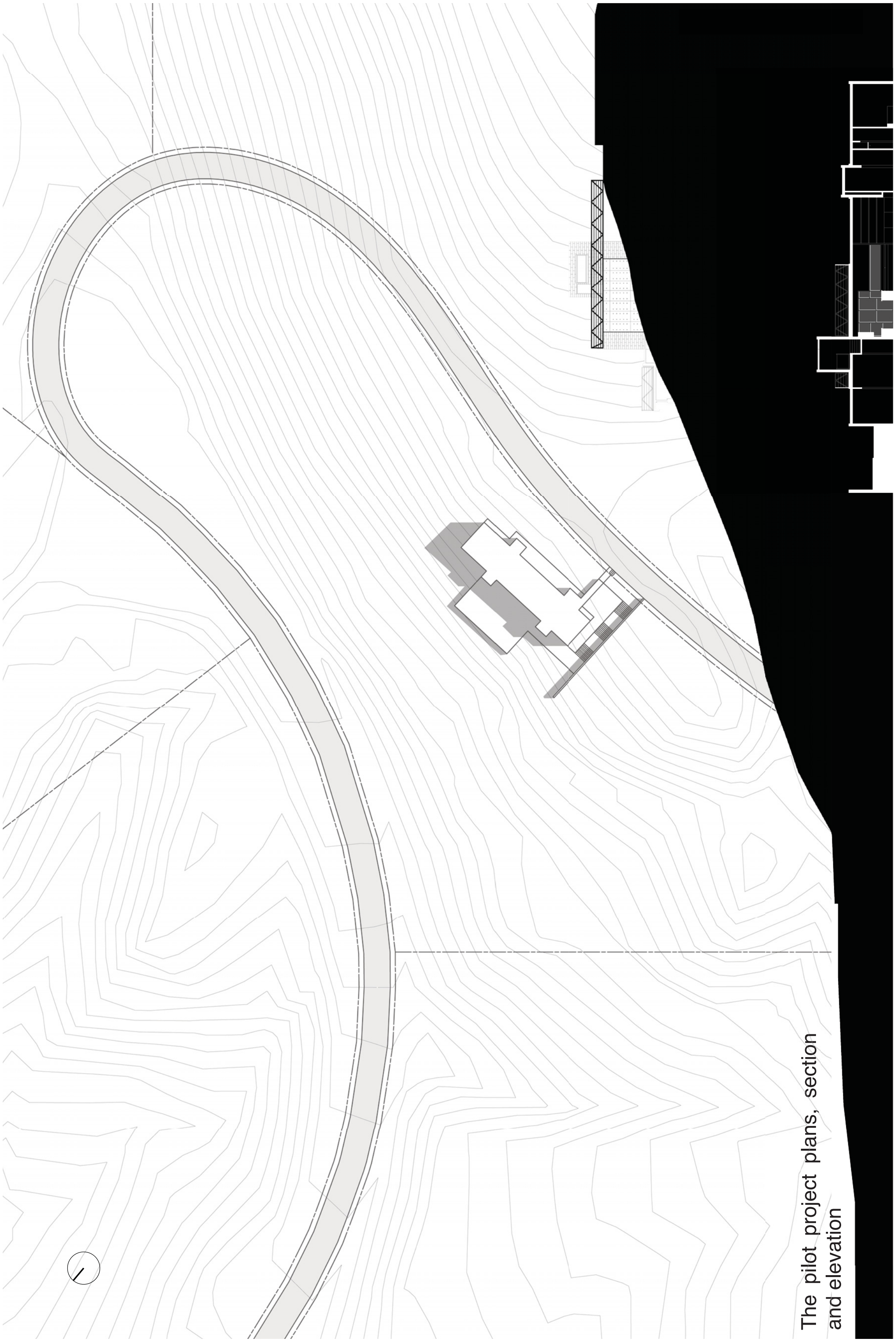


Pilot Project Floor Plan

At the site scale, the design proposed to connect two cul-de-sacs, improving the ability of residents to evacuate the area in the event of a fire. The building is sited on the road, using it as an infrastructural break to the south side of the house. To the west, a stairwell extends from the road to the back of the house, providing defensible space along the most vulnerable wing of the house, as fire is most likely to come from a south-westerly direction.

The most important landscape feature to consider is the significant slope. Rather than flatten the site, a bridge connects the road to the roof of the house, where the main entry is located. The remainder of the roof is largely covered in water, with a small concrete pad for various activities.

Cladding materials are all non-flammable: the main structure is finished concrete and the cores are stone from a nearby quarry.



The pilot project plans, section and elevation

CHAPTER 3: CONTEXT

The Okanagan Valley. Photo by Mark Aseltine (2010).

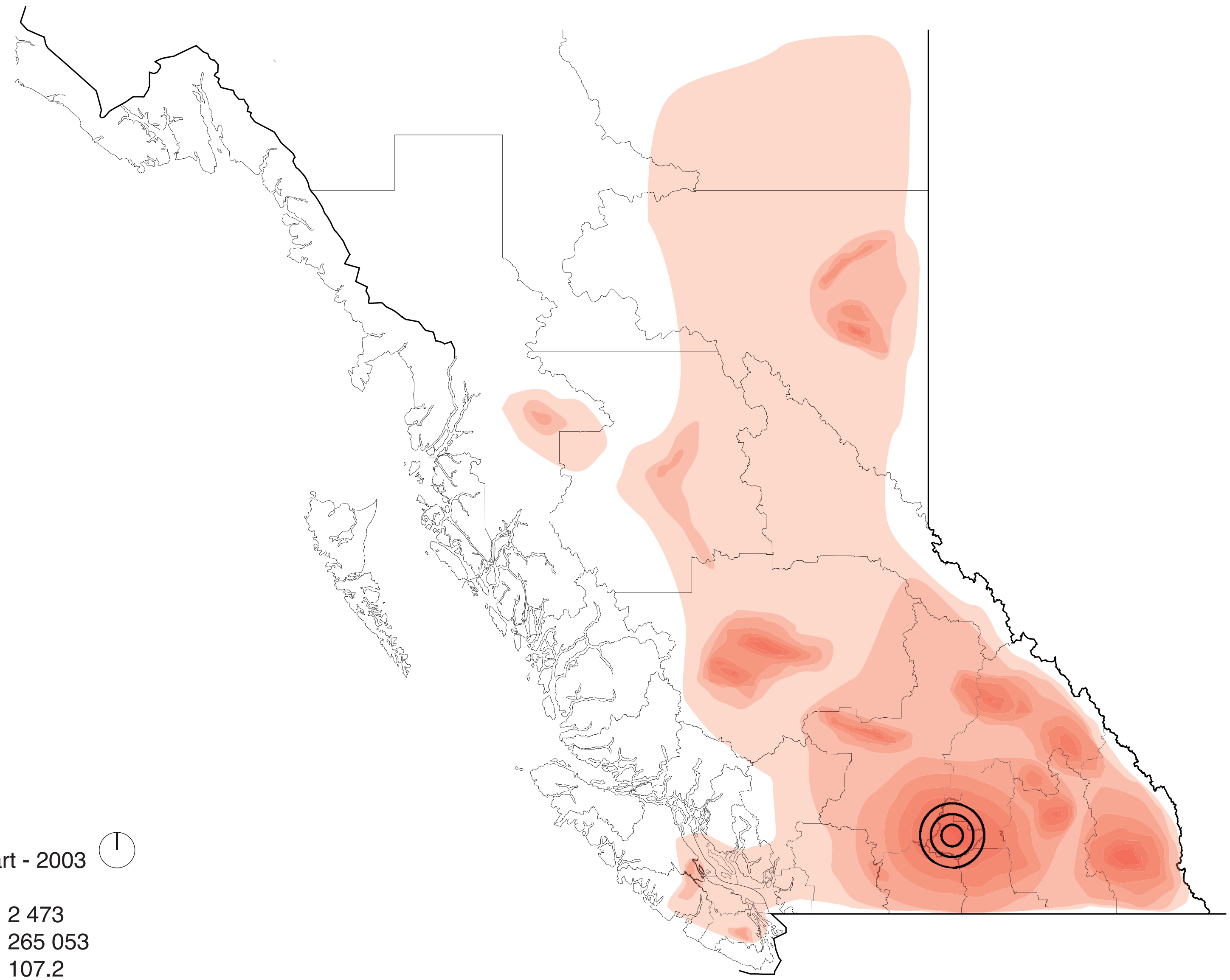
The Okanagan and the City of Kelowna

The Okanagan Valley is a region of British Columbia, running through the southern interior of the province and is defined by Okanagan Lake that runs through its center. The landscape of the Okanagan is characterized by sagebrush covered hills and steep, Ponderosa pine-filled mountains.

The region's largest city, Kelowna, is centrally located along the eastern shore of Okanagan Lake and is Canada's fastest growing community, accounting for 180 000 of the 350 000 Okanagan population. Kelowna is bordered north, east and south by forest.

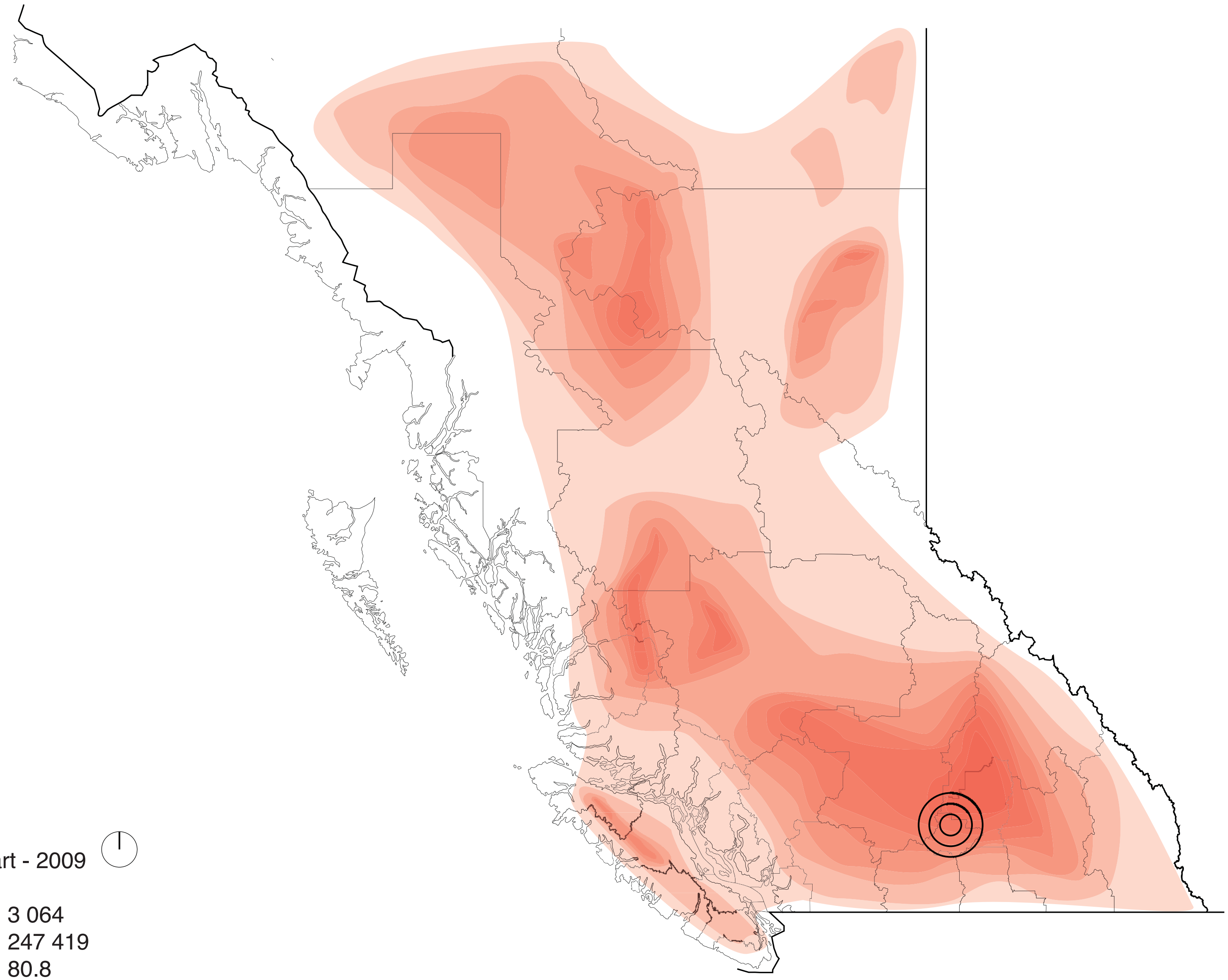
The climate of the city is semi-arid and desert-like, with low levels of precipitation. Between May and October, temperatures fluctuate between high and low 20s. This combination of forested landscape and dry, warm weather makes Kelowna a desirable locale for a population seeking to escape from the hectic city life of nearby metropolitan centers like Calgary or Vancouver. However, the surrounding area is also a perfect incubator for severe forest fires. As the following maps on pages 20 and 21 show, the Okanagan consistently faces the highest intensity of hectares lost to fire.

Kelowna, B.C.



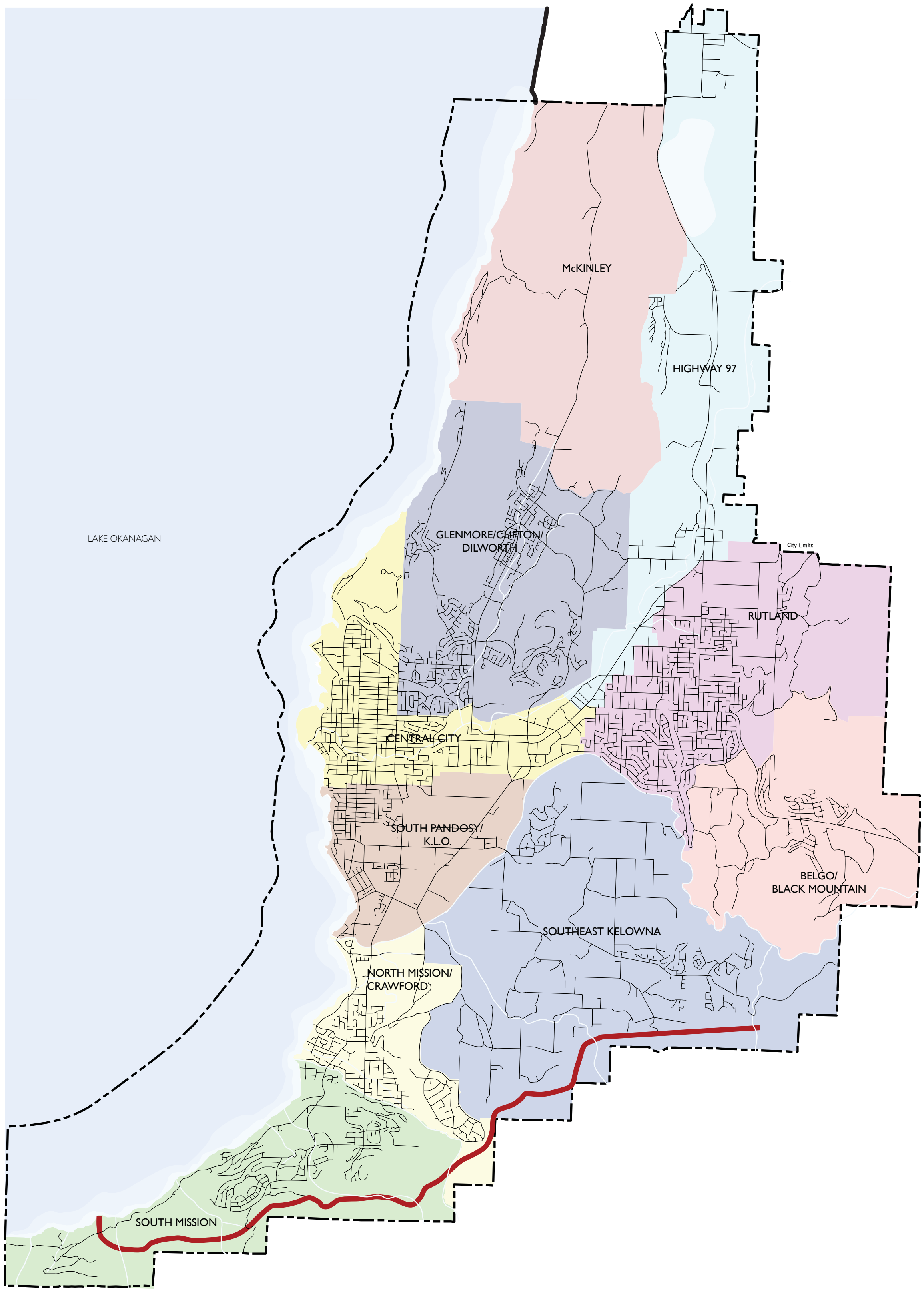
British Columbia
Forest Fire Density Chart - 2003

Total Fires	2 473
Total Hectares	265 053
Avg. Hectares/Fire	107.2



British Columbia
Forest Fire Density Chart - 2009

Total Fires	3 064
Total Hectares	247 419
Avg. Hectares/Fire	80.8



City of Kelowna
Neighborhood Map

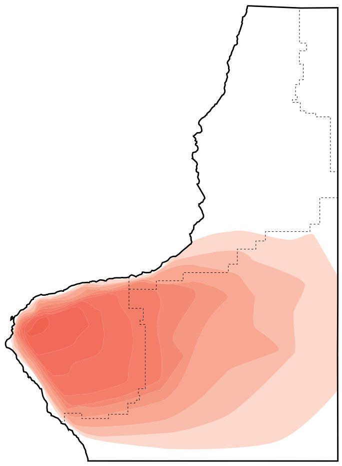
2003 Okanagan Park Fire

> Residents compared the towering columns of fire and smoke to the gates of hell. (Freake and Plant 2003, 59)

Every year, the landscape of British Columbia is continually at risk of damage from forest fires. In 2003, 2473 fires consumed 265 000 hectares of forest costing the province over $371 million. In 2009, the province spent $382 million dealing with a record high of 3064 fires. While 2009 had more fires, 2003 was significant due to the elevated number of urban interface fires. “Usually BC faces one interface fire a season. In 2003 it faced fourteen” (Freake and Plant 2003, 13).

One such interface fire was the Okanagan Mountain Park Fire of 2003, which devastated the Okanagan Mountain Park south of Kelowna, and became the most destructive fire in Canadian history until the recent conflagration in Slave Lake, AB. The fire spread into Kelowna’s southern city limits and destroyed 334 homes. “At one time during the fire, 27 000 people in Kelowna were evacuated, almost a third of that city’s population” (Freake and Plant 2003, 11).

Below: *Okanagan Mountain Fire (2003)*. Photograph by Steve Devries, from Freake & Plant, *Firestorm.*



Okanagan Mountain Park Fire progression.

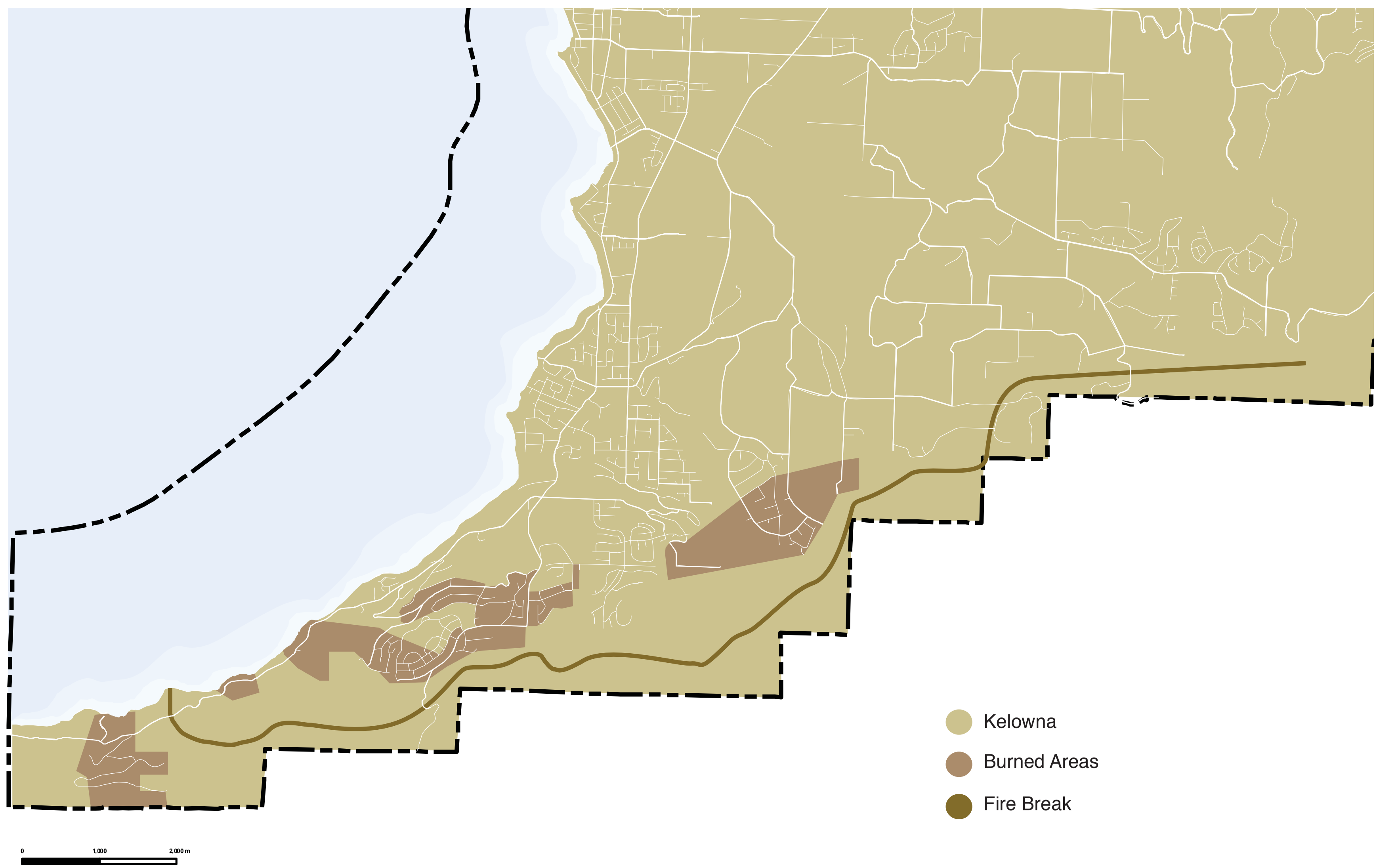
The fire was fuelled by the 10 000 hectares of untouched land in the Okanagan Mountain Park, a landscape in which fire had been completely suppressed over a period of 50 years. “Fuel on the ground, dead trees, withering heat, the driest weather in a century, lightning strikes and high winds helped create ‘perfect-storm’ conditions” (Freake and Plant 2003, 15).

Creation of a Fire Break

At the outset of the 2003 fire, there was a constant source of fuel for the flames, leading straight across the southern border of Kelowna. After the fire was deemed a danger to the city, evacuation orders were issued and the local fire management teams evaluated strategies, resulting in the construction of a fire break on public land along the city’s border. It ran 16km from the shore of Lake Okanagan to the eastern border of the city, allowing the fire fighters to battle the fire along a consistent line, bringing it out of the tree crowns and back to the ground.

Firebreak being constructed outside of Kelowna (2003). Photograph by Gary Nylander, from *Firestorm.*

While the fire jumped the 50 meter width of the break in various locations, the fire break is credited with saving hundreds of homes, having slowed the breach and providing a predictable front to attack the fire.



2003 Okanagan Mountain Park Fire
Damage & Location of Fire Break.

CHAPTER 4: DESIGN

Fire Break to Fuel Break

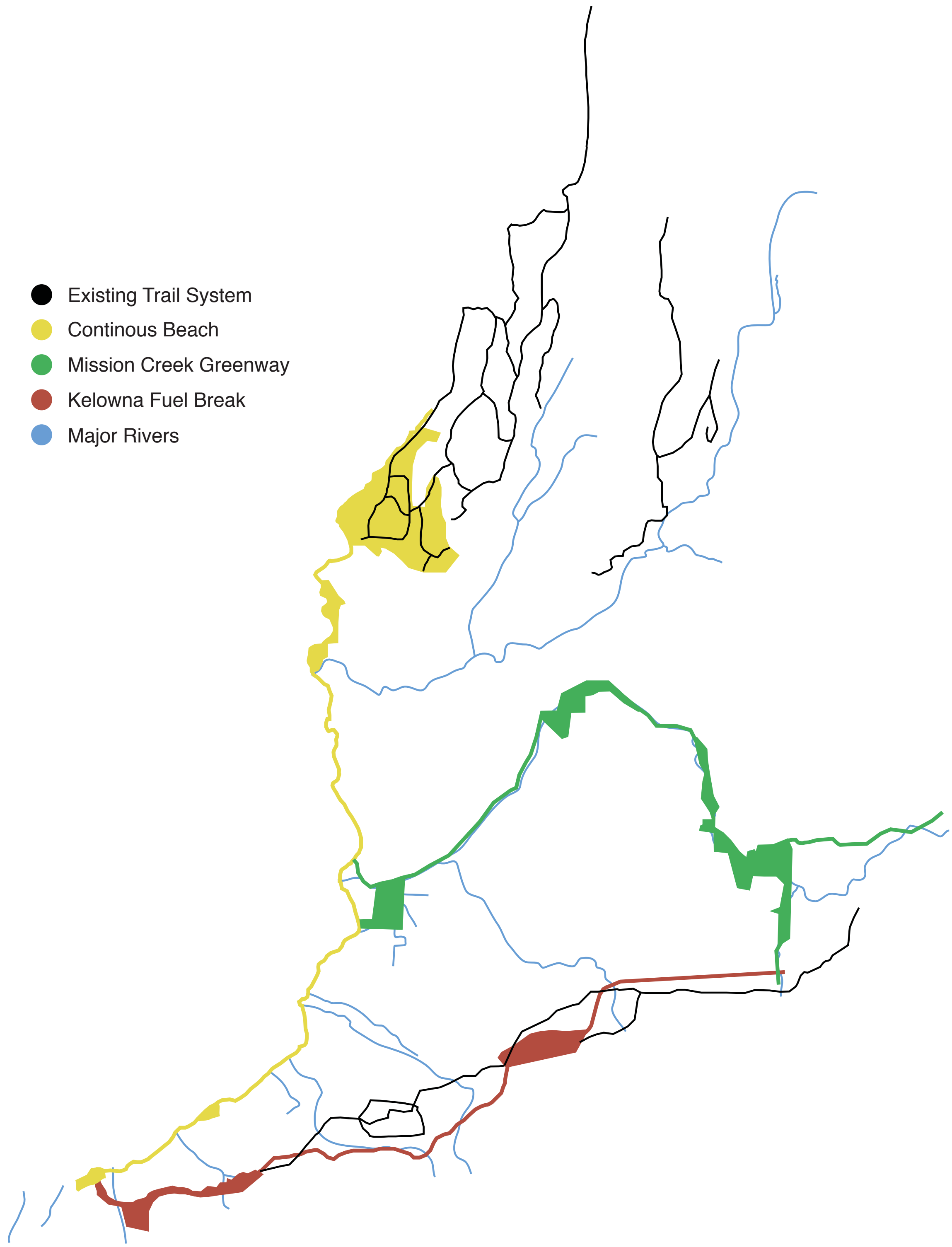
After the fire of 2003, the Okanagan Fire Recovery Society examined solutions for mitigating future events of a similar magnitude. One suggestion - to construct fuel breaks in the southern region of the city by building new roadways - sought to expand on the measured success of the unplanned fire break.

This thesis takes a different approach. It proposes transforming the existing fire break into a landscaped fuel break programmed to support public recreation. This will provide an amenity to residents of nearby communities, and serve as civil infrastructure. It would be visible from much of Kelowna and the tourist-filled beaches of Lake Okanagan. This linear "park" would be developed and maintained as public land, linking to the existing trail system, the beaches of Lake Okanagan, and the Greenway which runs through central Kelowna (as seen in the map on page 27). Recreational facilities could easily be programmed into the park. The original 50m width of the fuel break would be expanded to 100m to decrease the likelihood of fire successfully jumping over the gap.

In a sense it would be a Maginot line on the city's southern border, defending it from oncoming flames, except rather than military fortifications it would be defined by parks, walkways and public buildings.

Five Sites

To explore the potential of the fuel break as a site for public



New fuel break connecting to the public park infrastructure in Kelowna buildings, five sites have been chosen to explore varying degrees of program intensity. On page 29, a model of the fuel break is shown with all five sites highlighted. Along its 16km length, the fuel break cuts in and out of communities. As a result, some of the proposed sites are particularly isolated from the everyday population and are programmed appropriately.

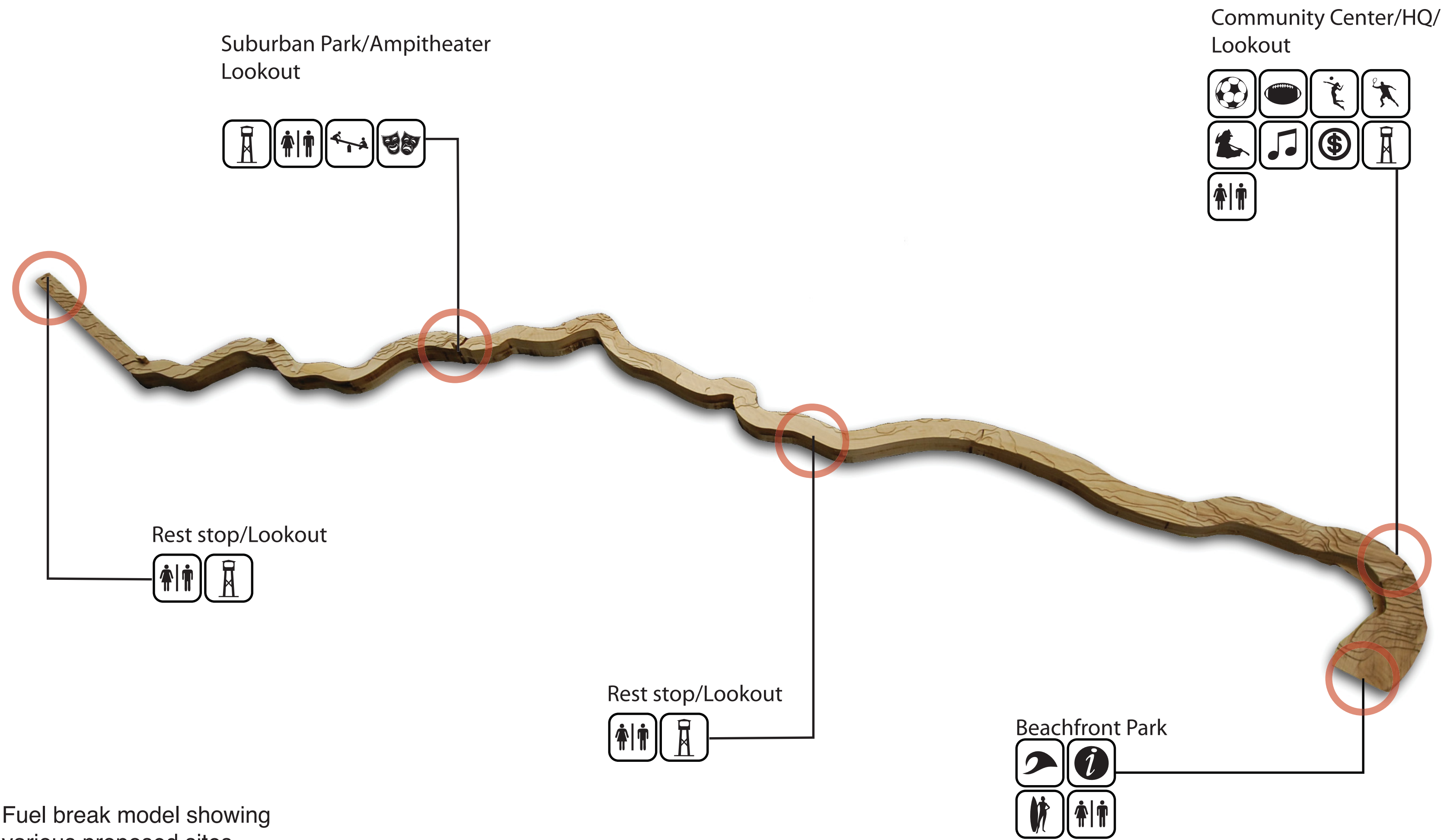
The first site, where the fuel break meets Lake Okanagan, is a beach front park, similar to the various parks that line the lake throughout Kelowna. This site would have access to the water for boat launching and swimming, and recreational activities such as beach volleyball.

Up the hill from this, is a community centre and lookout. These buildings would provide a hub for community activity to a fast growing residential neighborhood in need of civic instutions.

The third site is isolated, best reached by the hiking trails that cut in and out of the fuel break. The program here reflects this isolation, offering a simple rest stop and lookout pavilion.

The fourth site is close to the established communities of the North Mission and Southeast Kelowna. It offers an outdoor theatre and a children's playground.

The fifth site is where the Mission Creek Greenway and the fuel break cross paths, signalling a change in the treatment of the forest and pathways. Like the other isolated site, it is programmed with a rest stop and lookout.

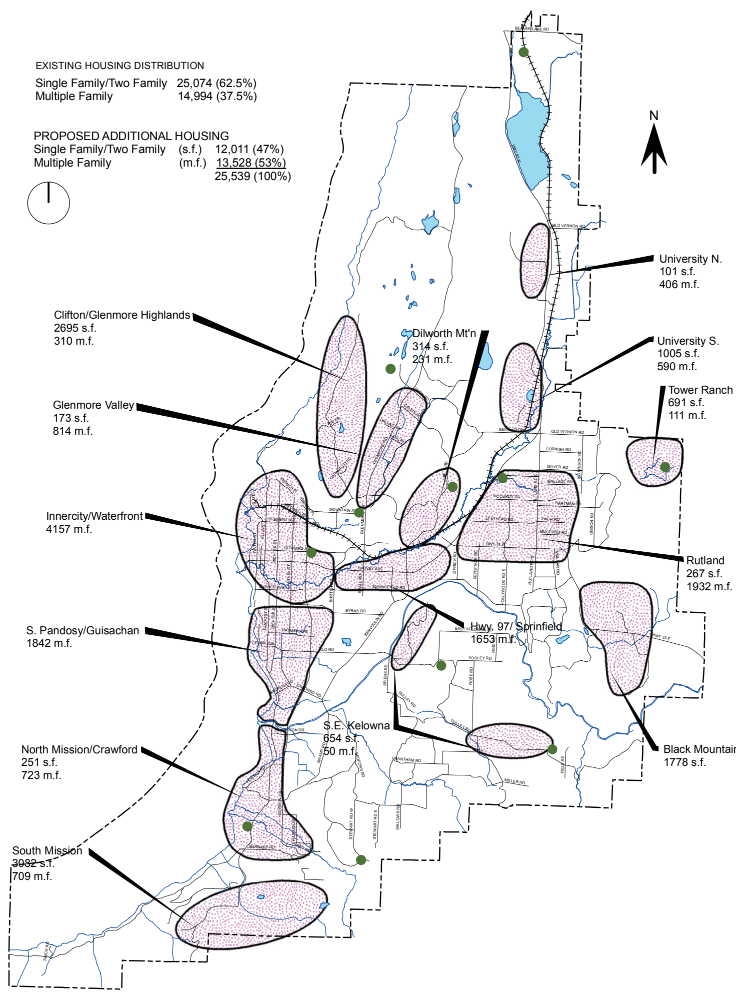


Fuel break model showing
various proposed sites

South Mission

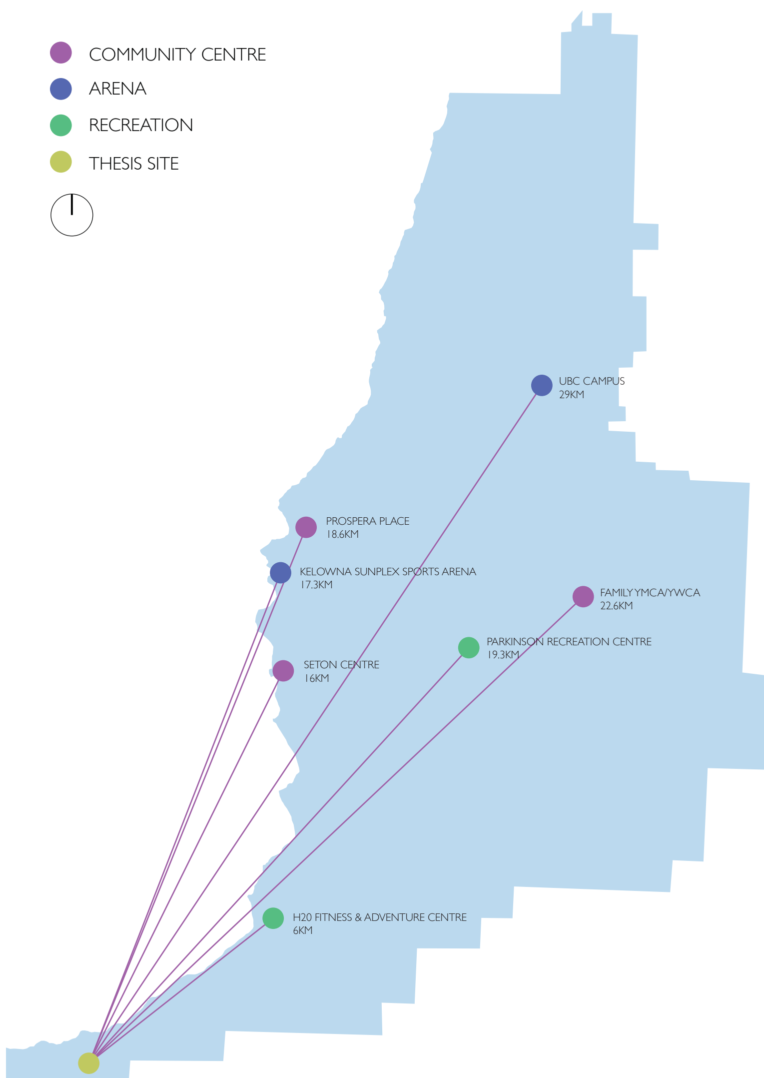
Rather than fully developing all five sites, this thesis aims to explore the community centre and tower from the second site. To justify the programming choices for this site, it was important to determine local demographics and identify community needs.

The South Mission district, where site two is located, is currently populated with retirees (who have predominated since its establishment), and increasingly, young families as the city extends southwards. The citys plan for 2020 shows residential population expanding in the South Mission, with a plan for 3082 single family homes, making it the fastest growing community in Kelowna.



Kelowna 2020 plan for housing distribution.

South Mission lacks the civic institutions to support its projected growth. As can be seen in the map below, the nearest community centre is approximately 16km from South Mission. Currently, most of the city's recreational sites are centered near its urban core. A community centre in the south end of the city will serve as a social hub for the growing community.

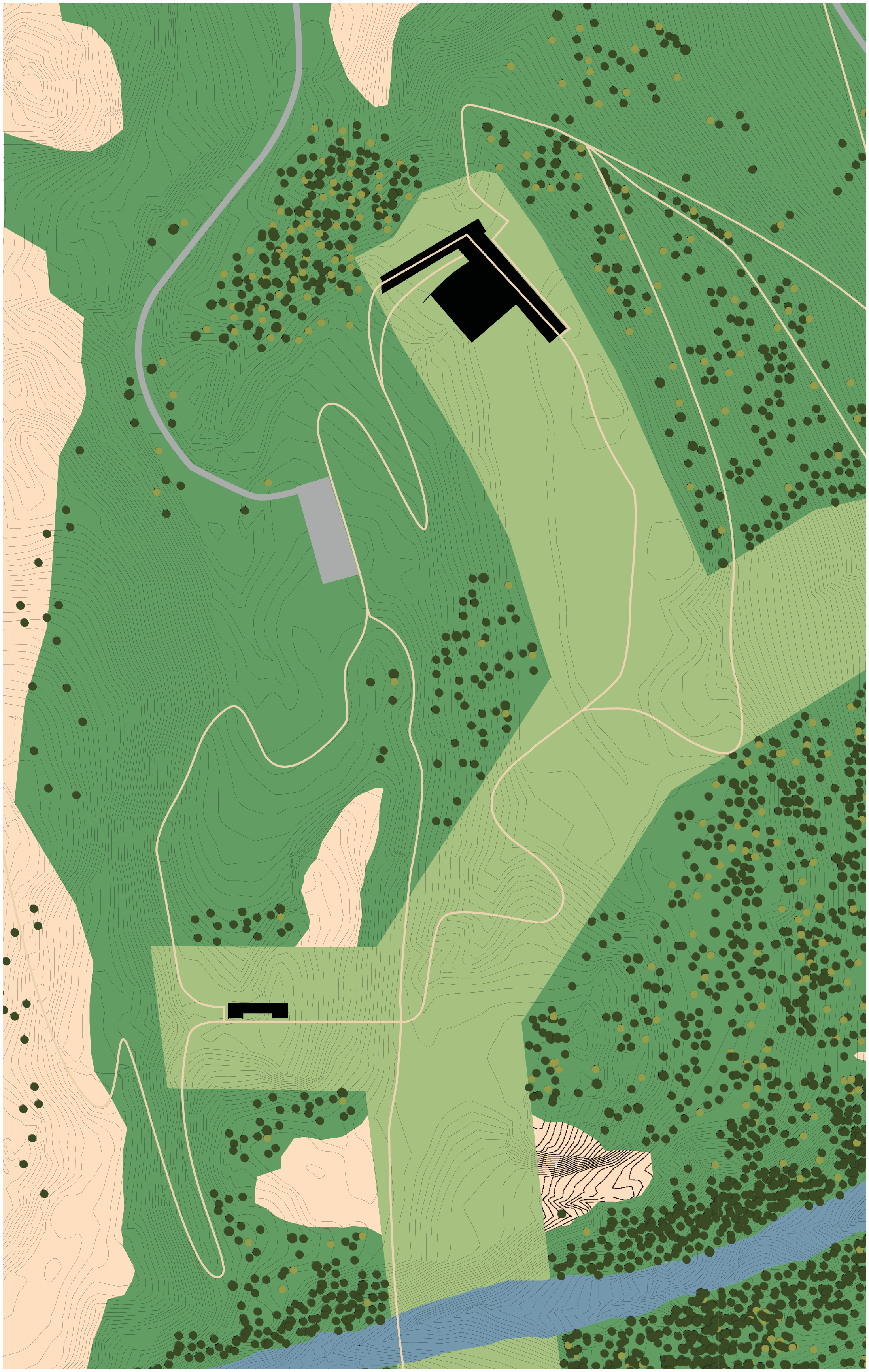


Kelowna Civic Institutions

Site

Located near the head of the fuel break, the site is easily accessible to residents of the surrounding community. The site looks north, offering a panoramic view of both the city and Okanagan Lake. It is approximately half a kilometre from the lake shore, and would be accessible to hikers walking the fuel break, or through driving. The main road for the region, Lakeshore Road, loops into a newly formed residential neighbourhood, bring in visitors directly to the site. Because this region was heavily burned in the 2003 fire, the surrounding landscape is littered with charred trees and low-lying new growth. The fuel break to the east of the site, with cleared vegetation extends into it, as seen on the site map on page 33.

View of the community centre site from the site of the tower.



Site Plan

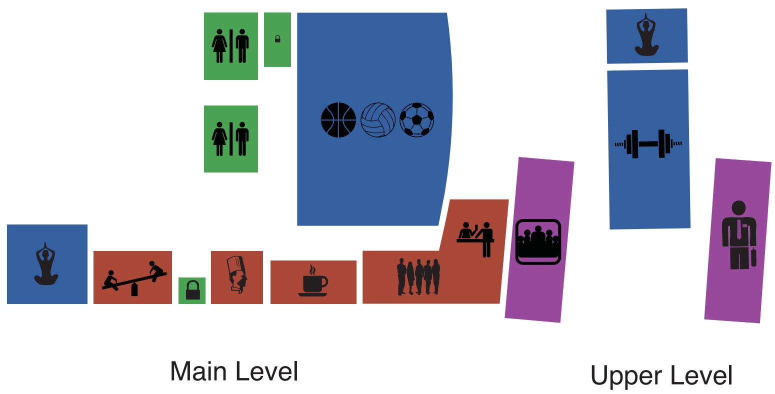
Community Centre

Everyday Use

The centre includes a sports complex with multi-functional spaces plus support spaces, such as locker rooms, offices, and food service.

Program Diagram:
Everyday Usage

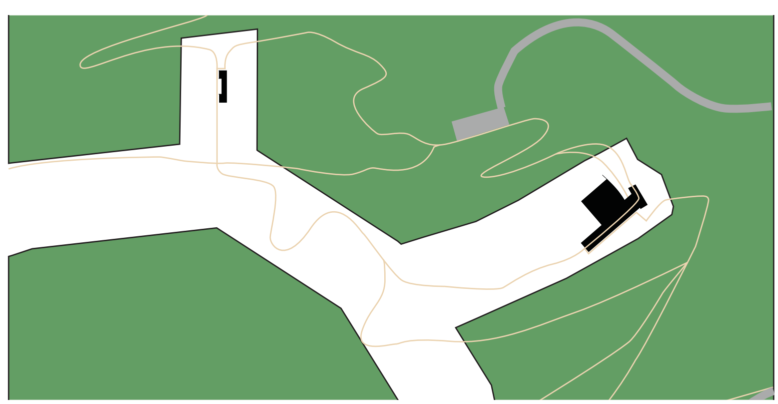
- Recreation
- Ancillary
- Offices
- Service



Open green spaces outdoors, including an accessible green roof, are linked to a trail system consisting of existing and new hiking routes. The tower acts as a trail head for the route that runs along the fuel break.

Site Diagram

- Untreated Land
- Buildings
- Roads
- Trails
- Fuel Break

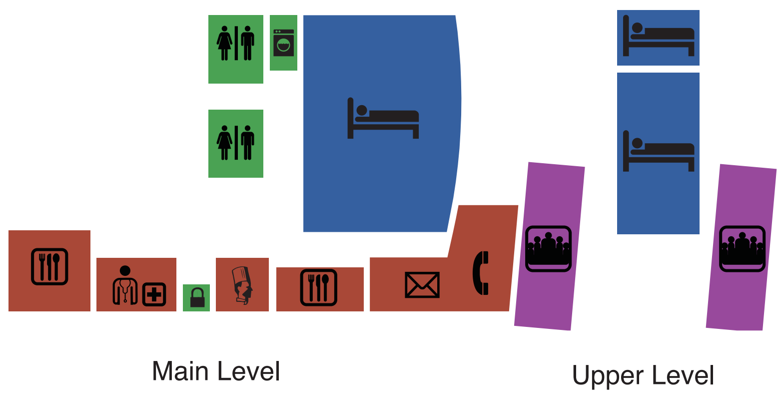


Fire Scenario

When a major fire occurs, crews from outside the city are brought in (7,600 people helped fight the 2003 Okanagan Mountain Park fire). The centre would aid in housing some of these men and women during future fires, with the gymnasium and exercise areas turned into sleeping quarters for the crews, and the multipurpose spaces housing medical stations and food services. The office block would open up to planning and meeting rooms, while the foyer would be a communication hub.

Program Diagram:
During Fire Usage

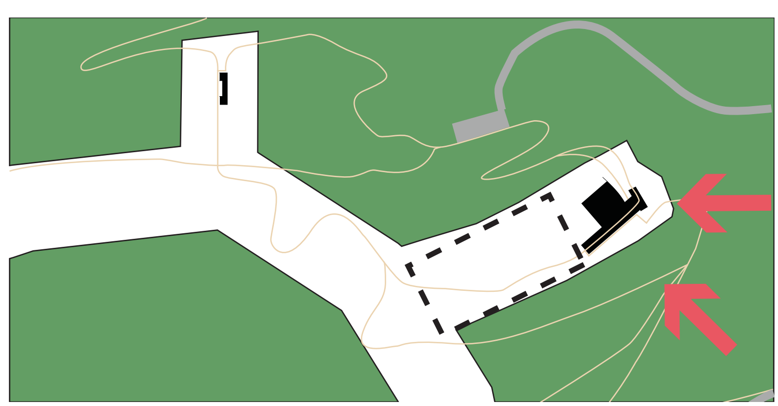
- Sleeping Quarters
- Ancillary
- Meeting Space
- Service



As the fuel break is the optimal line of defense against the fire, the community centre and its surrounding site would serve as a staging area for the equipment and personnel tasked with holding the flames back. The crew could take advantage of the flat nature of the site that extends to the fuel break.

Site Diagram

- Untreated Land
- Buildings
- Roads
- Trails
- Fuel Break
- Staging Area
- Direction of Fire

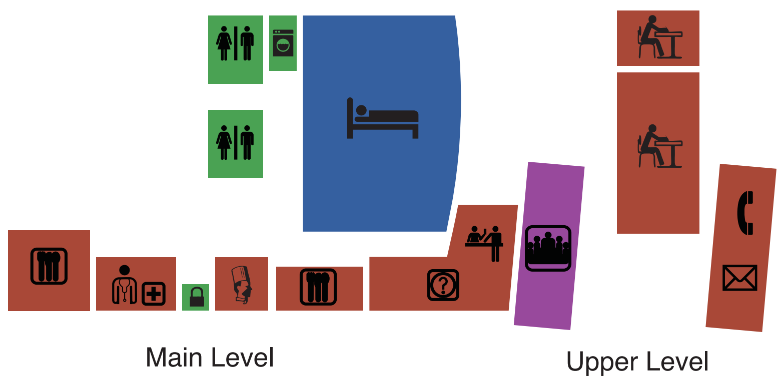


Post-Fire

Following a forest fire, the centre would function as a base for organizing relief efforts, and as an emergency shelter for people displaced by the fire. The programming would be similar to that of the fire scenario: the gymnasium housing the sleeping quarters, and the ancillary spaces providing medical care and food service. The bottom floor of the office block would support meetings and planning sessions, while the upper floor of the this block would act as a media centre, for families to stay in contact. The upper fitness area would provide classroom space for children.

Program Diagram:
Post-Fire Usage

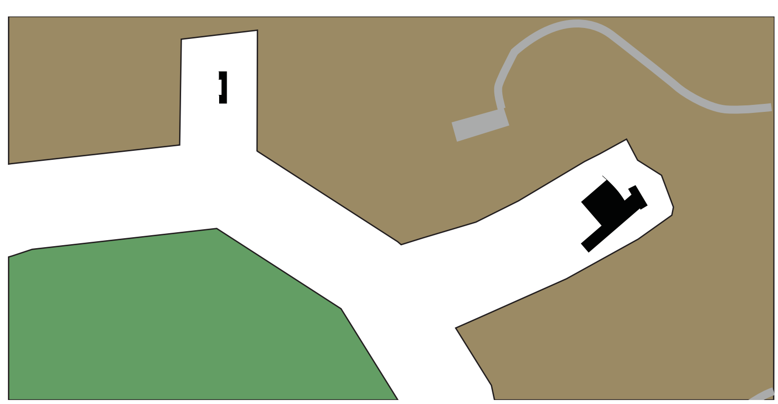
- Sleeping Quarters
- Ancillary
- Meeting Space
- Service



The surrounding site would likely be devastated by the fire, with much of the plant life and trails either burned or torn up by the fire crews. Provided the fuel break was successful, the plant life on the opposite side of the fire break would still be alive.

Site Diagram

- Burned Land
- Surviving Land
- Buildings
- Roads
- Fuel Break

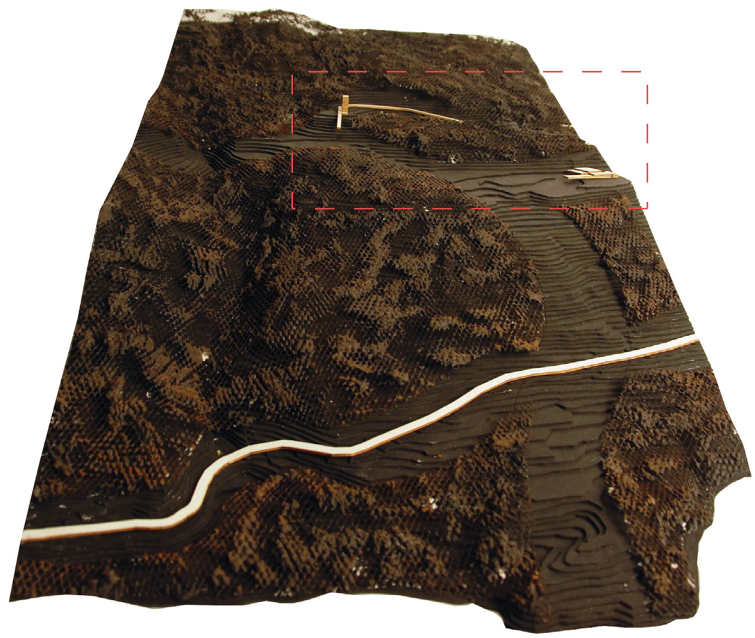


Principles

The community centre employs the fire resistant design principles discussed previously.

Site Choice

The south end of Kelowna is a steeply sloped landscape, making it prone to quick moving fires as they travel uphill. The community centre takes advantage of a relatively flat plot of land, anchored between two slopes and directly adjacent to the fuel break.



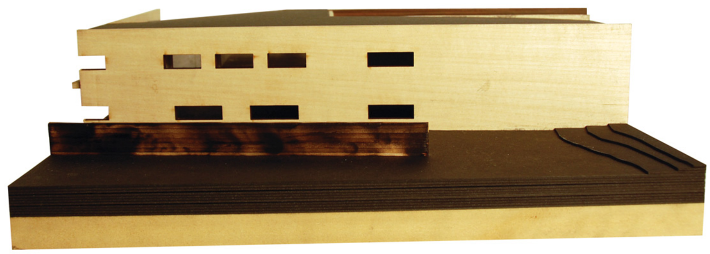
Site model showing the steep landscape and the relative flatness of the site.

Weak Point Defense

I identified the gymnasium as the main weak point of the building. Its combination of the long span steel trusses and the large amounts of glazing makes it the most vulnerable structure in the event of a fire.

To protect the gymnasium, a solid office core and earth berm along the western axis of the building, will itself act as a fire wall. The office core has minimal glazing along its western face, and these are protected by shutters triggered by approaching fire. Additionally, a sacrificial concrete wall surrounds the western and northern facades. On the north and west side of the wall, burned wood cladding collected from the site acts as a memory of past fires.

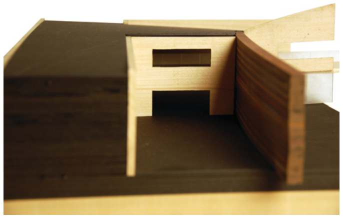
Model of the western wing of the community centre, showing the burned wall, earth berm and the minimal glazing of the office block.



Defensible Space

The building is located in an extension of the fuel break, with flammable vegetation removed in a 10 meter perimeter. A plaza to the north and a water way which runs along the north, west and east walls are extensions of this defensible space.

Plaza to the north of the community centre, including moat and barrier wall.



Model showing entrance condition with curved wall and earth berm.

On-Site Water Storage

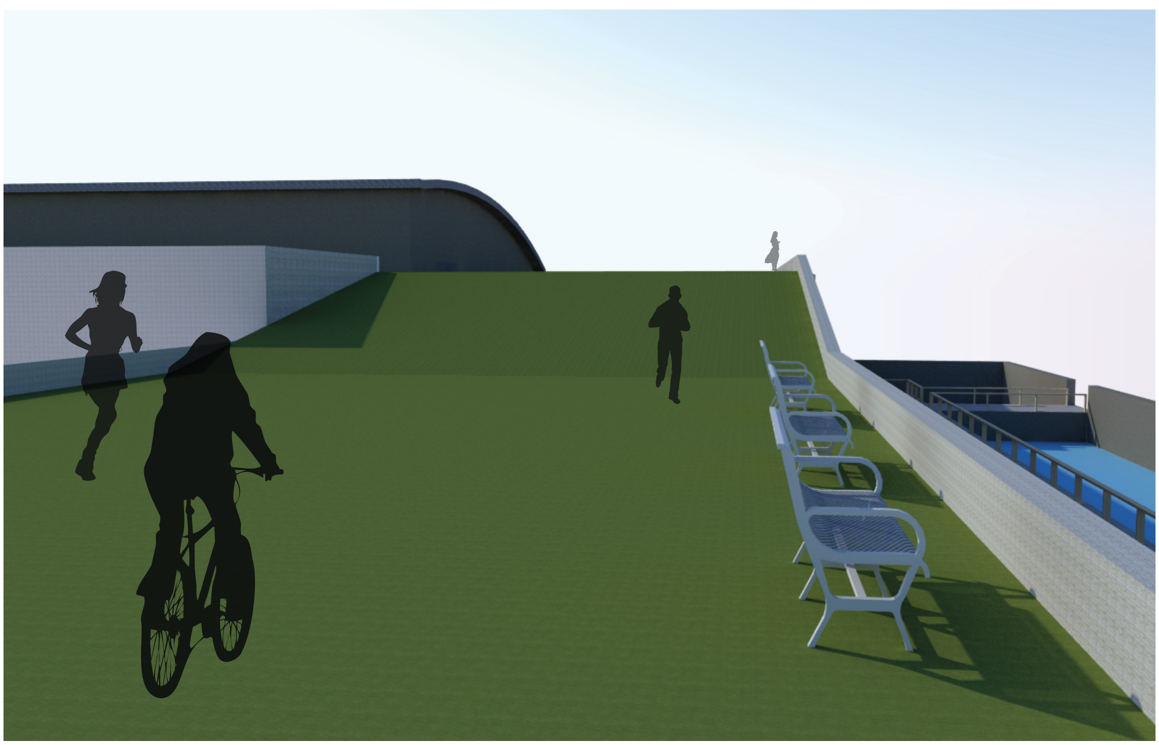
The contours of the site are naturally shaped to a drainage path that collects the runoff of the sloped site south of the building. A collection basin east of the community centre stores the water in channels that run along the building.

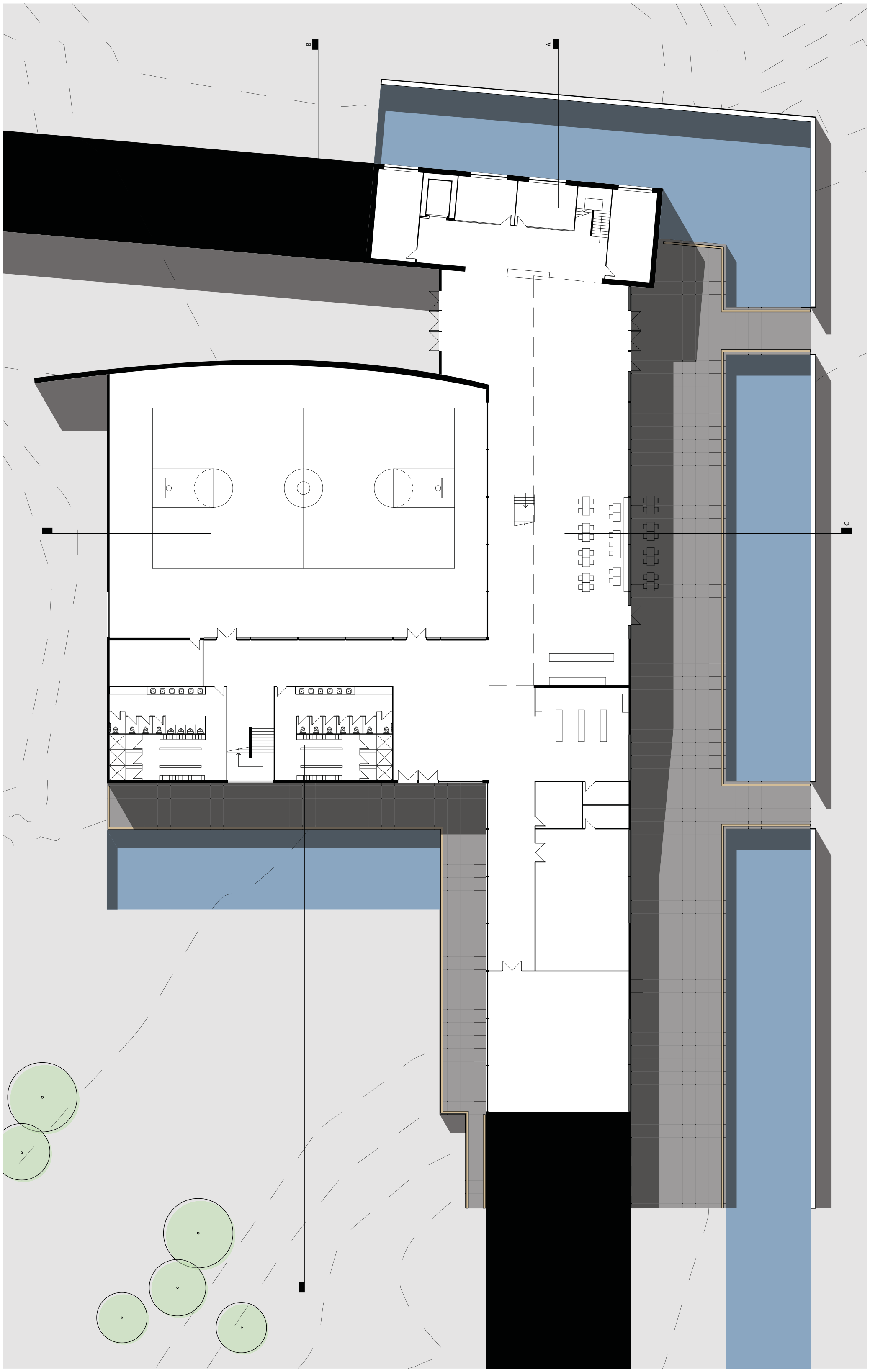
Roof Design/Material Choice

The reasoning behind the material choices has been discussed previously. A curved rammed earth wall acts as a feature wall for the gymnasium and softens the main entry condition. The remainder of the building is a mix of concrete, steel and glass.

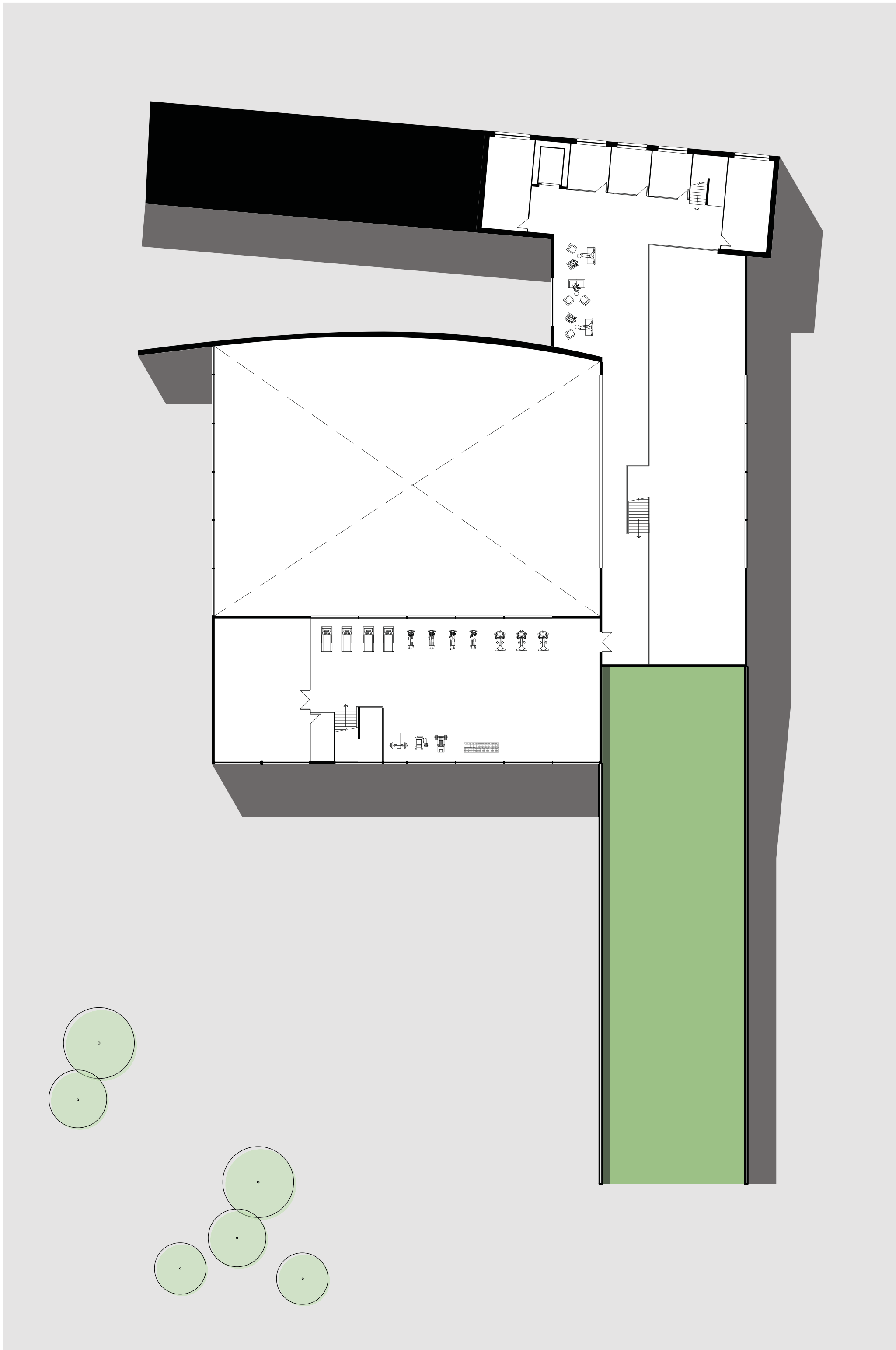
The green roof is a fully accessible walking path that is integrated into the trail system of the surrounding landscape.

Green roof of the community centre, and water collected in moat below.



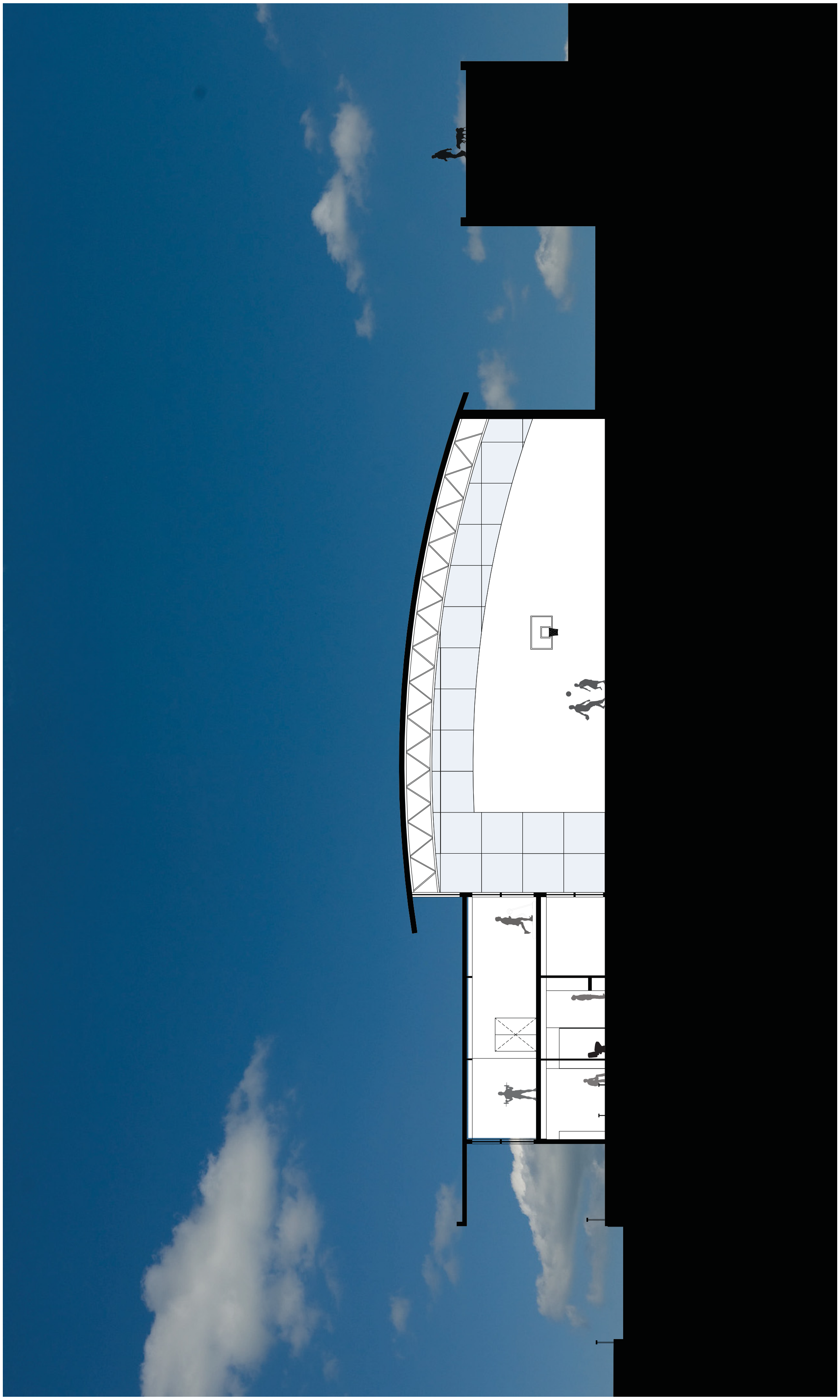


Community Centre
Main Level Floor Plan

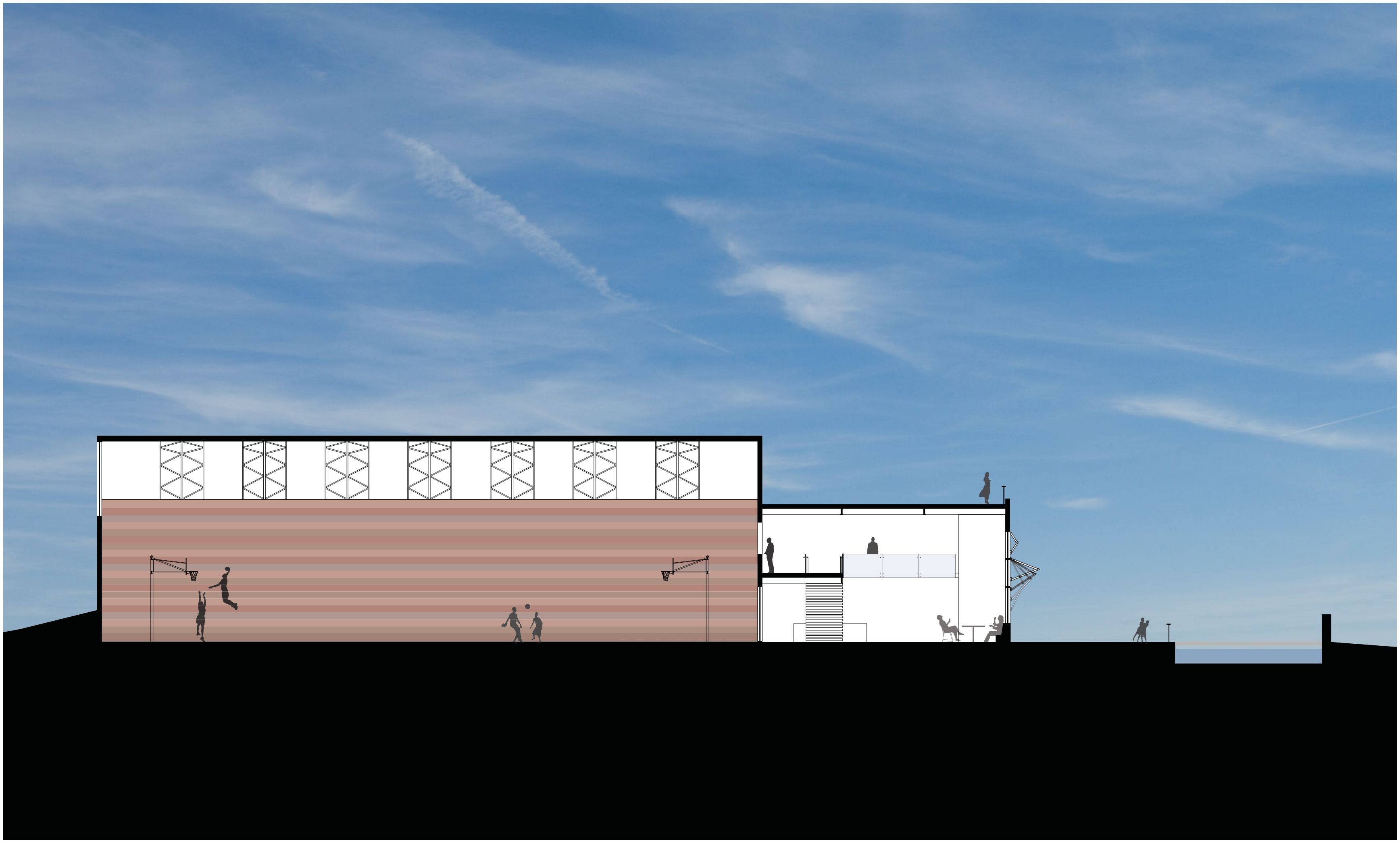


Community Centre
Upper Level Floor Plan

Community Centre
Section A



Community Centre
Section B



Community Centre
Section C

Double Height space of interior lobby.

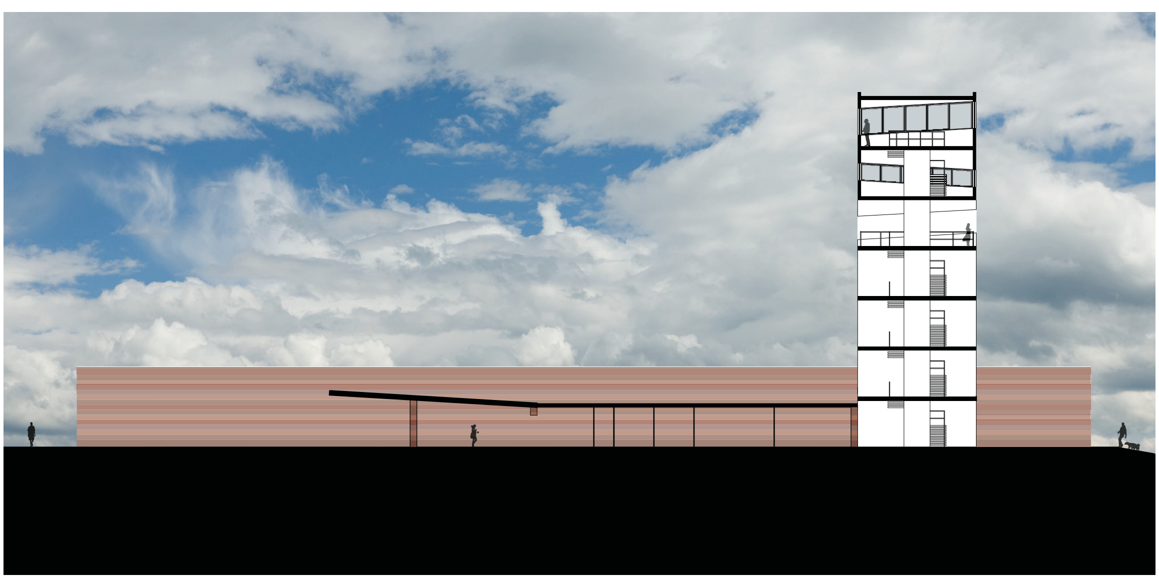
Fire Tower case study showing a 90’ tower with small open cab.

Fire Tower

Since the Okanagan has such an extensive history of fire, it is also home to numerous fire towers. Historically, these towers have played a major role in the suppression of fire. While many of these towers have fallen into disrepair, a number are still being used on a volunteer basis, such as Rhoderick Dhu Lookout and the Goat Peak Lookout. These towers are staffed by the British Columbia Forest Service when fire activity is most likely.

The tower proposed for this thesis draws heavily from these historical precedents in its design and program. The 70’ fire tower is elevated on a prominent ridge and is encased in a perforated steel cladding punctured by three bands of glass which wrap the building on all sides.

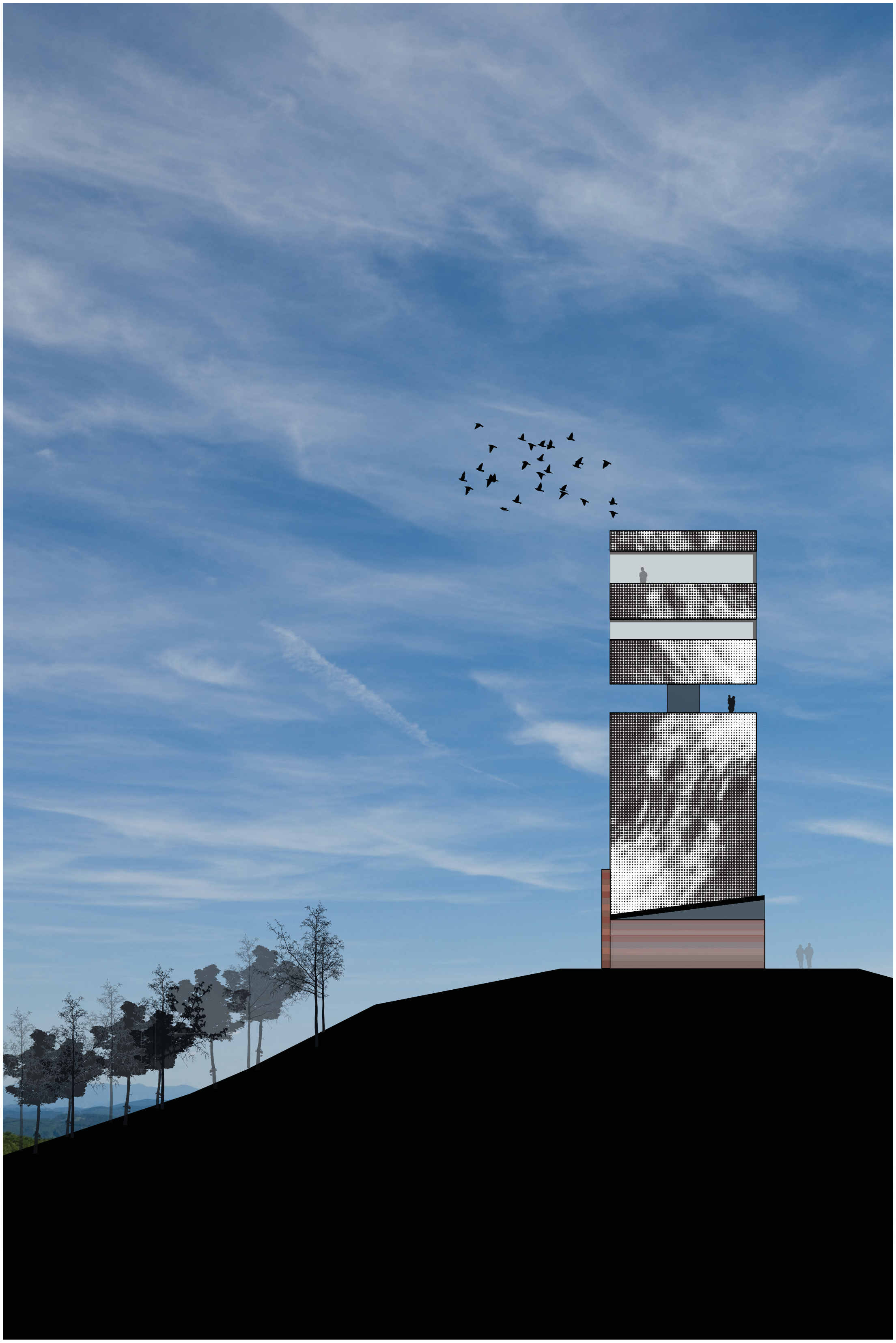
Proposed Fire Tower
Section A



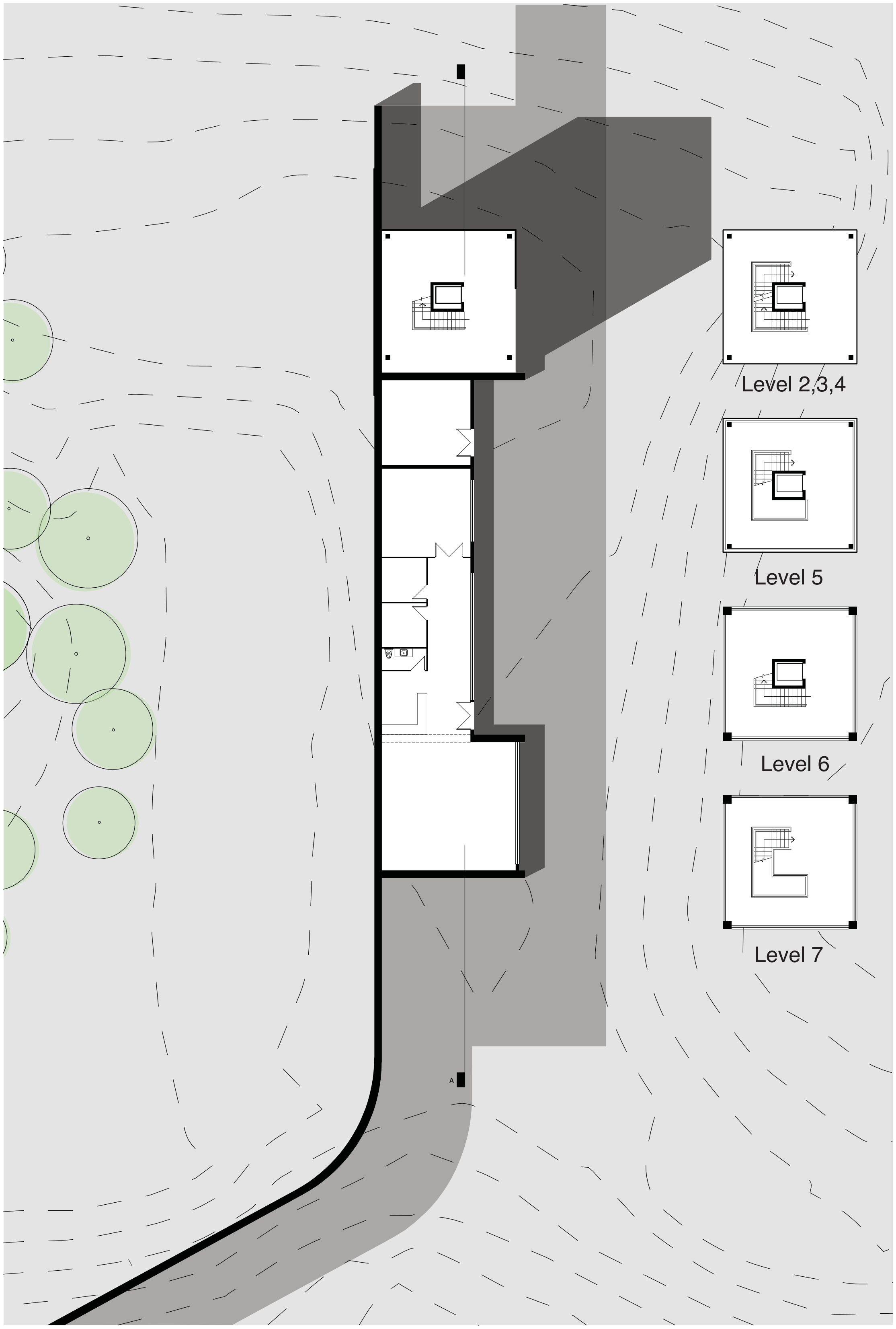
The purpose of the tower is to integrate into the British Columbia Forest Service network of towers. The top two stories are designed to be occupied by a volunteer while the remainder of the tower is open to the public, providing unobstructed panoramic views.

An ancillary building at the base of the tower provides teaching tools to residents concerning fire conscious design, as well as a memorial for past fires.

Proposed Fire Tower
Model



Tower
North Elevation



Tower
Floor Plans

CONCLUSION

In conclusion, this thesis has explored various applications of architectural and design principles for fire-prone regions. Through research of existing fire-safe home design manuals and discussion with fire management personnel in British Columbia, these concepts were condensed into six principles. The subsequent siting and design of a public building and its architectural implications were subsequently approached with these principles in mind.

A rigorous study of the surrounding community and the immediate landscape of the site was necessary to appropriately program and design the community centre and adjacent tower. The building tackles significant social and technical issues with regards to emergency planning and defense against fire, while also providing an asset to the city with the provision of a successful community centre.

This thesis serves as a reminder that the typical building practices in areas prone to forest fires often ignore the consequences of poor planning and design standards. Too often the consequences of these poorly chosen design standards are forgotten following a fire. In Kelowna today, less than ten years after the 2003 Okanagan Mountain Park fire, new homes are being built on top of the charred remains of communities lost to the fire. Many of these homes are still sited on steep slopes, feature flammable exterior materials and have vegetation overhanging shingled roofs. The fire cycle of the Okanagan suggests a similar fire will occur in the future, and no amount of fire management techniques will offer safety to homes that disregard these basic principles.

Home built near the community centre site.

One weakness of the thesis is the limited focus on individual building details, such as screens to better protect large glazed openings or structural fail safes if fire were to breach the building. Also, further consideration of the remaining sites along the fuel break would have strengthened the overall argument for this massive fuel break. However, the investigation in this thesis was necessarily limited, and I hope to supplement the work done here by continuing to explore these concepts in the future.

It is my hope that, as climate change and living patterns alter our forests and fire cycles, the ideas put forward by this thesis will add to the discussion of city planning and building design in the fire prone regions, and provide a useful tool in the protection of communities, homes and people.

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