A Hydrology-Based Approach to Sustainability and Resiliency in the Brandt's Creek Watershed

IGS585 Group 1 (2022) | Anjali Desai, Annie Furman, Ilyas Kanybek, Thomas Letcher-Nicholls, Hoda Pourpirali, Leandra Vanbaelinghem

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Executive Summary

Brandt's Creek is one of the three major waterways in Kelowna. It was heavily channelized between 1938 and the 1950s (Thibeault, March 14, 2023). Brandt's Creek currently faces multiple sustainability and resiliency challenges which we have identified from guest speakers, class discussions and outings. These include:

- Lack of hydrology and water-quality-based understanding of Brandt's Creek.
- Lack of knowledge of the interactions between Brandt's Creek and its ecosystem.
- Limited policy reach and application to Brandt's Creek.
- Limited Indigenous representation in local governance of spaces like Brandt's Creek, as there is no Indigenous representation in the Central Okanagan governance.
- Flood risks associated with Brandt's Creek's channelization.
- Lack of care from the City of Kelowna and its community, approached in this report via a case study of the Mithi Nadi River in Mumbai, India.
- Lack of representation of the unhoused community who require consideration in any future development or relevant acquired knowledge of Brandt's Creek, as urban green spaces are important in providing privacy, survival, and solace to those experiencing homelessness.
- Problematic culverted channelization, anti-meandering course, and lack of riparian vegetation, approached in this report via a rehabilitation case study of Baxter Creek in California, USA.

Compounding these sustainability challenges is a lack of documentation and understanding of the creek; and this poses an additional layer of complexity to the problem. This is because attempting to determine sustainability priority efforts within the holistic and interconnected nature of the issues at hand, while also needing a fundamental understanding of

the system, does not support informed decision-making. Hence, out of the numerous potential sustainability solutions for Brandt's Creek, this study specifically addresses the lack of hydrology and water-quality-based knowledge, as it is seen as a foundational step to understanding the current resiliency state and stream health of Brandt's Creek. The overarching goal of addressing this specific issue is to provide ground for subsequent science-based decision-making for future rehabilitative and sustainability interventions. This study proposes to fill this knowledge gap through hydrological and water-quality testing via a citizen science approach in the education system to build community care and nourish a sustainability viewpoint in future generations.

The project took an unexpected turn when we found the "2021 Annual Drinking Water and Filtration Deferral Report" from the 2021 City of Kelowna Annual Water and Filtration Deferral Report, which contains water-monitoring of waterbodies in Kelowna, including Brandt's Creek (Hope, 2022). This monitoring report slipped through our intense search queries and the expert speakers of Brandt's Creek. As a result, a parallel priority issue was identified: knowledge mobilization gaps between interested parties, stakeholders, and rightsholders. Communication difficulties surrounding Brandt's Creek are a barrier to sustainable and resilient development of Brandt's Creek. Therefore, we have identified potential known information on Brandt’s Creek from a subset of interested parties, stakeholders and rightsholders as well as potential information of interests for these groups. Lastly, we propose a communication pathway and an interactive, collaborative website as a start-point to improve the dissemination and cooperation between the different interest groups of Brandt's Creek.

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Section 1: Introduction

1.1: Report Objectives

This report aims to synthesize existing knowledge about Brandt's Creek as presented to the authors by City of Kelowna officials, academic experts, and interested neighbourhood parties; present a hydrologically-focused survey of the current known and unknown conditions of Brandt's Creek; and broadly outline a needed flow of communication to ensure more sustainable attention and care is paid to this urban waterway.

1.2: Working Definitions

1.2.1: Sustainability

Sustainability is a complex term with multiple layers of meaning and whose definition varies widely across disciplines and scholars. The meaning of sustainability changes according to the employed context, dimensions, and intended purpose. For the purposes of this report, sustainability will be understood as the quality of a system determined based on that system's ability to persist as a stand-alone and with other subsystems and environments through a mutually nourishing exchange (Parrott, January 31, 2023). In the context of Brandt's Creek and this report, we apply a system's approach to sustainability; but more specifically, we focus on water-quality and hydrology as central determinants of the quality of this system. We seek to understand Brandt's Creek's ability to persist both as a stand-alone riparian segment and as a facet of a larger system; the associated riparian species living in, around, and with the creek; the surrounding environment and adjoining human communities; and input and outputs of local businesses into the waterway.

1.2.2: Resiliency

Sustainability and resiliency are both descriptors of a system, but sustainability focuses on the outcomes of a system at a large spatial and temporal scale (Marchese et al., 2018).

Resiliency, in contrast, focuses on the property of the explored system on usually a smaller spatial and temporal scale (Elmqvist, 2017). The common understanding of resiliency is the idea that a system will not change from one domain to another, or recover despite exogenous disturbance (Derissen et al., 2011). The difference in terminology and scale between sustainability and resilience places resiliency as a descriptor of sustainability in most situations (Marchese et al., 2018). However, the interconnected nature of the terminologies makes sustainable actions major contributors to a resilient system as well (Derissen et al., 2011). In the context of this analysis, resiliency for Brandt's Creek would mean improving the stream's health such that the waterway can continue to support (and even improve upon) all its current ecosystem and societal services. Resiliency would thus also mean supporting disturbances from the associated riparian species living in, around, and with the creek; the surrounding environment and adjoining human communities; and input and outputs of local businesses into the waterway.

Section 2: Brandt's Creek Background & Problem Identification

2.1: Geography and Topography

Brandt's Creek is a small waterway that is approximately 13 kilometres long, flowing from the Glenmore Valley and Highlands (north of downtown Kelowna) down into the city and downtown Kelowna; the creek then enters the Rotary Marsh estuary where it empties into Okanagan Lake (Lewis, February 14, 2023). Where the creek begins in Glenmore, there are two branches: the western branch makes up Brandt's Creek Linear Park in Glenmore. This walking trail winds through residential areas, and there are a number of parks along the length of the trail. These have been shaped largely according to stormwater management needs—the parks are sunk down where water can gather safely (Lewis, February 14, 2023). The eastern branch of the river flows alongside the sidewalk along Valley Road. The two branches then join at Valley Glen Wetland before flowing toward downtown Kelowna (Lewis, February 14, 2023).

When the creek flows out of Glenmore and into downtown Kelowna, it moves westward. Here, there has been some riparian restoration of the creek's banks, though these efforts have not been thorough (Lewis, February 14, 2023). Then, as the creek flows into the city, it enters the North End industrial area. This area is the focus of this report. Here, the creek has been used essentially as a draining channel for waste, stormwater, and industrial runoff. The creek has been heavily channelized, ditched, and made into culverts; its banks are concrete, and water flows straight and narrow. However, after leaving the industrial area, the creek becomes a park again at Sunset Drive Linear Park. It then empties into the Rotary Marsh and Okanagan Lake (Lewis, February 14, 2023).

It should be noted that the creek is somewhat difficult to trace and follow because it often goes underground through engineered subterranean drains; where its sources are difficult to trace on maps. Further, all along the creek's route, storm drains empty into the creek, making the water flow somewhat unpredictable. According to Ray Lewis, approximately 60% of the creek has no riparian shrub cover or tree canopy, and the creek suffers from bank instability and erosion (February 14, 2023). This is especially notable along Wedell Place.

Compared to Kelowna's two larger creeks—Mission Creek and Mill Creek—we believe the importance of Brandt's Creek waterway has been overlooked. There are very few readily accessible sets of data, statistics, or sources describing Brandt's Creek. And in the North End industrial area—the primary focus of this study—the creek is in significant need of more careful attention in order to create a more resilient system in the face of increased flood disturbances.

2.2: Indigenous History and Relationships

We, as a research team, respectfully acknowledge our positions as uninvited guests living and working on the unceded territory of the Syilx (Okanagan) People. The research in this report was undertaken on and makes recommendations about their ancestral lands. The Syilx People were this land's first custodians, storytellers, and scientists. As a research team, we are conscious

that we are still learning about what it means to live here in the Okanagan, and the specific obligations and responsibilities that come with that privilege. We think it is essential in this report on Brandt's Creek to think deeply about First Nations' relations to this place—but we are painfully aware that as newcomers, we might lack the expertise and knowledge to do so.

Brandt's Creek, as we know it now, did not exist before colonization. As we have mentioned, the land through which Brandt's Creek now flows was once a marsh or a floodplain. The creek exists as it does now through colonial engineering and modification. On a visit to the Sncewips Heritage Museum, Syilx knowledge keeper Coralee Miller explained that nowadays, the creeks in Kelowna are heavily contaminated. Many native plants that once would have been a source of nutrition are now dangerous to consume.

We note the weight of the history of this area—that, like throughout Canada, its history will be one of dispossession and violence. We do not think it is our place to reproduce this history and trauma here, but rather hold space for Syilx People as the land's traditional custodians. We hope that any recommendations we make in this paper will be brought to the Syilx People and, if this report is taken forward, it will progress in cooperation with Syilx knowledge keepers.

2.3: Settler-Colonial History

The settler-colonial history of Brandt's Creek is somewhat difficult to trace. Official sources and documents are scarce, and over the years, it has been variously called Brandt's Creek, Brant's Creek, or Brandt Creek (Madeline Donald, February 14, 2023). Madeline Donald, PhD candidate at the University of British Columbia Okanagan, has found an unidentified archival document titled "Report on Brandt Creek" from August 22, 1974. The report describes the creek as "not very significant" but contributing to the pollution of Okanagan Lake (Donald, February 14, 2023). Donald shared parts of the report that seem to describe the part of the creek in the North End industrial area, the focus of our report. The 1974 report describes how "Brant

Creek has been completely rechannelled. It flows through a man-made ditch for most of its length," and it says that the creek is a "channel [that] is artificial and straight throughout, with abrupt rather than gentle curves where the channel changes direction" (Donald, February 14, 2023). The report fails to shed any light on how the creek came to be this way.

However, from historical photos of the landscape in the Kelowna Heritage Museum and City of Kelowna archives, we can suggest that what is now known as Brandt's Creek was once a seasonal marsh or floodplain. It was likely home to more wetland plant species than trees by comparison to the more southerly Mill Creek and Mission Creek watersheds (Donald, February 14, 2023; Thibeault, March 14, 2023). At some point in Kelowna's history between 1938 and the 1950s, the creek was heavily modified into a straight channel, possibly beginning with the stretch immediately north of modern-day Recreation Ave., which archival aerial photographs suggest may have been channelized as early as 1938 to protect the then-existing horse racetrack from flooding (Thibeault, March 14, 2023). However, finding concrete written information on the processes and plans that led to this channelization has been challenging.

Figure 1: 1938 aerial photo of Brandt's Creek area. Note the intensity of meanders, suggesting extensive marshland. Area circled in red is potential early channelization north of the racetrack. (Thibeault, March 14, 2023)

However, more recent developments to the creek seem to have improved the creek's sustainability and resilience. As noted above, in Glenmore, the creek has been modified into Brandt's Creek Linear Park, which is both a walking path and a series of parks for families, but also contains several stormwater retention ponds designed to prevent flooding. According to signs posted in Brandt's Creek Linear Park, these modifications were carried out in the early 2000s.

Similarly, where the creek empties into Okanagan Lake, it has been modified into the Rotary Marsh estuary. This project is significantly better documented (*Rotary Club Kelowna*). In 1992, Rotary Club members John Woodworth and Art Hughes-Games drew up a plan to rehabilitate the creek, which at that point was carrying industrial waste, agricultural chemicals and city rubbish into the lake (*Rotary Club Kelowna*). The plan was to install "settling ponds" in the marsh to filter the creek and, at the same time, create a community space. The plan was approved in 1994, and the Rotary Marsh was opened in 1995. It is considered a real success for the area, home to a variety of wildlife and also a boon to the local community (Lewis, February 14, 2023).

2.4: Hydrology

Hydrology is the study of the movement, distribution, and properties of water below and above ground, as well as its relationship with the environment (Bales, 2015). Understanding hydrology is fundamental in solving problems related to water quality, quantity, and environmental protection, given that water is one of the most valuable resources on Earth (U.S. Geological Survey's Water Science School, 2019). Brandt's Creek is shorter than the two other main creeks of Kelowna: Mission Creek and Mill Creek. Brandt's Creek has mostly been channelized and modified from its original marshy state, shifting the landscape of Kelowna from wetland to dry land (Donald, February 14, 2023). Kelowna's North End was turned into a drier landscape with straighter waterways to stabilize the ground and build property for Canadians

returning from World War II (Donald, February 14, 2023). The man-made transformation of the creek has had several effects on the waterway, including the loss of riparian habitat, which has been replaced by agricultural land, parks, and urban infrastructure (including non-porous cemented roads, residences, etc.).

Currently, one of the main functions of Brandt's Creek for Kelowna is collecting and directing stormwater and providing irrigation. There are 22 stormwater outfalls into Brandt's Creek, ranging from 6.2cm to 1m wide (Swain, 1990). Stormwater outfalls contribute to large amounts of nutrient loading into the creek and ultimately into Okanagan Lake, including materials such as aluminum, copper, lead, zinc, nitrogen, phosphorus, as well as other suspended solids (Swain, 1990). Nutrient loading into Brandt's Creek is higher than Mission or Mill Creek (Swain, 1990). Phosphorus and nitrogen concentrations are significant and require close monitoring as high concentrations can cause excessive algae growth on water surfaces—a process known as eutrophication. Eutrophication is a detrimental condition for a waterbody, as it causes oxygen concentration in the water to decrease, which can ultimately be depleted and shift a creek or river into a marshland (Khan and Mohammad 2014). This irreversible land shift speaks to how eutrophication can threaten waterways' resiliency like Brandt's Creek.

The flow rate of water bodies is crucial to water quality and management. Flow rate is critical to determining flooding risk, creek geomorphology, aquatic life health, and pollutant load calculations (Donald et al., 2008). The last publicly available flow measurements of Brandt's Creek were in 1972, 1973, and 1975, with an average 7-day flow of $0.023 m^3/s$ (Swain, 1990). Brandt's Creek water flow is significantly slower (by about $1/10^{th}$) than that of Mission and Mill Creek. Its flow rate is seasonably variable and has been reported to be even lower in the summer (Swain, 1990). Additionally, Brandt's Creek has one water withdrawal station on license for 11.7 dam^3/a, which is used for irrigation (Swain, 1990).

Permitted water discharge into Brandt's Creek (Permit PE 1434) is 2650m3/d with a concentration of suspended solids at 35mg/L, BOD5 at 20 mg/L, nitrogen at 6 mg/L and phosphorus at 2 mg/L (Swain, 1990). This discharge is about 0.030 m^3/s, which is concerningly higher than the average flow rate of Brandt's Creek of 0.023 m^3/s. Plant performance regarding following permit guidelines and the effects of waste discharge into Brandt's Creek was first investigated in 1985 (Swain, 1990). Recorded discharge concentrations in 1985 showed that around 1/4 to 1/3 of measurement stations recorded concentrations above permitted levels (Swain, 1990). Reports from these examinations spawned a discharge impact investigation on Brandt's Creek around the same time. Discharge impact results included a severe increase in phosphorus, decreased pH, increased turbidity, and a moderate increase in ammonia, nitrate, and nitrite (Swain, 1990). Non-point source discharge is another essential consideration in the hydrology of Brandt's Creek. Urban runoff affects the southern portion of Brandt's Creek, and agricultural runoff affects the northern part (Swain, 1990).

The most recent publicly available water-quality tests dated back to 1988 and were performed according to British Columbia's provincial criterion to protect irrigation water supplies. Multiple tests yielded positive results; pH ranged between 7.5-8.6, which fits within the 4.5-9 pH range for irrigation water protection (Swain, 1990). Additionally, all hardness and metal measurement values fell below the BC criterion to protect irrigation water. However, tests considered irrelevant to irrigation were not accounted for. These included nutrient levels, as high levels are viewed as favourable from an irrigation viewpoint. Similarly, dissolved oxygen and oxygen-consuming materials/solids were not tested. Dissolved solids concentration was tested as high concentrations can cause soil salt build-up. Results were unsatisfactory and particular concern was attributed to residual salts from winter roads getting carried into the creek through stormwater.

Bacteriological quality is an important assessment of water bodies as it is an indicator of waterborne disease risk factors for wildlife, pets, and humans (Gebrewahd et al., 2020). Fecal coliform concentrations were tested and made publicly available in 1988 and 2007. Results indicated water quality concerns, and public swimming close to the mouth of Brandt's Creek was closed at the time as a result of the findings ("Cultural Impacts," 2011; Swain, 1990). Other bacteriological indicators were not tested on Brandt's Creek. Around 2014, water quality tests were paid for and performed by a volunteering organization in Kelowna, whose concerning results were provided to the City of Kelowna. However, no following information or course of action followed (Lewis, February 14, 2023).

Currently, then, one key sustainability and resiliency challenge for Kelowna—in the context of Brandt's Creek's hydrology—is the lack of monitoring and verification against environmental policies and guidelines. Past hydrological tests, from water flow rates to salt and nutrient concentrations to bacteriological tests, took place around 1988, with only one water quality test being as recent as 2007. The hydrological monitoring of Brandt's Creek is infrequent and dates to over a decade ago. This inhibits the ability to determine the resiliency of Brandt's Creek because any changes in the creek's chemical or physical properties would not have been traced and are still not being traced. For instance, sediment accumulation from erosion is a common factor that can invisibly increase flood risks and decrease habitat use in the watershed (Lewis, February 14, 2023). Additionally, the hydrology tests selected for assessment were incomprehensive as they were based on irrigation water protection, and therefore other potential environmental impacts or relevance were neglected. This lack of knowledge inhibits researchers' and officials' ability to assess Brandt's Creek's long-term sustainability.

2.5: Biology

Wetlands and riparian habitats are notable hotspots for biodiversity worldwide. Despite many of the challenges Brandt's Creek currently faces, it continues to be an important and

diverse habitat for many plant and animal species of the Okanagan Valley. Brandt's Creek is considered to have no fishing potential (i.e. for rainbow trout or kokanee spawning), compared to Mission Creek, which is a noted kokanee spawning habitat. To date, carp have been the only fish spotted in Brandt's Creek (Swain, 1990; Lewis, February 14, 2023; Donald, February 14, 2023). Other prominent wildlife includes but is not limited to turtles, muskrats, tule, herons, red-winged blackbirds, ospreys, cattails, roses, hawthorns, watercress, Siberian elm, Russian olive, smartweed, European starlings, and beavers (Donald, February 14, 2023). There are several notable non-native invasive species along Brandt's Creek, though it remains ambiguous how harmful or damaging these non-native species are to the creek (Donald, February 14, 2023). For instance, some invasive species have been considered helpful to the surrounding ecosystem of Brandt's Creek by contributing to bird reproduction and providing shade, which increases habitat availability (Donald, February 14, 2023). Nevertheless, understanding the resiliency of the creek requires a thorough comprehension of Brandt's Creek's ecosystem dynamics and interactions.

Figure 2: Cattails and snowberries spotted along Brandt's Creek in 2022 (photos by Madeline Donald).

The City of Kelowna specifically manages a few species along Brandt's Creek. For example, the creek is annually dredged to remove the build-up of watercress (Donald, February 14, 2023). Watercress is a non-native plant to North America that is known for rapidly colonizing

the surface of freshwater ponds and streams, potentially outcompeting native plants and preventing sunlight from reaching lower portions of the pelagic zone and therefore necessitating its periodic removal. Within the city limits of Kelowna, the dredging of aquatic land is not permitted by private individuals. This watercress removal is therefore carried out by the City of Kelowna, which applies for permits under the Water Sustainability Act (City of Kelowna, 2021). Along Weddell Place, a road severely impacted by erosion, the City of Kelowna also maintains metal fencing around the trunk of an individual Siberian elm tree whose root system is integral to the structural integrity of the bank. This metal fencing is believed to be in place to deter beavers from interacting with the tree and endangering the soil's stability (Donald, February 14, 2023).

2.6: Flooding

2.6.1: Overview

As seen in aerial photography of Kelowna's North End (Figure 1), land use around Brandt's Creek has rapidly shifted over the past 85 years (Thibeault, March 14, 2023). While most land abutting the creek along the lower portion of its course is primarily industrial, land use in this area is increasingly becoming residential and recreational. In the case of flooding, what would happen to the infrastructure facilities around the creek? A water treatment facility, power distribution voltage regulators, a baseball stadium, residential structures, new apartments under construction and an unhoused encampment are all concentrated near the creek. What are the potential hazards and impacts for these structures and residents in case of a flooding incident?

Increased climate variability has been having effects on the hydrological cycle all over the world, including increases in both floods and droughts. In British Columbia, one of the effects of climate change that has become increasingly exacerbated in recent years has been prolonged periods of drought (frequently paired with wildfires), followed by periods of intense rainfall. Severe flooding may occur when soils cannot absorb these record rainfall events (Schreier, February 7, 2023). For Kelowna's waterways specifically, the greatest flood risk is

during freshet. Heavy rains during April, May, and June melt snowfall at higher elevations, potentially causing flooding downstream at lower elevations. In Kelowna, the highest flood threat occurs when significant snow cover is followed quickly by a hot spring. Land use changes can also exacerbate flooding scenarios. As urban densification increases, more land is compacted and impervious to water (i.e. increased asphalt and concrete paving). This results in more land incapable of absorbing water, leading to more runoff during flooding events (and potentially increased pollution runoff from parking lots that floodwaters have flowed over as well) (Schreier, February 7, 2023).

While the exact water flow capacity of Brandt's Creek is unknown, the land abutting the section of the creek discussed in this report is almost entirely covered by impermeable material (i.e. roadways, parking lots, etc.). This puts the area at significantly elevated flood risk. Additionally, while at first glance Brandt's Creek may not seem significant in terms of size, it nonetheless plays an important role in the water quality of Okanagan Lake, which may also be negatively impacted by flooding in this area. Water that washes over parking lots will pick up pollutants, and it remains unclear how resilient industrial infrastructures such as the Heidelberg Materials concrete plant are to flooding. Pollution entering floodwaters from these sources would then be transported directly to Okanagan Lake, deteriorating water quality both in the lake and the creek itself.

2.6.2: Flood Challenges

There have always been floods in the Okanagan – a valley born of water and ice. As times change, with changing weather patterns and ways of living, the story of flooding in the Okanagan changes with each generation. It is a story of resilience, regeneration, balance, and community (Okanagan Basin, 2023).

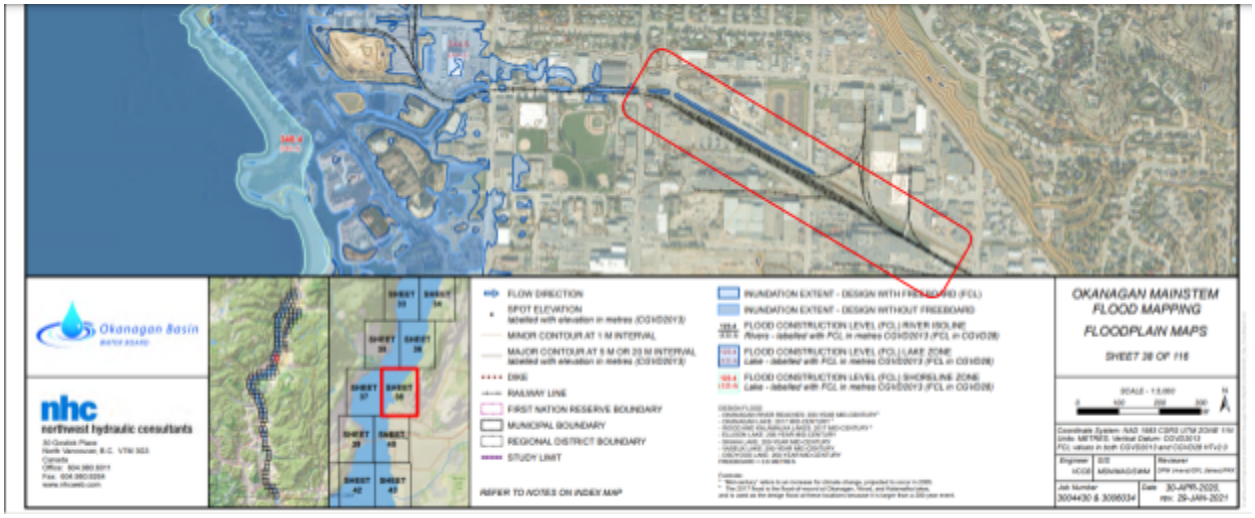

Figure 3. Brandt's Creek flood mapping (Okanagan Basin, 2023a)

Figure 4. Flood in Kelowna, 2017 (KelownaNow, 2017)

Below is a summary of several notable challenges to the stream health of Brandt's Creek that we have observed, followed by potential solutions. This list of challenges is not exhaustive of concerns surrounding Brandt's Creek. Notably, all probability policies in this section need permitting requirements, and their implementation needs to be evaluated.

2.6.2.1 Floodplain Investigation

We have carried out measurements of the distance between the creek and surrounding land for flood risk in the North End industrial area of Kelowna. On the north side of the creek, the mean distance from the creek to the paved road is about 3 meters; and it is 14 meters to the

industrial facilities. To the south, it is about 14 meters to the road and 33 meters to the industrial facilities. As the immediate floodplain area of the creek, these areas should be investigated for safety and resiliency during flood occurrence. Restoring and preserving natural floodplain functions would help reduce the impact of flooding by acting as a natural buffer zone. To maximize this benefit, it is important to preserve and restore riparian areas, which can assist in slowing down and absorbing floodwaters.

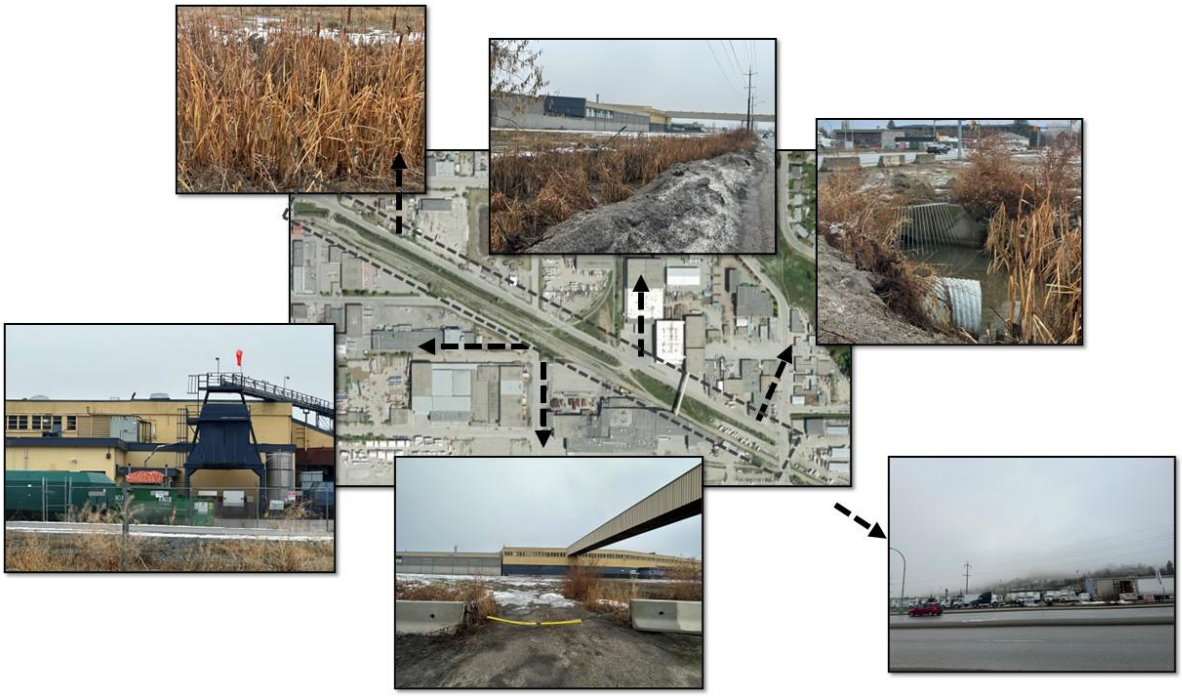

Figure 5: Pictures of land use distances to the Creek.

2.6.2.2: Branches' Impacts on the Creek

There are several different branches to Brandt's Creek. Water flowing from these branches into the creek comes from several different sources, potentially challenging flood control design and implementation. However, the abundance and type of vegetation in a watershed can decrease the likelihood of flooding. Vegetation can influence flood hazard by:

- Reducing the intensity of precipitation, as when rainfall hits multiple layers of leaves and result in smaller drops hitting the ground, thereby protecting the soil
- Creating a layer of organic material above and the soil, which can protect the soil from the direct impact of rain
- Holding soil together with roots
- Absorbing water from the soil, thus increasing soil water storage capacity (World Wildlife Fund, 2016)

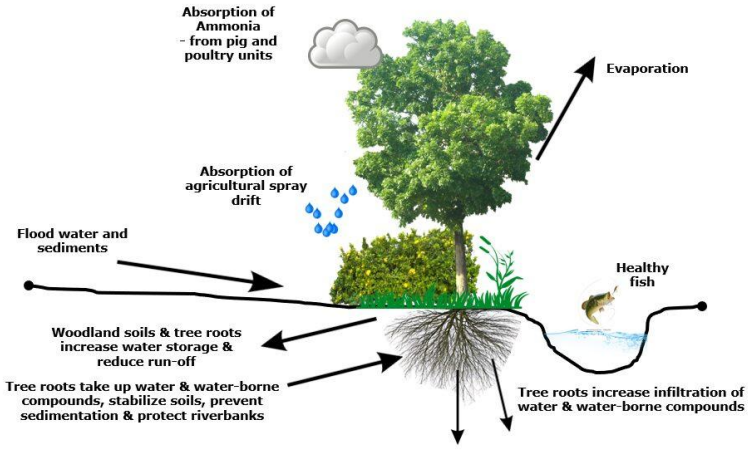

Figure 6: The role of the vegetations in flood management (https://forestrycommission.blog. 2022)

Implementing natural flood control measures, such as planting trees and creating wetlands along these branches, can help slow down and absorb floodwaters before they reach the main creek. This can help reduce the risk of flooding in the area and also provide additional benefits (i.e. wildlife habitats). However, flood risk pertaining to these branches should be studied both as a cohesive system and individually.

2.6.2.3: Channelization

A naturally stable stream channel maintains its dimension, pattern and profile such that the stream does not degrade through erosion; nor does it become overly sedimented. Stable

streams migrate across the landscape slowly over geologic time while maintaining their form and function. Naturally stable streams must be able to transport the sediment load supplied by the watershed. Instability occurs when scouring causes the channel bed to erode (degrade) or excessive deposition causes the channel bed to rise (aggrade). A generalized relationship of stream stability is shown as a schematic drawing in Figure 7. The drawing shows that the product of sediment load and sediment size is proportional to the product of stream slope and discharge—or stream power. A change in any one of these variables causes a rapid physical adjustment in the stream channel (North Carolina stream restoration institute et.al, 2003)

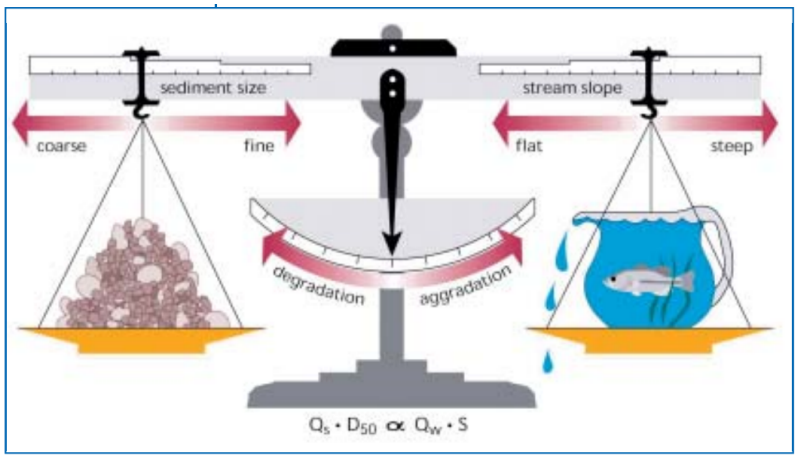

Figure 7: Factors affecting channel degradation and aggradation (North Carolina stream restoration institute et.al, 2003)

Channelization has changed the natural slope of the creek, leading to an increased slope in some sections of the creek. This, in turn, can lead to sedimentation downstream and water-quality deterioration. Naturalizing the creek involves restoring the natural slope and meander of the creek, which can help improve water-quality and reduce sedimentation. This could involve removing or modifying existing infrastructure, such as channels or culverts, to restore the creek's natural flow. Another approach to this issue is developing a sediment and erosion control plan to identify areas of the creek where sediment and erosion are likely to occur

and outline measures that can be taken to prevent these issues. This could include implementing best management practices, such as stabilizing streambanks and reducing the number of impervious surfaces in the area.

2.6.2.4: Bank Stabilization

As discussed in previous sections, vegetation is a riverbank stabilization method. Roots of trees can significantly stabilize the banks from erosion. With Brandt's Creek, many of the trees along the banks have been cut down, leading to increased erosion and decreased banks' stability. Planting native vegetation along the stream can help stabilize the banks from erosion and provide additional benefits, such as habitats for wildlife. Trees, shrubs, and grasses can all be used to help stabilize the banks and improve the overall health of the creek. Additionally, bioengineering techniques, such as using live stakes or brush layers, can help stabilize the banks and promote vegetation growth. These techniques involve using live plant material to anchor the soil and create a foundation for additional vegetation to grow.

Figure 8: Picture showing cut-down trees along Brandt's Creek

2.6.2.5: Impermeable Surfaces

Groundwater permeability along Brandt's Creek is low due to construction and land-use changes in Kelowna. Permeable services lower the watershed's capacity to absorb water, increasing flood risks and impacts.

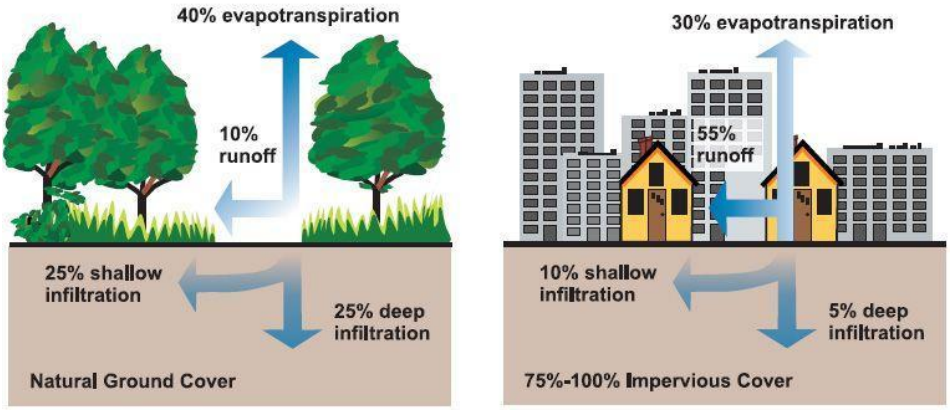

Figure 9: Illustration of relationship between impervious surfaces and surface runoff (U.S. Environmental Protection Agency (EPA). 2003)

Green infrastructure measures, such as vegetated swales, rain gardens, permeable paving, and green roofs, can help absorb and filter stormwater runoff before it enters the creek. These measures can help increase the water permeability of the surrounding land and reduce the impacts of floods.

Figure 10: Low permeability of the creek

2.7: Economy

Economic activity has historically grown along riverbanks, dating back as far as early civilizations in Mesopotamia along the Euphrates and Tigris Rivers and along the Nile in Egypt. This also holds true for smaller rivers and creeks, as flowing water in any volume can provide

essential ecosystem services. Brandt's Creek has many industrial sites along its length and also serves many other purposes, such as recreation.

A 2017 study by the National Recreation and Park Association (NRPA) revealed that when a local government must cut spending, parks and recreation tend to be the service that sees the largest funding cut (NRPA, pp. 22). According to the study, this could be because public officials do not perceive parks and recreation as critical contributors to economic development. In Kelowna, many attempts to hire individual experts to improve the public parks and watersheds like Brandt's Creek were unsuccessful for many reasons, the most prominent of which is the differential institutional architecture of local governance designed for industrial needs. For rehabilitation processes to be successful, the core logic of city governance has to change. Governance designed to generate income today for the needs of tomorrow cannot invest in the park's rehabilitation.

One recent meta-analysis, by Bockarjova, Botzen and Koetse (2020) defined the following characteristics for determining the economic value of parks and park-like spaces: area, GDP, population density, type of protected area, water and general complexity. Parks or protected areas of different sizes receive different treatment, and parks in urban areas with higher average income receive a higher value. As cities get denser, protecting parks and areas that generate water is ever more critical for perceived value. Finally, the more diverse the landscape and the ecosystem services the protected area provides, the higher its value. These common frameworks can be used for cross-geographic analysis to identify the best practices and foundational basis for conservation projects.

The western branch of Brandt's Creek flows into the Linear Park in Glenmore, which is a walking trail that winds through residential areas, and there are a number of parks along the length of the trail (see Section 2.1). It is important to point out that the recreational capacity of any riverbank is essential for its economic well-being (Kauffman et al. 1997). The economic

output of Brandt's Creek must be analyzed in relation to its regenerative capacity as a natural resource. The section of Brandt's Creek that flows through the North End Industrial Area, which is the focus of this report, is essential to understanding the economic reality of the creek and its actual necessity for businesses to be located along it. The underlying goal is to find a possible way for a consensus between improving the environmental situation of Brandt's Creek without significantly harming or diminishing the economic output of the North End—resulting in a win-win scenario for the city council, community, and local businesses. In that regard, it is essential to understand that the global approach to economic activity has significantly changed since the establishment of the North End. Though it has been a common practice in earlier parts of the 20th century, within the last fifty years, industries have realized the detrimental impacts of utilizing creeks as draining channels for waste, stormwater, and industrial runoff, which degrade both the environmental and tourism aspects of waterways (FISCRWG 1998). In order for Brandt's Creek to achieve economic resiliency, the City of Kelowna must continue to develop policies ensuring adequate water-quality in the creek.

In its core, a win-win scenario is not about keeping every party satisfied but reaching the intended outcome offering plausible solutions and alternatives to parties affected by the changes. In the case of Brandt's Creek, the North End Industrial Area will be affected by much coveted changes. It will require first and foremost, a strong political will from the local governance to push for the change despite an expected pushback from the industrial powers. There is no magical formula to win-win scenario, and it typically is a matter of least damage with the highest benefit.

We would argue that it is a more economically viable solution for the City of Kelowna to invest in the recreational economic capacity of Brandt's Creek rather than backing hazardous industries along its banks (i.e. the Heidelberg Materials concrete plant). This approach promotes

social entrepreneurship, provides opportunities to engage in flood mitigation projects, and contributes to local residents' social well-being.

2.8: Community and Culture

2.8.1: Current Opportunities for Community Engagement

The City of Kelowna currently provides opportunities for direct community engagement with Brandt's Creek through their "Adopt-a-Stream" program. Interested "organizations, families, individuals, clubs and community groups" can contact the Parks Office to make at least a two-year commitment to adopt a section of a Kelowna stream, where Brandt's Creek is one of several options. According to the City of Kelowna's website, "[t]he minimum requirements include picking up litter along the stream a minimum of once a year, but preferably twice." The Parks Office provides supplies to facilitate these clean-ups, including garbage bags, gloves, and garbage pickers (City of Kelowna, 2022).

The section of Brandt's Creek that this report specifically addresses is currently adopted by Ray Lewis, who organizes twice-yearly community clean-ups and submits photographs of the work to the city. Lewis reports that different groups of adopters rarely interact or coordinate their efforts, citing difficulties in organizing large groups of people (Lewis, February 14, 2023).

As part of the North End Neighborhood Plan, which seeks to guide growth and development in the neighbourhood where this section of Brandt's Creek is located, the City of Kelowna asked community members to contribute to a map of visions and directives for the North End. Community comments from Spring 2022 about desires for the area over the next two decades include statements like: "This is a great opportunity to restore this stretch of Brandt's Creek and continue the great work tone in Rotary Marsh Park and Sunset Drive Park. Setbacks could be increased (maybe move or get rid of Weddell Place), channelization could be reversed, and native vegetation could be restored. Every creek should be celebrated, not tolerated. [...]," "Naturalize the creek through this zone between Richter and Gordon. Lots of space for this

alongside rail trail. Would create a beautiful corridor vs what it is today, " and "This wide strip of vacant land between the rail trail and creek would be ideal for a community garden, or lots of revegetation/trees" (City of Kelowna, 2023). Based on the responses highlighted on the North End Neighborhood Plan map, it seems clear that the local community has at least some basic knowledge of Brandt's Creek, and that certain members have explicitly stated a desire for a different, more productive relationship with the creek in the future.

Madeline Donald, a PhD candidate at UBC Okanagan, is also currently engaging in a community-based project to deepen the relationships between the people of Kelowna and the many diverse beings of Brandt's Creek. As part of this project, called Riparian Reanimation, Donald is hosting ongoing public giant puppet-making workshops at the Rotary Centre for the Arts in downtown Kelowna. These free workshops began in March 2023 and will run through August 2023, with the puppets (representing diverse beings currently or historically found along Brandt's Creek, including a black bear, cottonwoods, mason bees, cattails, and a beaver) scheduled to make appearances at various Kelowna functions throughout the summer and fall of 2023, flooding the historic floodplain of current-day downtown with their presence (Donald, February 14, 2023). Thus far, there have been around 15-20 participants at each event, some of whom have not interacted with the RCA and/or Brandt's Creek before and some who have. As there have only been three workshops at the time of writing this report, it is too soon to conduct any sort of detailed analysis of participant demographics.

2.8.2: Unhoused Community

As a research team, we also consider it essential to hold space in this report for the community of people who live along Brandt's Creek and are currently experiencing homelessness. We believe that considering this community with intention and care is fundamental to any plan for Brandt's Creek, especially as there is currently a City of Kelowna-approved area along Weddell Place for those experiencing homelessness to camp.

We also, however, acknowledge our limitations in expertise and training when it comes to the question of homelessness, and this is why our report will not directly address the question of the unhoused community by the creek and would urge the City of Kelowna to engage with those who do have the proper expertise and training to facilitate conversations with the unhoused and ensure their voices and desires are also represented in future policy plans for Brandt's Creek.

That said, we believe that our proposed project of water testing will not affect the unhoused community in any negative way. We believe that having data and information regarding water quality is critical before anything can happen at Brandt's Creek. When development becomes possible, we would call upon relevant parties to work with experts (social workers, community groups, and so on) and, most importantly, members of the unhoused community themselves as an urgent part of any plan for the creek. It is also essential to acknowledge that urban green spaces are not only sites for middle-class leisure opportunities; they also act as essential spaces for privacy, survival, and solace for those currently experiencing homelessness (Speer & Goldfischer, 2019). As Speer and Goldfischer point out in their discussion of urban green spaces in the memoirs of unhoused community members,

> [h]omeless writers describe engaging with nature as part of everyday life, rather than as a temporary retreat, and finding solace in the face of domestic violence, eviction, and police surveillance. These central themes—privacy, survival and solace—should be understood as clear manifestations of an alternative and often unseen use value of urban parks.

The City of Kelowna should keep this use of urban green spaces and their values to unhoused communities in mind when considering policy planning for Brandt's Creek, as it is likely providing these essential services (privacy, survival, and solace) to some of the people living along its banks.

Section 3: Existing Policy

3.1: Brandt's Creek: Owners, Stakeholders, Rightsholders

We acknowledge that Brandt's Creek is an important and sacred part of the unceded, ancestral lands of the Syilx Okanagan People; and we affirm that any discussion of who Brandt's Creek "belongs to" must begin there. Today, however, Brandt's Creek falls under the jurisdiction of the City of Kelowna. As a research team, we have found that the question of *who* within the city is responsible and accountable for the Creek is less clear. In the course of this project and from our guest speakers, we have learned that "the City of Kelowna" (as is the case with all other cities) is not a monolith, but rather is made up of many moving parts. We have also identified problems in knowledge mobilization and communication within the city. For example, we were surprised that Mr. Aaron Thibeault, who is responsible for the North End Plan (NEP), did not know about the "2021 City of Kelowna Annual Water and Filtration Deferral Report" (further discussed in Section 8). This is not at all a criticism of Mr. Thibeault, whose contributions to our class were invaluable – but it is rather a reflection of the challenges faced by the city in terms of communication and collaboration. Nonetheless, it is essential for the NEP to consider the long-term health of Brandt's Creek. These problems of knowledge mobilization and communication will be discussed further and in more depth in section 8, where we try to map out some solutions to these challenges.

Moreover, while the City of Kelowna is ultimately responsible for Brandt's Creek, it is also necessarily beholden to other parties with interests in the creek. The stretch of Brandt's Creek in the North End includes the industrial businesses in the area, other businesses such as the breweries, and of course, the local community (more on this below). As the body responsible for the creek, the City of Kelowna's ability to enact policy in relation to Brandt's Creek will be enabled or constrained by its need to consult with other stakeholders and interested parties. However, we do note that there are opportunities for the City of Kelowna. Mr. Thibeault explained that the City can acquire land by establishing zoning and development agreements

when land or property is redeveloped or changes hands (Thibeault, March 14, 2023). This could allow the city to acquire industrial land near the creek for naturalization purposes with the opportunity for daylighting meandering the creek in some places.

In this report, we believe it is vital to distinguish between interested parties, stakeholders and rightsholders. In particular, it is urgent and necessary to mention rightsholders whose voices are often overlooked. This includes, as noted above, the Syilx Okanagan People, and the members of the unhoused community who live along the creek. These communities have important and intimate connections to the creek but are often silenced or ignored. Our position as a research team (as noted in sections 2.2, "Indigenous History" and 2.8.2, "Unhoused Community") is that any proposal for revitalization must engage meaningfully with experts and, above all, with members of these communities themselves, for whom the value of the creek goes far beyond economics.

3.2: Biology Policy

While British Columbia has the greatest biodiversity and most assessed species at risk of any Canadian province, it is also known for having some of the weakest provincial endangered species legislation. British Columbia does not have specific endangered species legislation. Instead, the province relies "on an inadequate patchwork of legislation and resulting policy decisions to manage species at risk" (Westwood et al., 2019).

On a provincial level, the Wildlife Act (1996) does offer some protections to vertebrate animals (except fish), including regulations for hunting and trapping. However, the Wildlife Act does not protect animals from being hunted, killed, or trapped on private property (i.e. many of the industrial and residential privately owned parcels of land abutting Brandt's Creek) (Government of British Columbia, 2023). The City of Kelowna's urban wildlife management rules and responsibilities for residents appear to start and end at "don't feed the wildlife" (City of Kelowna, 2023). In effect, this means that should any species at risk be identified along Brandt's

Creek (whether they are plant or animal), there is currently very little federal, provincial, or municipal legislation to offer them any protections.

3.3: Hydrology Policy

Many federal and provincial water guidelines exist to address waterbodies' sustainability and resiliency. In most of these regulations and policies, Brandt's Creek appears to fall through the cracks of monitoring and environmental management. A renewed Memorandum of Agreement for Water Quantity Surveys—initially signed in 1975 by the federal Minister of Environment and the provincial Minister of Lands, Forests, and Water Resources—acknowledges responsibility for water in British Columbia (Ministry of Environment and Climate Change, 2013). Specifically, the agreement harmonizes water monitoring through efficient hydrometric data collection in the province to develop national hydrological monitoring, aiming to support the sustainability of our environment, economic activities, and public health and safety (Ministry of Environment and Climate Change, 2013). Monitored sites are outlined in this agreement, including Okanagan Lake and Mission Creek in Kelowna (Ministry of Environment and Climate Change, 2013). Brandt's Creek is not on the monitoring list, and the justification for site selection and site re-consideration date is not outlined in the agreement. However, in order to meet the aim of the agreement, re-consideration of site monitoring selection and criteria for selection should be imposed in a timely fashion to recognize problematic, less resilient streams or unknown stream conditions (such as is the case of Brandt's Creek as highlighted in Section 2.4 of this report).

The Water Sustainability Act (WSA) is another policy currently in place, with recent key changes to regulations having been updated in 2016 (Government of British Columbia, 2023). These changes include stronger protection for aquatic ecosystems and expanded protection of groundwater. As mentioned earlier, Brandt's Creek has a significant amount of water outflow and inflow that are unaccounted for (Donald, February 14, 2023). According to WSA's expansion of

groundwater protection, such groundwater outflow and inflow in non-monitored watersheds that could be used by the public (i.e. Brandt's Creek) deserve attention.

In the context of Brandt's Creek, waste discharge is particularly important, considering testing has surpassed regulations in the past, as explained in Section 2.4. Waste discharge agreements are not the only waste flow entering the creek, due to agricultural and industrial runoffs, as well as other non-point discharges and forms of pollution. The Waste Discharge Regulation under the Environmental Management Act (EMA) defines authorized activities and types of waste (Government of British Columbia, 2023a). Per the definition of waste in the EMA, Brandt's Creek is exposed to many types of non-regulated waste that require attention. They include effluent waste from runoff, garbage from nearby unhoused communities, and air contaminants from the Heidelberg Materials concrete plant (Lewis, February 14, 2023). Attempts are being made to solve the input of these wastes, but they have thus far been shown to be inefficient. The municipal-run Adopt-a-Stream volunteer program collects garbage waste twice a year from Brandt's Creek—however, this response is not dealing with the underlying causes of garbage pollution but merely provides a delayed course of action on the matter (Lewis, February 14, 2023). Additionally, carcinogenic air contaminants from cement factories along the southern part of Brandt's Creek have been given a two years window by the City of Kelowna to make changes to come into line with regulations, but after two years, the cement company sold the problematic cement plant to another company (Heidelberg Materials), using the change in ownership to circumvent the mandated changes (Lewis, February 14, 2023). This demonstrates the inefficiencies associated with addressing environmental policies, despite urgent public safety concerns and having Brandt's Creek as a proximal transfer medium for such contaminants.

Policy statements in the form of water quality reference documents are available for use province-wide to help assess water quality (Government of British Columbia, 2023b). The primary purpose of these reference documents is to protect water value, help inform

decision-making, and achieve water quality objectives (Government of British Columbia, 2023b). Although most suggested analytical methods have remained the same for over a decade, most policies have been updated as recently as 2019 and 2021. Policy objectives for water quality are determined based on a priority basis for waterbodies of regional, provincial, interprovincial, international and Indigenous significance (Ministry of Environment and Climate Change Strategy, 2021). Brandt's Creek is the third largest creek in Kelowna, a size which does not make it of "regional significance." However, considering Brandt's Creek feeds into Okanagan Lake, which is of regional significance, more attention should be given to the water quality guidelines policy for the creek. This is particularly important as past water-quality assessments, such as aluminum concentration, dissolved salt and bacteriological testing, have been of concern, as explained in Section 2.4. Additionally, through the partnership between Sun-Rype and the City of Kelowna, hot pipes of liquid used in the nearby Sun-Rype factory are made to cool down by passing through Brandt's Creek's waters, which creates a local warm water environment, a factor that should be assessed against the Water Quality Guidelines for Temperature (Lewis, February 14, 2023; Government of British Columbia, 2023b).

Similarly, an Environmental Flow Needs (EFN) policy for British Columbia is available to offer guidance on stream health. EFN is the volume and pace of water flow needed for proper aquatic ecosystem functioning (eg. habitat and environmental conditions for fish, small invertebrates and microbenthos). This policy would be a valuable aquatic ecosystem indicator and offer guidance for Brant's Creek, considering the creek's low flow rate, as discussed in section 2.4 (Ministry of Environment and Climate Change Strategy, 2023; Swain, 1990).

Section 4: Comparison Case Studies

4.1: Rehabilitation — Baxter Creek (California, USA)

In any work related to environmental rehabilitation, it is essential to research the available best practices from similar cases. For the purpose of this study, where the central importance is given to the factors of sustainability and resilience, one beneficial comparison is with the urban stream restoration projects of Baxter Creek in California, USA. The restoration of this creek involved opening a previously culverted channel (in the case of Brandt's Creek, rehabilitation would involve bringing back to the ground level parts of the creek that have been channelized underground), planting riparian vegetation (in the case of Brandt's Creek, a comparison would be expanding the linear park in Glenmore), and adding in-stream step-pool sequences and sinuosity (Purcell et al. 2002). Though not all of the rehabilitation activities from Baxter Creek can and should be translated to Brandt's Creek, many suggest useful ideas.

In 1992, the El Cerrito City Council in California (the governing municipality of Baxter Creek) determined that it was more economically feasible to open and restore a 70m section of underground culvert in the east end of Poinsett Park than to repair and maintain the culvert over time (Purcell et al. 2002).

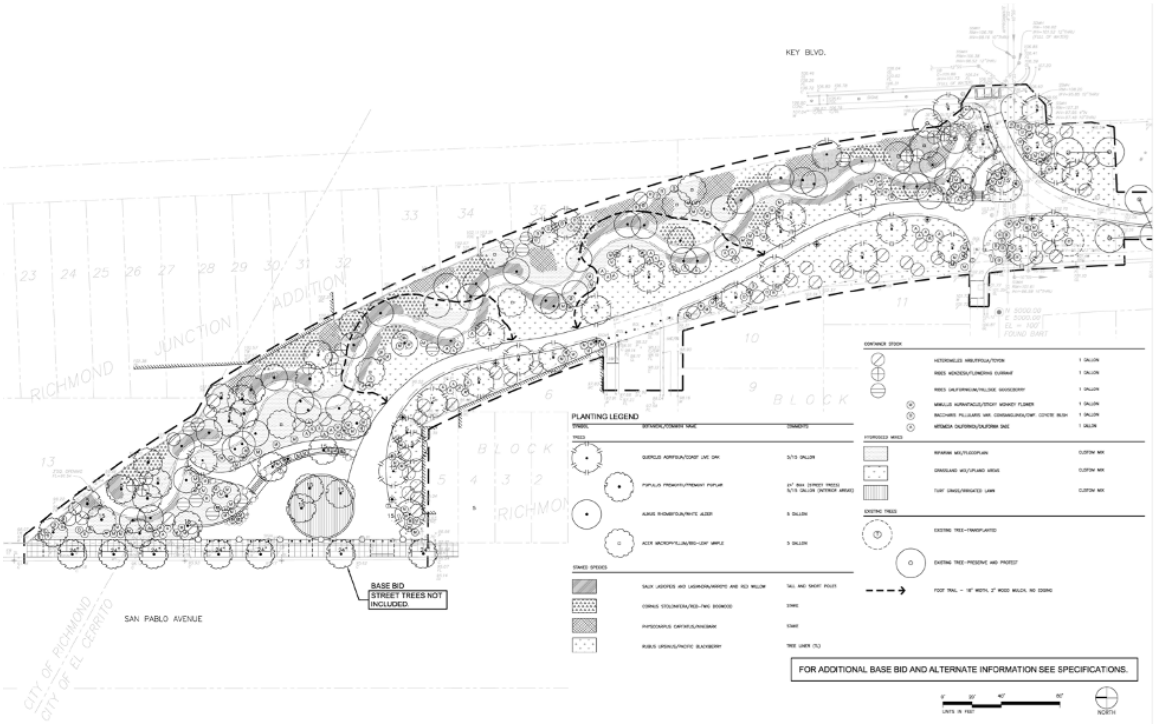

Figure 11: Rehabilitation plans for Baxter Creek (retrieved from Purcell et al., 2002).

In approaching the rehabilitation of this creek, the city council conducted multiple different assessments prior to the start of the project. One of them was assessing habitat quality, which is a critical part of stream monitoring because aquatic fauna often has distinct habitat requirements independent of water quality (Barbour et al. 1996). Furthermore, a biological assessment of the benthic macroinvertebrate assemblage was conducted by collecting a sample at each of the nine sampling areas in the three study sites in July 1999 (Purcell et al. 2002). Such comprehensive assessments on Brandt's Creek would be beneficial.

Restoration of Baxter Creek involved changing a covered waterway to an open one, not just solely improving chemical water quality and the natural vegetation cover of the riparian zone. In actuality, many projects that improve channel conditions are referred to as "restorations," when they are more accurately described by the term "rehabilitation" (defined by Kauffman et al. (1997) as the process of reinstating the use of a land area after natural or anthropogenic disturbances). Based on the biological and habitat assessment results, the

restoration project at Baxter Creek improved habitat and biological conditions significantly compared with those at the unrestored site (Purcell et al. 2002). This rehabilitation evaluation also identifies that involving the residents in the planning process had both positive and negative results (Purcell et al. 2002).

With respect to Brandt's Creek, one of the most important lessons to be learned from the Baxter Creek project is that the rehabilitation of urban creeks has not just environmental value but also significant recreational, social and economic values. Additionally, it is important to re-iterate that comprehensive assessments were carried out prior and used for rehabilitation planning.

4.2: Water Pollution — Mithi Nadi (Mumbai, India)

Water pollution is pervasive worldwide, especially in urban and semi-urban areas. As we try to work with Brandt's Creek, we look at similar cases of water pollution and river degradation in urban and semi-urban areas from different parts of the world. The case of the Mithi Nadi is one such urban waterway that provides valuable examples for this project.

Located in Mumbai, India, the Mithi river stretches for 17.84km from northwest to the west of the city, where it finally meets the Arabian Sea (CWPRS, 2006). The river's hydrology, geography, and overall ecology have changed throughout time, threatening the river's very life.

Figure 12: Pollution along the Mithi Nadi (obtained from Maharashtra Pollution Control board)

The banks of the river are encroached upon by over 1,500 industries, including textiles and dyeing, vehicle washing centers, tanneries, and more than 3,000 illegal establishments which directly dump waste into the water. The channels are clogged, and the river's width is narrowed to 10-15m and a depth of 5.5m by the 80-110 metric tonnes of plastic waste, chemical discharges, concrete and cement debris, mud, and household waste, which had disastrous effects during monsoon seasons (Ravi and Asad, 2006).

Literature (Abdel-Satar et al., 2017) on river pollution often brings up themes of such pollutants, toxic metals impacting the energy flow and production, biomass, density, and diversity. The river's appearance varies throughout its length, and in addition to the sewage, chemicals and plastics, it is also diseased with biological pests, which negatively affect the riparian ecosystem. Also, the mineral content increase in the water due to pollution increases the algal content, leading to eutrophication.

Figure 13: Water quality impacted by bio- pests: Water Lily. (Obtianed from Smart Cities Council

The Mithi River has been abused and treated as a backyard atrocity with its dynamic being severely disrupted by urbanization and change of its natural course. Such modifications result in the eradication of the natural riparian system, the disappearance of aquifers, open spaces for people, and, most importantly, the local extinction of numerous plant and wildlife species that help to balance the environment.

Type	Station Code	Station Name	Apr	Dec/Oct	Average	District	Taluka	Village
SW	2168	Mithi River at near bridge	22	47	42	Mumbai	Bandra	Mahim
Saline	1318	Mahim creek at Mahim Bay	56	72	53	Mumbai	Bandra	Mahim
	2165	Sea Water at Gateway of India	45	57	53	Mumbai	Colaba	Colaba
	2166	Sea Water at Charni Road Choupathy	45	56	54	Mumbai	Mumbai	Girgaon
	2167	Sea Water at Worli Seaface	50	55	55	Mumbai	Worli	Worli
	2169	Sea Water at Versova Beach	49	57	54	Mumbai	Andheri	Versova
	2808	Sea Water at Nariman Point	49	54	54	Mumbai	Colaba	Colaba
	2809	Sea Water at Malabar Hill	46	56	55	Mumbai	Mumbai	Walkeshwar
	2810	Sea Water at Haj Ali	46	54	53	Mumbai	Worli	Worli
	2811	Sea Water at Shivaji Park (Dadar Choupathy)	51	63	54	Mumbai	Dadar	Dadar
	2812	Sea Water at Juhu Beach	49	63	55	Mumbai	Santacruz	Juhugaon

Surface Water		Good to Excellent	Medium to Good	Bad	Bad to Very Bad	Dry	Not collected	No Data
Ground Water	Excellent	Good	Poor	Very Poor	Not suitable for drinking	Dry	Not collected	No Data

Figure 14: Water quality status of Maharashtra 2019–20 (Water Quality Status of Maharashtra 2019–20 [Compilation of Water Quality Data Recorded by MPCB], February 2021)

While the issue has been pervasive, the river has seen municipal intervention only after a major flooding event in 2006, taking 1000 lives and bringing the city to a standstill.

Over the years, the authorities have taken the following steps to remedy the problem: In 2013, 239 industries were asked to shut down as a result of polluting the river. To enforce these demands, 100 of these industrial units were issued closure notices by the Maharashtra Pollution Control Board (MPCB) in 2015, and by 2018, electricity and water supply was disconnected for 200 industrial units which were operating around Mithi. The Mumbai Metropolitan Region Development Authority (MMRDA) is incorporating the process of bioremediation and phytoremediation to improve water quality. Other restorative suggestions include: Desludging the entire river and river beds to clear the decomposing garbage hindering the river flow and municipal intervention to facilitate the treatment of sewage and industrial wastewater (Ranjith and Sherla, 2022).

The river has garnered the attention of various citizen, student and NGO led groups who have undertaken various initiatives to contribute in the capacity they can. The phrase “River as the Soul of the City” has been increasingly used by municipal authorities to encourage people to get involved. Clean-up events on the river banks have been undertaken by various leaders and groups, including the Dawoodi Bohra community and The Jallosh Clean Coasts.

Figure 15: Beach Clean Ups. (Obtained from Hindustan Times August 6, 2021)

Linking this case study to Brandt's Creek, we find that it runs through Kelowna in a similar fashion, both in terms of water pollution and flood risk. Brandt's Creek has been overlooked and used as a source of waste discharge for industries like the Mithi river (see section 2.4). While the cities and waterways vary considerably in terms of size, population density and demographic, the perception of Brandt's creek and lack of attention and care is similar to that of the Mithi river. Additionally, Kelowna has experienced its share of calamities driven by climate change, e.g., the wildfires and drought in 2017 and 2018 due to the record high precipitation followed by extreme heat (City of Kelowna, 2020). The Climate Projections for the Okanagan region 2020 report by the City of Kelowna predicts the increase of such extreme climate events. This brings attention to the need for flood evaluation and hydrological exploration of Brandt's Creek to mitigate potential flood risks. Applying the lessons learned from the Mithi river, restoring the natural course of the river, widening and deepening the creek to allow room for increased volumes of water during swells and monitoring the influx of pollutants from nearby industries to understand the water quality of the creek would be beneficial for Brandt's Creek.

Section 5: Issue of Focus - Hydrology-Based Challenges

5.1: Water Quality

5.1.1: Overview

Streams like Brandt's Creek are valuable resources that support humans, flora, and fauna, as well as contribute to many essential ecosystem services such as leaf litter decomposition and nutrient retention (Helmholtz Centre for Environmental Research - UFZ, 2022; Woznicki et al., 2015). To perform such functions, a stream must be a resilient and sustainable ecosystem—a concept also known as "stream health," which is usually described as requiring no anthropogenic assistance (Kannan et al., 2018). Hydrological conditions and water-quality are two of the most critical factors affecting ecological functions. Changes in hydrological components and physical

and chemical water quality can degrade stream health in several ways, including disrupting biota structure and functions and damaging the resiliency of a water body (Atique & An, 2018). Changes in water-quality, even just a single change, can affect multiple ecosystem services (Keeler et al., 2012). Figure 16 illustrates the different linkages between changes in water quality, changes in ecosystem goods and services, and changes in value. Although some of these linkages between water-quality, ecosystem services and value are beyond the scope of Brandt's Creek (i.e. lake and river fishing, commercial fishing, and boating, etc.), the graphic conveys the interconnectivity of these factors. It is essential to point out that even though a decrease in water-quality affects the ecosystem and societal services and the value of the space negatively, an increase in water-quality can ultimately positively impact the perceived value of Brandt's Creek and its surrounding. Furthermore, as Brandt's Creek connects to Okanagan Lake, the creek's hydrological services and value ultimately flow into the value of Okanagan Lake. Considering Kelowna's tourism industry's connection to Okanagan Lake, it is in the city's best interest to ensure Brandt's Creek's state does not degrade that of Okanagan Lake. Therefore, understanding Brandt's Creek's hydrology and water quality is essential to assessing and comprehending its resiliency, sustainability, and potential influences on Okanagan Lake.

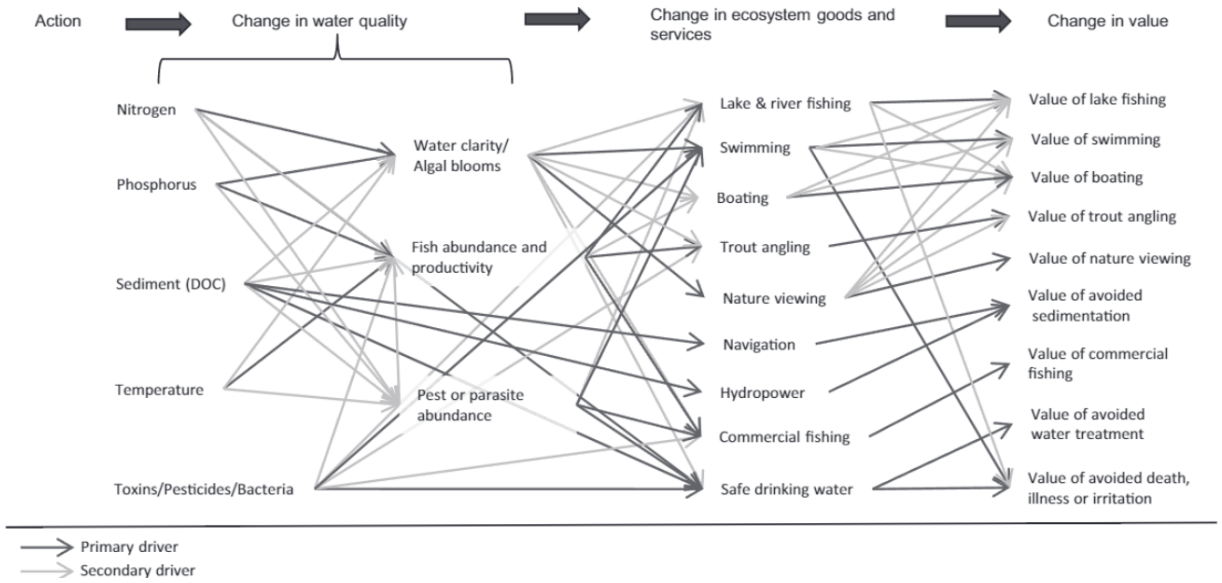

Figure 16: Effects of water quality change on ecosystem services and value (retrieved from Keeler et al., 2012).

Unfortunately, little hydrological and water quality information on Brandt's Creek is known or accessible. As discussed in Section 2.4, most assessments are severely outdated (being at least a few decades old) as well as incomplete, as tests were selected to evaluate irrigation water protection only. In addition, results from these assessments were mostly negative and exceeded test thresholds established at the time. More recent water quality testing had been performed by a volunteer group, whose concerning results did not yield any outcome from the City of Kelowna (Lewis, February 14, 2023). Hence, we do not know the current hydrological and water-quality status of Brandt's Creek, so we have little knowledge of how resilient or sustainable the creek's ecosystem is.

Addressing this knowledge gap is essential for multiple reasons. Understanding the resiliency and sustainability of the creek is important for preserving water as a resource and all its functions, including supporting wildlife, flora, Kelowna's communities, and Kelowna's history. Additionally, Brandt's Creek passes through the entirety of Kelowna and exposes a number of people to its water, from trail walkers and domestic animals, to unhoused

communities, to swimmers of Okanagan Lake. It also poses a flooding risk, as explained in Section 2.6. This high public exposure makes the lack of hydrological and water quality knowledge a safety concern for the environment and population of Kelowna. Lastly, investigating the hydrology and water quality and Brandt's Creeks a fundamental before addressing other creek issues, such as riparian area expansion, water flow, or pavement permeability for flood risk mitigation. Understanding Brandt's Creek's health status and resiliency state first would help support science-based decision-making on what future sustainability interventions should be prioritized.

5.1.2: Proposed Water Quality & Hydrology Monitoring

Recreational water quality testing, nutrient concentration of phosphorus and nitrogen, water flow, and sediment accumulation monitoring are proposed as initial water quality and hydrology investigations for Brandt's Creek. Recreational water quality guidelines provide an understanding of the safety of water from a human health perspective (Health Canada, 2012). These guidelines are intended to guide provincial and regional decision-making in the management of waters (Health Canada, 2012). Recreational water quality testing for secondary contact is also proposed. Under these guidelines, "secondary contact" is defined as activities where limbs are regularly wetted but where greater contact is unusual, i.e. head submergence (Health Canada, 2012). This would suit the primary investigation needs of Brandt's Creek, as body immersion and swallowing of water by humans are likely infrequent (but certainly may occur). Additionally, phosphorus and nitrogen concentration testing is proposed as excess concentrations of these nutrients can lead to eutrophication, severely impacting ecosystems like Brandt's Creek and its resiliency (see also Section 2.5- discussion on watercress implication) (Hwang, 2020). Lastly, water flow and sediment accumulation are essential information for flood risk evaluation and would be useful for future mitigation strategies, as flood risks are increasingly concerning in Kelowna.

Section 6: Literature Review of Place-Based Methods

The following Place-based engagement literature summary outlines the importance, benefits and guiding principles of community engagement and place-based learning for climate action and for nourishing a sustainability mindset. Particularly, we recognize the importance of integrating children and young people into participatory research, which made us consider integrating such groups into our proposed solutions for this project, which is explained further in section 7.

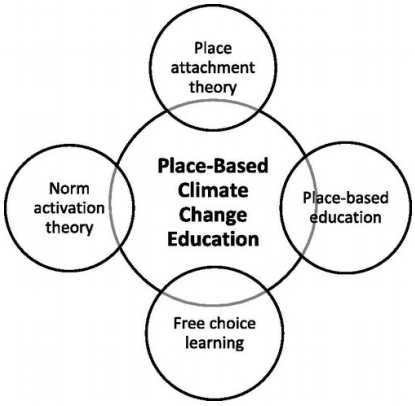

Figure 17: Place-based approaches to climate change education (retrieved from Khadka et al, 2021).

As seen in Figure 17, principles of place attachment theory, place-based education, free-choice learning, and norm activation theory all relate to the power of engaging citizens in action-based learning at physical places, which are also symbolic sites for inspiring political action and learning about climate change impacts (Khadka et al., 2021; Schzeizer et al., 2013). Schzeizer et al.,(2013) talks about engaging a local community by tapping into the power of cultural values and beliefs. Personalisation of initiatives in place-based research methods which incorporate local features and observable impacts have proved to be effective strategies for delivering climate change and sustainability instruction (Khadka et al., 2021). Schweizer et al., 2013; Sobel, 2004 in their studies have further rationalized the use of place- based methods and conclude that it leads to strengthening one's association with the place along with promoting knowledge, awareness, responsibility, and hope. For place-based learning to be effective,

engagement should incorporate: use of local environments and the focus on immediate threats instead of distant ones as it is more relatable.

Additionally, participatory methods are identified to be successful in getting the youth involved in environmental and climate activism (David and Cutter-Mackenzie-Knowles, 2020).The current generation is faced with the blatant use of unsustainable practices by the organizations and system in place and are left to deal with the consequences of the uncontrolled consumption of resources, population growth, waste production, habitat destruction, pollution, and contamination (McNeill and Engelke 2014). Lee (2013) thus recognizes the importance of giving the voice of the youth a platform in climate action and empowering them to contribute to driving change.

Section 7: Proposed Citizen Science Project

7.1: Overview of Citizen Science

Citizen science as a community-based approach was first used in the MIT Technology review three decades ago (Vohland et al., 2021). Any group of people including students, business people, retirees, and others willing to participate in scientific research can contribute (Gildesgame, 2018). Research evaluations of citizen science in ecological restorations from across the United States show that citizen science data can reliably support restoration and habitat improvement projects (Gildesgame, 2018). Citizen science has led thousands of people to engage with science and nature. It has built strong connections between communities and the ecosystems in their backyards. Therefore, it has both strong social and communal values.

The water quality and hydrology of Brandt's Creek are the systems at the core of this report. Collecting scientific data from across the 14km span of the river would be a costly and

time-consuming procedure if done by a single researcher or a small team of researchers. Citizen science is not just a solution to lowering the costs of data collection and hastening the work, but it also plays an important education and social role by increasing the level of engagement of different community members with the rehabilitation of the creek. It also provides opportunities to spark an interest in the creek and its rehabilitation among the very people who live along its banks. Many research examples show that public participation significantly increases the long-term success of a project.

Citizen science is not just a participatory way to contribute to scientific knowledge mobilization, but also an effective way to address a wide collection of societal challenges (Vohland et al., 2021). Citizen science also has a supportive mechanism for the educational processes in promoting hands-on applied science studies. As part of this study, our recommendations include partnerships with the universities that operate in Kelowna, namely the University of British Columbia Okanagan and Okanagan College, as well as local grade schools. Universities are committed to serving the community, and involvement in citizen science to improve the quality of water and overall hydrology of Brandt's Creek fits into that commitment. For grade schools, participation is an opportunity to implement community-based applied science classes and provide children with hands-on experience working with water.

The city council should also be involved by providing conditions for such a community-led cooperation effort, as it is doing the work that belongs to the city council in many ways. As a result, such a project would ideally represent an exemplary democratic implementation of sustainable initiatives. Citizen science would foster an open and participatory approach to science, reducing the distance between science and society, and contributing to the goal of an inclusive society (Vohland et al., 2021). This would also allow for broader and potentially more efficient dissemination of knowledge regarding Brandt's Creek among interested parties.

7.2: Proposed involvement from the University of British Columbia Okanagan

We have identified three water-quality tests that we believe tertiary students at the University of British Columbia Okanagan would be well suited to conduct. These tests include *E. coli, cyanobacteria,* and turbidity testing, as we have determined these aspects to be essential to developing an initial understanding of the stream health of Brandt's Creek. For more detailed information about these testing processes, please see Appendix A. We have ensured that the tests are feasible, valuable and above all safe for a citizen science project.

UBCO has a Biology program in the Bachelor of Science (BSc), which includes courses such as Freshwater Microbiology and Environmental Biology, where such tests could be appropriately integrated into the laboratory components of these courses (University of British Columbia Okanagan, 2023). Furthermore, our proposal provides opportunities for engagement across disciplines and faculties at UBCO. The Bachelor of Sustainability, which attracts students from various disciplinary backgrounds, requires its students to engage in community work – and our proposed project would fulfil this requirement. We believe, then, that our project would create connections across the BSc and Bachelor of Sustainability at UBCO; and we are sure there would be ways to involve other faculties). Students would also benefit from doing local, place-based work with concrete outcomes that support the city of Kelowna and its community (see the benefits of engaging in place-based environmental education efforts in Section 6). Our research confirms that tests are at a level suitable for these students and within the university's capacity.

Notably, UBC also provides funding opportunities for such community-engaged research at both its Okanagan and Vancouver campuses. UBC offers the Community-University Engagement Support (CUES) Fund that "awards up to $25,000 to support community-university partnerships that benefit communities across the province and advance collaborative research,

teaching, and learning" (UBC Vancouver). The CUES Fund reinforces the feasibility and value of our proposed project.

7.4: Proposed Grade 5 Student Involvement

Assuming initial fecal coliform tests (*E. Coli*) come back negative, we propose that Brandt's Creek provides an excellent opportunity to involve local grade 5 children in collecting further observations of the creek via an ongoing collaborative citizen science project. This could provide multiple opportunities for interaction between different groups at UBCO (Education students; Sustainability students; Community Engagement, Social Change, and Equity (CESCE) students, etc.) and the larger Kelowna community in order to share knowledge and collect stories about Brandt's Creek that could be used in future planning projects and sustainability policy development for this ecosystem.

More specifically, we propose that these younger students could assist in regular monitoring of water temperature, water flow, pH, and observations of species in residence along Brandt's Creek. These observations would help create a more thorough and consistent set of data on Brandt's Creek that would then be useful in developing further municipal policies, as well as giving community members a greater sense of care and responsibility for the creek. For grade school students, this project could also provide valuable opportunities for them to collaborate with scientists, graduate students, and city officials and better understand how the sustainability policies that impact their homes are designed and implemented.

Bankhead Elementary School is located right along Brandt's Creek, just east of Gordon Drive, and this project may be of particular interest to students and teachers there. If interested, testing may also be done by students on school property. This report contains several pages of a prototype "Brandt's Creek Journal" lesson plan/activity book that could be disseminated to teachers interested in working this citizen science project into their curriculum, which are available in Appendix B. Selected pages from this sort of journal could also be distributed to

breweries/restaurants along Brandt's Creek as a kind of activity book for children out to dinner with parents/guardians to encourage families to explore Brandt's Creek and think more about their relationship with it while they are visiting the North End.

Section 8: A Parallel Priority Issue — Information Flows

8.1: Change in State of Knowledge

Our research group set out to propose water quality testing to fill gaps in our knowledge about the health of Brandt's Creek. Our guiding principle was that this is a fundamental step in approaching the sustainability and resiliency of the creek—that mobilizing data and knowledge about the water quality should be a guiding factor in any future policy proposals regarding the creek. The class presentations this term convinced us that this was a vital and urgent step for an overlooked body of water. Inflows and outflows of the water were mysterious, as were the possible contaminants, which included concrete and dust; stormwater; and refuse and waste.

However, in the final stage of writing this report we discovered that the City of Kelowna is in fact, testing the water of Brandt's Creek. The details of this program can be found under the section "2021 Annual Drinking Water and Filtration Deferral Report" from the 2021 City of Kelowna Annual Water and Filtration Deferral Report (Hope, 2022). Section 8.2 first describes the findings of that report. Then, Section 8.3 will discuss its implications for our own proposal, specifically highlighting the way that the discovery of the report discloses challenges of knowledge mobilization and policy collaboration.

8.2: "2021 City of Kelowna Annual Water and Filtration Deferral Report"

8.2.1: Key Findings

- The City of Kelowna conducts regular monitoring at the mouth of Brandt's Creek in Rotary Marsh Wetland on Sunset Drive. Weather permitting, this happens 5 times per month.

- Samples are taken at two other sites, but only for first flush (initial surface runoff of a rainstorm) or rain events of 7mm or more. These two sites include a 750mm outfall pipe located on Gordon Drive and Weddell Place.
- The tests are comprehensive and include: ammonia, chloride, true color, conductivity, dissolved oxygen, *E. coli*, pH, total suspended solids, temperature, and turbidity.
- The results of these tests are compared to the following guidelines:
    - British Columbia Aquatic Water Quality Guidelines (BCAWQG)
    - Canadian Drinking Water Quality guidelines (CDWQG) Aesthetic Objectives (AO)
    - Canadian Council of the Ministry of Environment (CCME)
    - Guidelines for Canadian Recreational Water Quality (GCRWQ)

8.2.2: Overview of Results

While some of the results in the report fall within the limits of federal and provincial guidelines for water quality, much of the data indicates that Brandt's Creek is in poor health and reveal the pressing need for a sustainability and resiliency intervention (Hope 2022). Appendix C of the report contains graphs which presents some of these test results. Of particular concern are the following water quality indicators:

- **Colour**: Brandt's Creek "Apparent Colour Monthly Averages" range between 45 and 100 Pt-Co Units. The Guidelines for Canadian Recreational Water Quality (GCRWQ) limit is under ~20 Pt-Co Units. The colour of creeks is related to water flow and erosion; less waterflow and more erosion means the presence of more decomposing organic matter in the water. This leads to a dark brown appearance and the reduction in water clarity.
- **Dissolved Oxygen:** The concentration levels of dissolved oxygen in Brandt's Creek from January to the end of March were above the upper range limit according to the Canadian

Council of the Ministry of Environment (CCME). According to the report, these concentration levels can have a detrimental effect on aquatic life.

- ***E. coli*:** For the entirety of 2021, *E. coli* concentrations were well above the upper limit in the Guidelines for Canadian Recreational Water Quality (GCRWQ). The highest concentration reached 32 times higher than GCRWQ. Furthermore, the report included a graph with *E. coli* concentration between 2015 and 2021, displaying an upward trend from ~1000 (MPN/100ml) in 2015 to ~1400 (MPN/100ml) in 2021.
- **Turbidity:** Turbidity levels for the whole of 2021 were higher than Canadian Drinking Water Quality guidelines (CDWQG) Aesthetic Objectives (AO). The annual range was 10-50 times higher than the guidelines.
- **Phosphate**: The monthly phosphate concentration for Brandt's Creek ranges between ~0.06 to ~0.18 mg/l. According to the British Columbia Approved Water Quality Guideline (BCAWQG), phosphate concentrations above 0.05 mg/l for more than 6 months of the year puts a waterbody at risk of accelerated eutrophication, which applies to Brandt's Creek according to the concentration results. As detailed earlier in our report, eutrophication has devastating consequences for stream health and relieincy (see section 2.4), and high posphate concentrations can also trigger rapid watercress growth, which is already a problem to Brandt's creek as discussed in section 2.5.

8.3: Implications of the Report

8.3.1: Overview

This report explains (68) that "[t]urbidity and bacterial trends are noted and communicated to the respective utility groups to allow for operational adjustments or investigate possible storm-sanitary interconnect contamination" (Hope, 2022). While we are sure that this information is used in important ways, our research team believes that there is space for the knowledge of these trends to be mobilized to greater effect, which is elaborated upon in more

detail in the following subsection. We are concerned that Mr. Aaron Thibeault, Planner Specialist of the North End Plan for the City of Kelowna, and Mr. Ray Lewis, President of the Kelowna Downtown Knox Mountain (KDKM) Neighbourhood Association, did not seem to know about these tests—this is not a criticism of these two (and indeed none of the presenters mentioned it over the course of the term), but rather we believe this indicates a failure to mobilize and distribute information properly. Similarly, in our research we did not come across this information as it is not clear that the document would include this information for Brandt's Creek. The search queries to find this information were not intuitive, which is a barrier to making this information accessible to residents, the general public, and other concerned parties looking for information on the stream health and safety of Brandt's Creek.

Nonetheless, our team is heartened that the City of Kelowna is undertaking these tests that disclose important information about the water. This was the motivation behind our original project pitch. The testing, as stated above, shows that Brandt's Creek is suffering, and poor stream health does not support a thriving ecosystem—let alone a resilient one. Certainly, actions that can be done to improve the water quality and hydrology are context dependent and more research is needed to identify the sources of these negative test results. However, this data does provide important information that reveals some of the contaminants that are going into the water—and this may give clues as to the ultimate culprits of this contamination. Our team believes that the crucial next step is the mobilization of this information, for which potential pathways are elaborated upon below.

It is also important to note that the results of this report may potentially have a negative impact on the tourism industry of Kelowna, one of the main profit-generating areas in Okanagan. Efforts must be made to carefully approach the policy-making process so it compliments the tourism sector by promoting Kelowna as a city of regenerative and sustainable tourism that

prioritizes ecological well-being. Results of the report reveal necessary research data that should be used to improve the situation..

8.3.2: Stakeholders, Rightholders, and Interested Parties in Knowledge Mobilization

Our expert speakers' lack of awareness of the "2021 Annual Drinking Water and Filtration Deferral Report" reveals communication flow challenges regarding Brandt's Creek (Hope, 2022). Like this report, other information on Brandt's Creek may be known by some interested parties and wished to be known by others. Even though the water-quality test results are of high environmental and public safety concern, to the extent of our knowledge no public dissemination or actions are being taken to address water quality issues. This points again to Brandt's Creek's knowledge mobilization and policy collaboration challenges. Communication difficulties are, therefore, another fundamental sustainability issue, as they represent a barrier to any other sustainability and resiliency interventions for Brandt's Creek. To address this parallel issue of focus in this report, we identified a subset of interested parties, stakeholders and rightsholders of Brandt's Creek, as illustrated in Figure 18 below. Potential known information and information of interests pertaining to these groups are summarized below:

- *Syilx People.* Brandt's Creek (and the entirety of Kelowna) is located on the ancestral and unceded land of the Syilx People. In future policy for Brandt's Creek, it is essential to both understand and acknowledge that the creek holds its current shape as part of the ongoing legacies of colonialism in British Columbia. It is also vital that non-Indigenous policy makers respect and include Syilx knowledge about relationships between various different beings residing in and around the creek and Syilx interests in policy changes regarding the creek.
- *City of Kelowna.* Municipal officials working for the City of Kelowna in various different offices interact with Brandt's Creek in different ways. These officials include people like

Aaron Thibeault, who is working on the North End Neighborhood Plan, as well as employees at the Parks Office (running the Adopt-a-Stream program), City Services employees (compiling reports such as the "Annual Water and Filtration Deferral Report"), and city council members (who's residents may come to with requests and/or complaints regarding creek management policies). Efficient information flow between these departments is essential to creating policy for Brandt's Creek (i.e. the Parks Office should know about dangerous levels of *E. coli* from City Services, City Services should know from the North End Neighborhood Plan team what services residents need, etc). Municipal officials must also effectively and transparently disseminate testing and policy knowledge about creek health to the public.

- *North End residents.* Individuals and families living in the North End need to know whether or not the water quality in Brandt's Creek is safe (especially those with small children who may intentionally or accidentally play in the water). They also need to know about specific flood risks posed by Brandt's Creek and flood mitigation efforts. Residents may also have important local knowledge from regular observations of the creek about stream health challenges that they should be able to easily communicate to responsible city officials.
- *Unhoused community.* The unhoused community living along Brandt's Creek may also have important local knowledge from regular observations of the creek about stream health challenges, as well as knowledge about what important services/value the creek provides to those in the area experiencing homelessness. As the people regularly living in the closest proximity to the creek, they should also be kept well informed about the quality of the water and potential flood risks to ensure it does not pose additional challenges to their wellbeing.

- *UBC Okanagan academics (students and professors).* Several groups of academics at UBCO are involved in policy regarding Brandt's Creek, including both graduate students in this course as well as students and professors involved in Dr. Greg Garrard's ongoing Kelownafornia project. These students and professors have access to expert knowledge on many fields impacting Brandt's Creek, including but not limited to: biology, microbiology, economics, sustainability, community engagement, urban planning, etc.
- *Rail Trail users.* The paved bike path running alongside Brandt's Creek is regularly used by cyclists, pedestrians, and dog walkers. While we have not spoken with frequent users of the Rail Trail as part of this course, we imagine that the needs of this group include a safe and reliable transportation corridor. This requires good bank stabilization, proper flood mitigation projects, good local air quality (i.e. no dust particulate matter from concrete plant), etc.
- *Local businesses.* Specific local businesses would know best about their specific needs as they relate to Brandt's Creek. While we have not spoken with representatives from any of these businesses as part of this course, we hypothesize some of the needs and desires of some of the prominent businesses along the creek below.
    - *Breweries.* There are numerous local microbreweries along Brandt's Creek (including Railside Brewing, Rustic Reel Brewing Company, Jackknife Brewing, Red Bird Brewing, etc.). We imagine that these breweries would benefit from having a well-cared-for green space around Brandt's Creek, inviting patrons to spend more time walking or wheeling around the North End, discovering new businesses and enjoying dinner and drinks with a good view of a healthy creek.
    - *Gneiss Climbing Gym.* Many patrons bike to the climbing gym located directly south of Brandt's Creek. These patrons would also benefit from sustainable, resilient Rail Trail infrastructure.

    - *SunRype.* Historically, SunRype has been one of the potential sources of pollution for Brandt's Creek. Though they likely do not wish to disclose this information to the public, they should know what materials from their industry are making their way into the creek. It is essential for city officials to communicate with SunRype about potential points of pollution.
    - *Heidelberg Materials.* The concrete plant located directly north of Brandt's Creek has recently changed ownership in order to evade regulations on pollution of the waterway. City officials should more strictly investigate and regulate pollution from this industry, especially as it has negative effects not only on the creek but also on North End residents (both housed and unhoused).
- *Bankhead Elementary School.* Especially because the school directly abuts the creek, it is essential that the school be provided with updated, accurate information about the water quality of the creek. While we have not talked with school employees as part of this class, we imagine that they would also have a vested interest in having a safe, resilient green space in their backyard to benefit student health and learning.
- *Tourism Kelowna Society.* Kelowna's tourism industry should also have an interest in Brandt's Creek, as it empties into Okanagan Lake and pollution to the creek will ultimately find its way to one of the Okanagan's largest tourist attractions. The breweries near Brandt's Creek are also a large tourist destination for dinner and drinks, and having a more resilient creek ecosystem and surrounding green space would encourage visitors to spend more time in the North End supporting local businesses.
- *Sports Teams.* Sports teams that use the facilities along Recreation Ave (directly south of Brandt's Creek and built above the racecourse that may have initiated channelization of the creek in the 1930s) may not interact with the creek directly in their practices, but

coaches seeking to foster team building among players may be interested in opportunities to contribute to creek clean up activities.

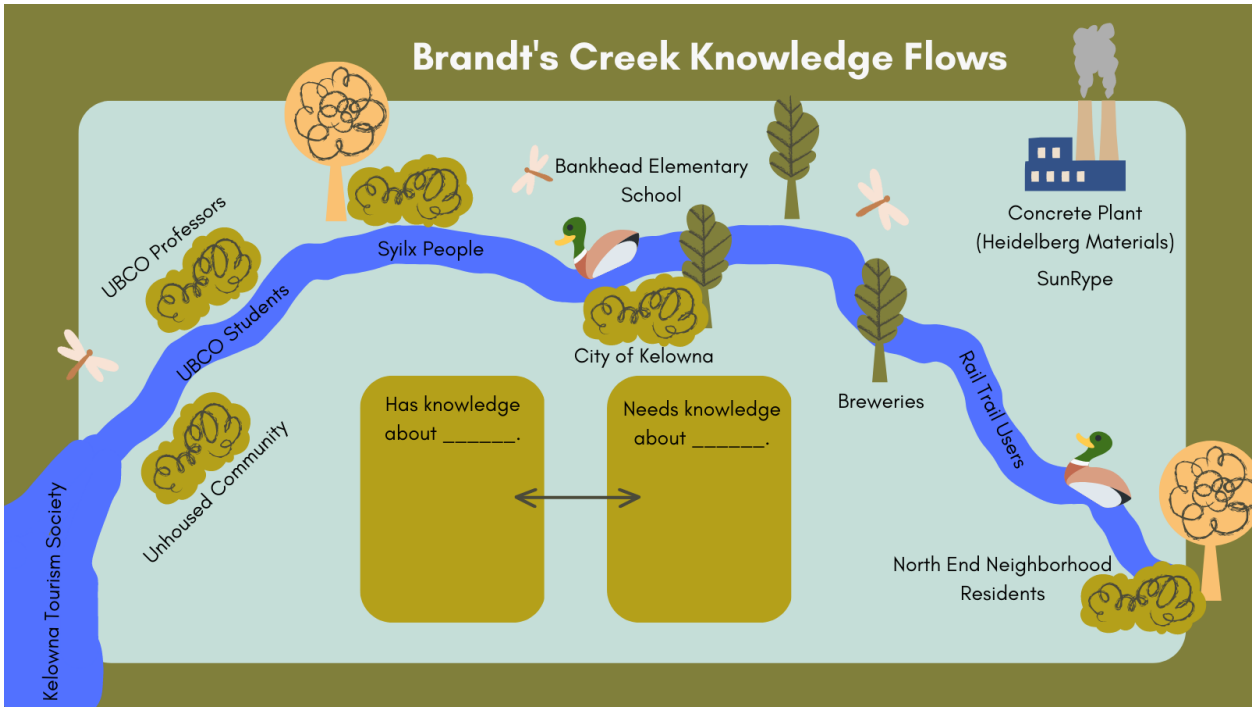

Figure 18: Interactive knowledge mobilization map for Brandt's Creek policy. Stakeholders discussed above are identified along the outline of the creek. This could be a helpful tool for the beginning of a communications plan between interested creek parties.

We propose an interactive and collaborative website as a potential starting point to improve communication pathways, dissemination, and cooperation between the different interest groups of Brandt's Creek. The main component of the website would include an interactive information request exchange between interested parties, stakeholders and rightsholders. This exchange would function by requesting a "Needs knowledge about____" (see Figure 18) to the interested groups, who could then respond to the information request. Additionally, to display updates and new information to other interested groups, a function "Has knowledge about____" could be shared (see Figure 18). This idea is in a preliminary stage due to our lack of website-making expertise between our interdisciplinary team and the time-constraint tied to this report. We suggest further research and work on Brandt's Creek to focus on communication

pathway solutions, like the one described above, along with incorporating communication research tools such as social network analysis. We also propose that in-person methods of communication about Brandt's Creek water quality could be an important method of knowledge mobilization. Water quality sign boards (similar to the forest fire risk signs used throughout the Okanagan Valley) could be posted at critical points along the creek where areas of interaction are highest (i.e. near unhoused encampment and schools) to make the public aware of potential risks associated with poor stream health. These sign boards could also house findings from citizen science projects as a point of communication with the public.

Section 9: Conclusion

In this report, our group has shown that Brandt's Creek, and specifically the section of the creek that is our focus in the North End of Kelowna, is a complex system that poses unique challenges for sustainable policy interventions. In addition to the clear problems posed by the modifications (specifically concrete channelisation) made to the creek, we have identified a lack of information regarding the water quality in the creek system (Parrott, January 31, 2023). But moreover, other urgent challenges included a lack of representation and input from the local Syilx People and the unhoused community, as well as an overall lack of concern from relevant authorities.

In response, we have settled on proposing a program of water testing, affirming that this is a fundamental step to fill knowledge gaps regarding the sustainability and resiliency of Brandt's Creek. In this report, we have posited a framework that defines sustainability as the creek's ability to sustain itself both as an independent riparian ecosystem, and as an active agent in a much larger system, which includes the rest of the creek; the surrounding human communities; and the businesses and industries around the creek.

Resilience, meanwhile, is understood in this report as the ability of the creek to support the complex system described above—and in this report, it was our hope to make

recommendations that will improve the water quality of the creek and thus the health of the overall system. We connected our water testing recommendations to a program of citizen science in order to engage different groups in the local community of Kelowna. We have sought to show that this will make knowledge and engagement with Brandt's Creek more inclusive and diverse, and how it will foster feelings of intimacy and care for the creek.

However, in the course of our research, we also identified an urgent parallel issue of focus—communication gaps between interested parties, stakeholders, and rightsholders that pose a significant challenge to knowledge mobilisation. We realised that water testing is being done, but that this information is not being shared or activated in ways that support the creek and its system. And even more urgently, this water testing shows that Brandt's Creek is a very real and serious health risk for the local community, most specifically the unhoused community living along the creek. In response, then, we formulated and proposed a communication pathway map, "Brandt's Creek Knowledge Flows',' which we believe could become an interactive, collaborative website that would facilitate communication, cooperation and knowledge mobilisation to protect the creek.

In this report, then, we have addressed multiple flows of the complex system that is Brandt's Creek. We have proposed solutions to knowledge gaps regarding the creek's water quality. At the same time, we have sought to fill a gap in care flowing between the people of Kelowna and the creek, and we have proposed a program of citizen science, at the core of which is young people, whose future is intimately tied up with sustainability. Our group has also addressed the important and wicked challenge of knowledge and information flows regarding the creek. How can relevant actors with a say in the creek's future communicate and cooperate? And just as (or maybe even more) importantly, how can the voices of those who are often overlooked,

specifically the Indigenous and unhoused community, be elevated and amplified? We believe that this is an essential, urgent and ethical challenge for the City of Kelowna. Our "Brandt's Creek Knowledge Flows" map and website proposal is intended to intervene in this problem of knowledge mobilisation, and to make any future policies for the creek as inclusive and comprehensive as possible. It has been humbling and moving to do this work; and it is our hope as a research team that our report will make a difference to the sustainability and resilience of Brandt's Creek, an important and living part of the complex, fragile system that sustains us all.

Appendix A: Essential Water Quality Tests

A.1: *E. coli*

Our report first proposes a method to test for the presence and quantity of *Escherichia coli* bacteria in Brandt's Creek. We suggest utilizing Method 1103.1 as it outlined by the United States Environmental Protection Agency (EPA); a comprehensive document of the method can be found in the references below (United States Environmental Protection Agency, 2010). The EPA recommends this test to measure the quality of fresh water in connection to recreational use and the risk of getting sick when swimming (EPA, 2010). *E coli*, according to the Centers for Disease Control and Prevention (CDC), is commonly found "in the environment, foods, and intestines of people and animals … Some kinds of *E. coli* can cause diarrhea, while others cause urinary tract infections, respiratory illness and pneumonia, and other illnesses (CDC, 2022). Method 1103.1 quantifies the number of bacteria using a membrane filter. The EPA describes the test process as follows (2010):

> A water sample is filtered through the membrane which retains the bacteria. After filtration, the membrane is placed on a selective and differential medium … Following incubation, the filter is transferred to a filter pad saturated with urea substrate. After 15 minutes, yellow, yellow-green, or yellow-brown colonies are counted with the aid of fluorescent lamps and a magnifying lens.

As a research team, we would recommend this method as it is extremely logistically viable. According to the EPA's outline, above all the method requires "the normal safety procedures required in a microbiology laboratory" (2010). The EPA also describes how to collect, handle, and store samples. The equipment, supplies and facilities necessary for the method are all found in a standard university laboratory. Taking all of this into account, we believe that this method would be well suited and safe for students at the University of British Columbia Okanagan to

undertake in cooperation with the City of Kelowna. In brief, this test is necessary to assess whether water is safe for recreational use, and for the health and safety of the public. The *Guidelines for Canadian Recreational Water Quality* (Third Edition) outlines the requirements for water to be considered safe for recreational use, and furthermore "recommends the adoption of a preventive risk management strategy that focuses on the identification and control of water quality hazards" (Health Canada, 2021).

A.2: *Cyanobacteria*

The second test for Brandt's Creek that our report recommends is to evaluate the levels of cyanobacteria (blue-green algae). In support of our recommendation, we draw on the Government of Canada's "Guidelines for Canadian Recreational Water Quality – Cyanobacteria and Their Toxins" (2022); and the British Columbia provincial government's "Decision Protocol for Assessing and Managing Cyanobacteria; Toxins in B.C. Drinking Water and Recreational Water" (2018). Cyanobacteria grow naturally in water bodies, but can develop into detrimental cyanoblooms. Moreover, some cyanobacteria produce cyanotoxins which, during a bloom event, can create concentrations of toxins that can be harmful to humans (British Columbia, pp. 2). According to the BC provincial guidelines,

> [a] risk management approach that focuses on the identification and control of water quality hazards and their associated risks before the point of contact with the recreational water use represents the best strategy for the protection of public health (pp. 2).

We believe that this aligns with and supports our proposed plan for water testing of Brandt's Creek.

To test for cyanobacteria, we suggest following the method put forward in the "Decision Protocol for Assessing and Managing Cyanobacteria; Toxins in B.C. Drinking Water and Recreational Water" by the Ministry of Health in British Columbia. This method involves first

screening for blooms by examining nitrogen and phosphorus concentration in the water, as well as visually checking for bloom formation (pp. 10). If the levels of nitrogen and phosphorus are above a certain level (658µg/L and 26µg/L respectively, or in a N:P ratio of <23), or if visual tests indicate a bloom, then it is necessary to sample raw water using a portable field kit (pp. 11). If this sample indicates the presence of toxins, then this needs to be indicated to the local and relevant health authority (pp. 12).

We would also propose this method because by testing for nitrogen and phosphorus, we will also be able to identify the creek's risk of eutrophication which, according to the United States National Oceanic and Atmospheric Administration (NOAA), occurs when water bodies become overloaded with excessive levels of nutrients, which can "lead to algal blooms and low-oxygen (hypoxic) waters that can kill fish and seagrass and reduce essential fish habitats" (NOAA, 2023). This also contributes to blooms of harmful invasive species currently found in Brandt's Creek (i.e. watercress).

A.3: *Turbidity*

The final test that our group proposes here is for turbidity levels. For this, we draw on the Canadian Government document "Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Turbidity" (2012). According to the document, "[t]urbidity is a measure of the relative clarity or cloudiness of water," which is ascertained through the "scattering and absorbing effect that suspended particles have on light" (pp. 1). Turbidity can be used "as an indicator of the effectiveness of drinking water treatment processes […] in the removal of potential microbial pathogens" (pp. 2). As a team, we believe this test is important because it will provide valuable information on the waterbody and the system of Brandt's Creek (pp. 7). According to the Turbidity Guidelines, testing for turbidity "provides key information for on-going health protection," (pp. 7). Turbidity can be measured in "nephelometric turbidity units (NTU)" with a turbidimeter device. "Guidelines for Canadian Drinking Water Quality: Guideline

Technical Document – Turbidity" outlines a number of applicable methods for the measurement of turbidity (pp. 11, 14).

Appendix B: Citizen Science Journal Prototypes

Included in this section are four example pages of possible prototypes for a citizen science journal aimed at grade school children (in or around 5th grade). Of course these pages are only prototypes, and should be edited to support specific course curricula if a local school district is interested in using them. Further instruction is required in some areas of observation, and of course students should not be collecting these observations unless accompanied by an adult.

Get Creative!

There are lots of ways to write about the things you observe in nature! For a fun challenge, try using your observations to write one of the prompts below:

A poem about what or who you found along Brandt's Creek today.

A conversation between two plants along the creek.

Do you see any animal tracks? Write a short story about the animals that might have made them.

Grab this booklet, a pencil, some weather-appropriate clothes, and head outside. Find a comfortable, quiet place to observe the creek in your neighborhood. What can you see? Hear? Smell? Feel? What's different about this spot that you haven't seen elsewhere in Kelowna? Write down your observations in the space below. Or draw them!

Temperature

Why do we measure water temperature?

Have you even been outside on a really hot day? How does it feel? Now imagine you're a being (like a fish or a cattail) that spends its life in the water. The water in Brandt's Creek won't get as hot as the air in downtown Kelowna during a heat wave, but it still might be uncomfortable for some of the creek regulars who are used to cooler temperatures!

But what actually happens when a stream gets too warm? Well, warmer water can hold less oxygen in it—which the fish need to breathe as much as you do! Warmer water in streams can also cause plants and soils to release more of other types of *nutrients* (the substances in food that help living things grow). And while that might sound like a good thing, sometimes having too many of a certain kind of nutrients isn't the best thing for plants and animals. Like if you've ever eaten too much dessert and had a stomachache afterward.

So it's important to monitor water temperature in Brandt's Creek so we know if it's healthy for the plants and animals living there!

Steps to Measure Water Temperature:

1. **Submerge** thermometer 2/3rds of the way underwater near the center of the creek.
2. **Hold** thermometer in water for at least **1 minute**.
3. **Remove** thermometer from water and quickly **record** date and temperature in the chart below.

Date	Temp.

Date	Temp.

Water Flow

Steps to Measure Water Flow:

1. With your stopwatch ready, **throw** your buoyant object upstream of your first marker.
2. **Start timing** when your object passes your first marker. **Stop timing** when it passes the second marker. Record time in the table below.
3. **Repeat** Steps 1-2 three times. Take the average of the three times and **record** it in the table below.
4. **Divide** your average of the three times by the distance from your first marker to your second marker. This is the *surface velocity* of the creek, or how fast the water is moving along the surface of the creek.

Materials Needed:

- tape measure
- stopwatch
- 3 *buoyant* objects (things that float) —sticks work great for this!
- 2 markers for the bank (like a wooden stake or a rock)
- clothes/shoes you don't mind getting wet!

Date	1st Throw (sec)	2nd Throw (sec)	3rd Throw (sec)	Avg. Throw (sec)	Surface Velocity (m/s)

Water pH

Steps to Measure Water pH:

1. **Fill** a cup with about 2 inches of water from the creek.
2. **Turn on** the pH meter. **Swirl** it one or two times in the cup, then **place** it in the cup.
3. **Record** the pH in the table below.

Date	pH

What is pH?

pH is a measurement of how *acidic* or *basic* a substance is. It is measured on a scale of 0 to 14. Pure water is a 7.0, a substance that is neither acidic nor basic, but water in creeks, streams, or rivers likely won't have a pH of 7.0.

The lower a substance's pH is (the closer to 0). the more acidic it is. The higher a substance's pH is (the closer to 14), the more basic it is.

Here are some examples of the pH of substances you might have encountered recently:

Stomach acid — 2.0
Lemon juice — 2.4
Vinegar — 3.0
Orange or apple juice — 3.5
Milk — 6.6
Pure water 7.0
Blood — 7.35 - 7.45
Sea water — 8.0
Hand soap — 9.0 - 10.0
Bleach — 12.3

Appendix C: Water-quality results from the "2021 City of Kelowna Annual Water and Filtration Deferral Report"

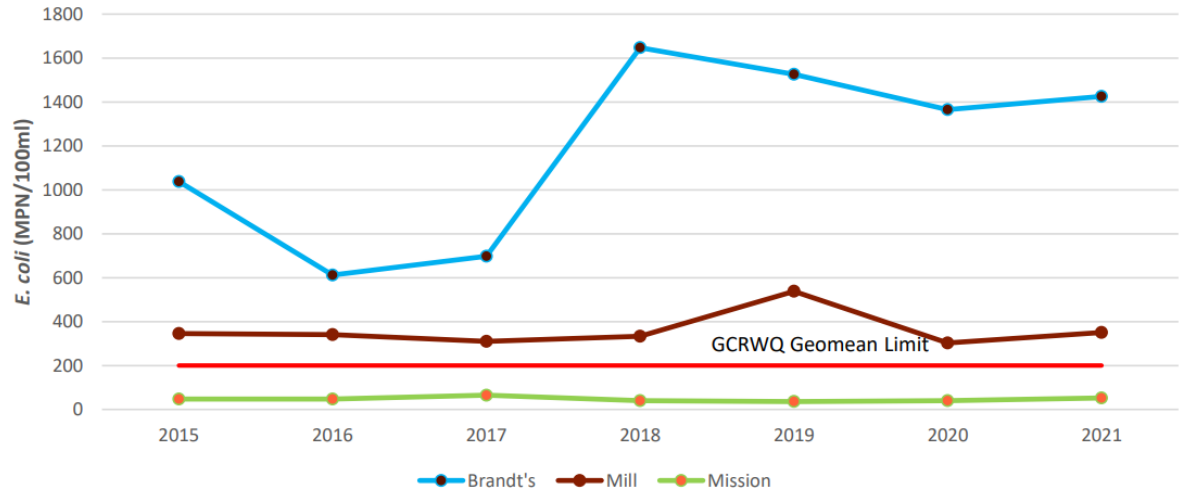

Figure 19.1: Annual concentration of E.coli (MPN/100ml) in Brandt's, Mill and Mission Creek. Red horizontal line represent the limit suggested in Guidelines for Canadian Recreational Water Quality. Figure obtained from Hope, 2022.

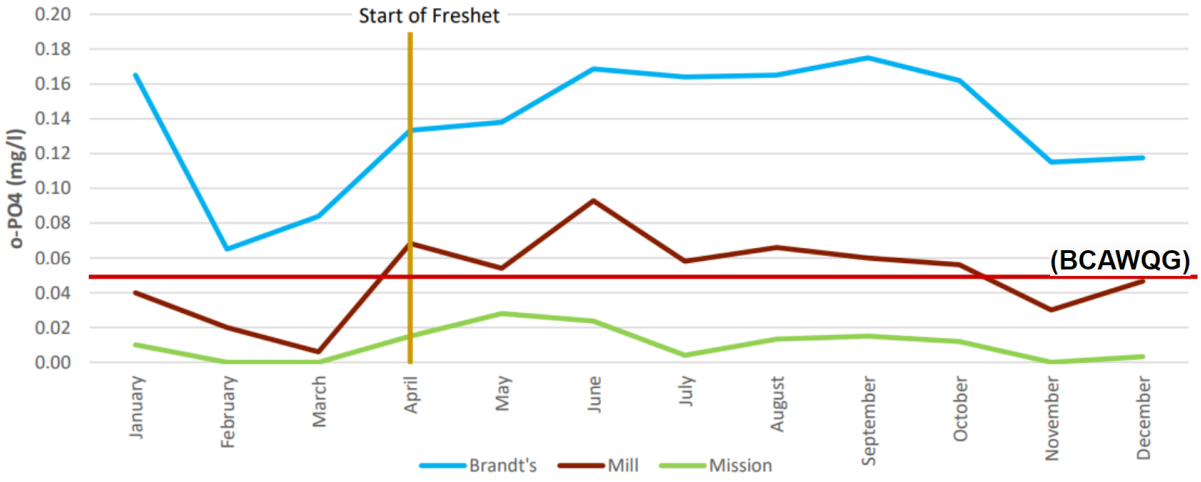

Figure 19.2: Monthly concentration of E.coli (MPN/100ml) for 2021 in Brandt's, Mill and Mission Creek. Red horizontal line represent the limit suggested in British Columbia Aquatic Water Quality Guidelines (inserted by the authors of this report). Figure obtained from Hope, 2022.

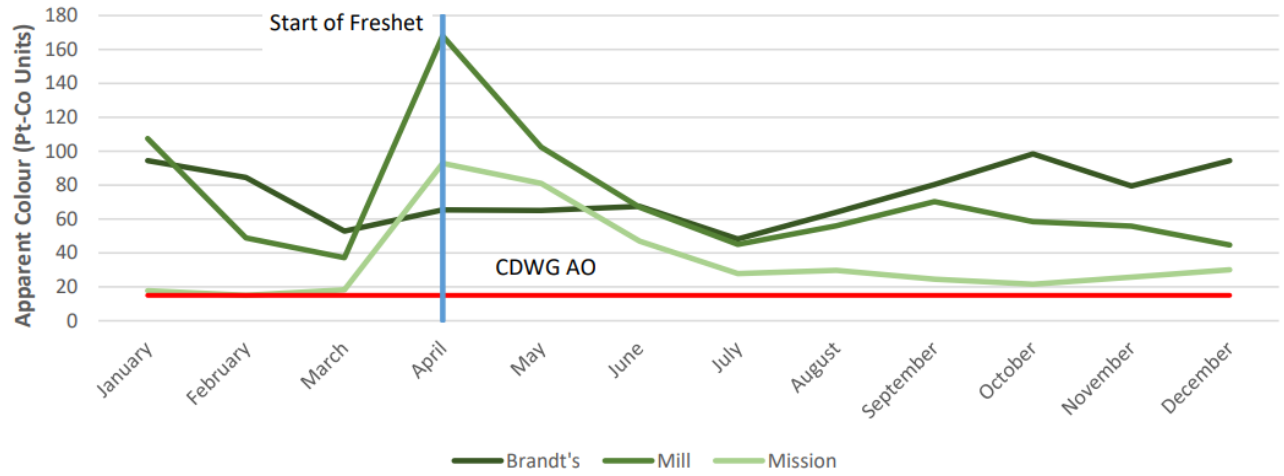

Figure 19.3: Monthly apparent colour (Pt-Co Units) for 2021 in Brandt's, Mill and Mission Creek. Red horizontal line represent the limit suggested in Canadian Drinking Water Quality guidelines Aesthetic Objectives. Figure obtained from Hope, 2022.

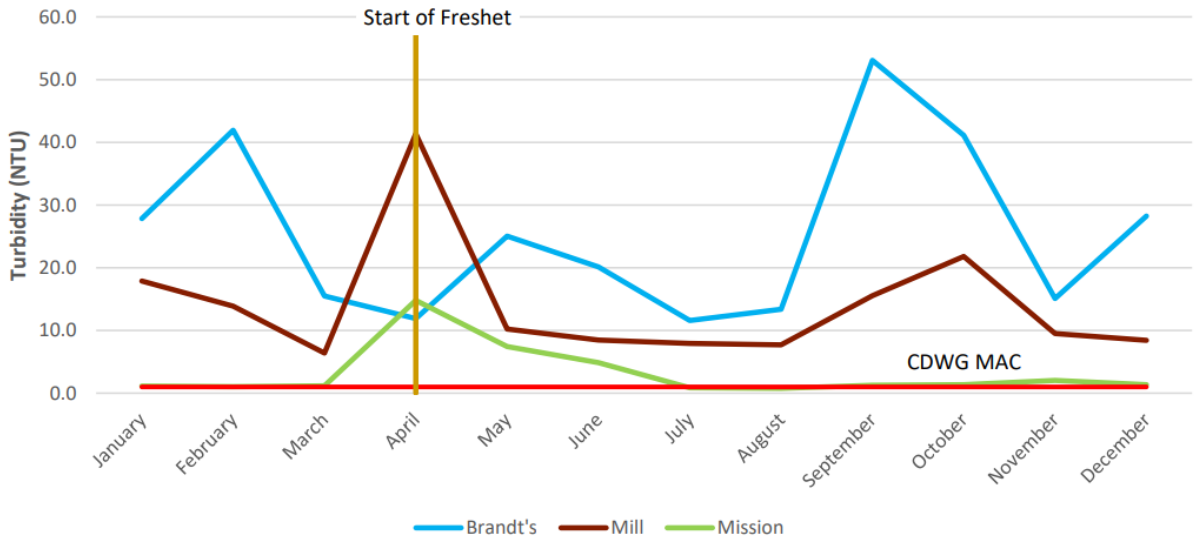

Figure 19.4: Monthly turbidity (NTU) for 2021 in Brandt's, Mill and Mission Creek. Red horizontal line represent the maximum acceptable concentration suggested in Canadian Drinking Water Quality guidelines. Figure obtained from Hope, 2022.

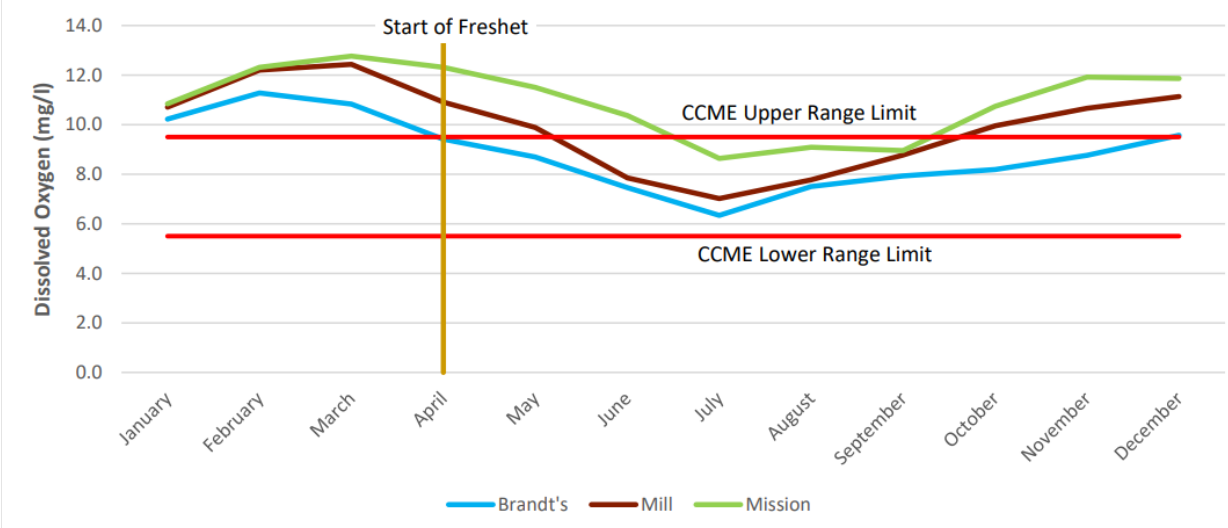

Figure 19.5: Monthly dissolved oxygen concentration (mg/l) for 2021 in Brandt's, Mill and Mission Creek. Red horizontal lines represent the upper and lower range limit suggested by the Canadian Council of the Ministry of Environment. Figure obtained from Hope, 2022.

Appendix D: Reflections

D.1: Reflections

Anjali Desai

Looking back at the experience working on this exploratory group project on the Brandt's Creek over the last few months, I would say that it has been a very enriching experience. Being a part of an interdisciplinary program and such a diverse community here at UBCO has enabled me to introspect and channelize my thoughts to form viewpoints while helping me understand the interdependencies of factors that we usually tend to evaluate in silos. The multiplicity of viewpoints, academic backgrounds and lived experiences makes it a perfect ground for engaging discussions in class. This project provided an opportunity to conduct a place-based study and also gain an understanding of the city as a newcomer. Embedding components of climate and sustainability in the curriculum remains to be the most effective method of increasing the knowledge of sustainable practices by allowing us to practically approach a real world problem.

Speaking of the project process, ensuring proper planning by laying out the basic structure of the report, democratically sharing the responsibilities, and having an empathetic approach towards each other helped us to efficiently work on the report. The guest lectures introduced us to a variety of climate mitigation and adaptation strategies, new sources of data and an account of the past and ongoing initiatives surrounding the creek helped us progress on the learning curve.

With the project now coming to an end, I am excited to have been able to come up with an in-depth report on the topic. Being a part of the City of Kelowna Youth Climate Working group, I am looking forward to seeing the developments on the Brandt's Creek by the City of Kelowna in the near future.

Annie Furman

I came to this project perhaps having interacted with Brandt's Creek more than the average UBCO graduate student, as I've been working as a research assistant on Dr. Greg Garrard's Kelownafornia project since Fall 2022. Particularly, I was recruited by Madeline Donald (cited multiple times throughout this report) to bring my performance background to her Riparian Reanimation project focusing on the revitalization of Brandt's Creek. That said, I was still very intrigued to take this course and look at Brandt's Creek from many more different perspectives, especially knowing how difficult it had been to find easily accessible public information pertaining to the creek.

I'm thankful to so many of the speakers who took the time to talk to our class—especially Dr. Lael Parrott, Dr. Hans Schreier, Madeline Donald, and Aaron Thibeault. This is the first IGS course I've taken, and it's been such a valuable learning experience to hear from experts in so many different fields. It's almost impossible to synthesize everything we've learned over the course of this term down to one paper. This project has also been a wonderful opportunity to

learn from fellow graduate students in different disciplines, and I'm so impressed and thankful for the variety of program and background experience everyone in this group has brought to this report, from literary studies to life cycle assessments and so many points in between.

It's really hammered home for me this term that in order to know anything about Brandt's Creek, you really have to know a little bit of everything. And when it comes to figuring out how to mobilize that knowledge, it's essential to remember that it's not just people from one field or background who are going to come looking for it. Even though it feels like we've just started to scratch the surface, I'm proud of what our group has accomplished through our collaboration and intrigued to see what's next for Brandt's Creek. I hope that there are those in the Kelowna community who find this report useful in thinking about approaches to Brandt's Creek.

Ilyas Kanybek

Our group is currently completing a project report together on Brandt's creek, and I wanted to reflect on my experience working with my team. Overall, I think we worked very well together as a team. We all had different strengths and were able to contribute our unique skills to the project. Communication was perhaps a key factor in our success, and we made sure to check in with each other regularly to ensure we were all on the same page. In my personal opinion it was also very beneficial that we knew each other before the group project started. We already went through breaking ice between each other and had warm ties with each other. In that sense we already had some foundation.

One area where we particularly were successful is with time management. We had a deadline, and thanks to my group mates being incredibly mature and responsible, I was pushed to complete tasks on time. As a student we have many deadlines and I think group projects often struggle from not meeting these deadlines, but in the case of our team it was the other way around, a true example. In the future, I think this experience would be helpful for me to

efficiently detail the timeline and allocate specific tasks to ensure we stay on track because now I am more experienced.

Effective cooperation and mutual support are key components of a successful team. When team members work together towards a common goal in a supportive manner, they are better able to leverage each other's strengths and compensate for each other's weaknesses. This leads to better overall outcomes and a more positive team dynamic. In that sense our group work was indeed a success and social and personal communication lesson.

Overall, I am proud of what we accomplished as a team. We were able to come together and create something we are all proud of. I think we learned a lot from this experience, and I am excited to see what we can accomplish in future projects. I also hope this project report will be useful to the City of Kelowna and other interested stakeholders in Okanagan.

Thomas Letcher-Nicholls

I am truly proud of the work that our group has done for this project on Brandt's Creek; and I am so excited by the outcome! I am also thoroughly impressed by what the other group has achieved, and thankful for their feedback and engagement during class discussion and workshopping sessions. I would also like to express my gratitude for all the expert guests who put in a lot of work and dedication into their presentations.

At the beginning of this course, I felt like I had a good grasp of classmates' and group members' understandings of the concept of sustainability – at least from those of my classmates and friends who are in the IGS: Sustainability theme. But I feel very lucky to have learned more about different understandings of sustainability from students in other themes such as Community Engagement, Social Change, and Equity. This was such an essential part of this project, and brought an urgent, thoughtful and deeply moving attention to vulnerable communities.

"Resilience", on the other hand, was a concept to which I had not given much thought – and I am thankful for all the presenters' different understandings of the concept; Dr. Lael Parrot's definition of the concept has seemed to be particularly compelling for everyone in the class. In relation to this concept, I found our class discussions of the distinction between "restoration" and "rehabilitation" very valuable; while the former may be desirable in some cases, rehabilitation is perhaps more inclusive and progressive in some ways: it is about caring for the resilience of a place while taking into account all of the subjects (human and nonhuman) for whom these places are important.

I have learned so much from my classmates and group members. Everyone has brought their own expertise and perspectives, including science, politics, and art – and this project would never have happened without the interaction between these fields and disciplines. I have also been humbled and moved by the way that my group members have much expertise that goes beyond their own disciplines; they have shown me how science can attend with care to the different needs and power distributions of stakeholders, interested groups, and rightsholders; or how art can be deeply engaged with communities on a local level.

Maybe the most moving way this project has shaped my approach to scholarship, sustainability and resilience has been related to the day-to-day, hard work of research. My background is in literary studies, and this can sometimes feel quite divorced from the "real world" – but I have been thoroughly grateful for the way that this project and my team members have engaged with the daily challenges and lived experiences that come with sustainability and resilience in a time of climate crisis and breakdown. Brandt's Creek is not a natural landmark or park like Yosemite, but it is an important agent in Kelowna with meaning for many different communities and groups – the Syilx Okanagan People, those experiencing homelessness, businesses and families. This project has helped me work through the process of *how* to do

interdisciplinary work in a way that can help make this place (even just a little) better -- and more inclusive, resilient, and sustainable.

Hoda Pourpirali

When I registered for the IGS 585 course titled Knowledge Mobilization and Sustainability Policy, I never knew that I would experience such a vibrant and exciting course. Our class included a diverse range of students and researchers who are exploring the concept of sustainability in a wide variety of fields. It was such a unique experience for me. Inviting lecturers with different backgrounds and approaches was great and I was fascinated to see how they all had one thing in common, sustainability. Many of the concepts were new to us and made me even more curious to read and learn more about them. I am very grateful for the way the class was conducted.

Our class project entitled "Sustainability Policies for the Brandt's Creek" was one of the most unique experiences this class had for me. My group mates in different academic fields from biology to art and literature and so on, each of which enlightened me with new approaches and perspectives of sustainability. I really appreciate the way the group worked together in different departments. Our team was able to handle the project like a full-fledged professional team. Timings and at the same time flexibility, face-to-face and online meetings, exchanging opinions, summarizing and decision makings, patience, and mutual understanding, all were valuable. I really believe that we grew together in this project, both scientifically and professionally.

Another thing to think about in this project is that working on the Brandt's Creek project was a great preparation for us to know how to manage our work when we are faced with a lack of documented information about the topic. One of our basic challenges in this group work was very limited access to documented and reliable information, which we were able to overcome by working together.

Another point that makes this class experience valuable is that the same project was defined for another group. This allowed us to see how two groups, with a specific issue, coped with the sense of difficulties. The other group's work was also very admirable, and I was very eager to see how they would proceed with this work, what ideas they would come up with and how they would present them.

I believe that this class has made us much more aware and prepared than before participating in two aspects. Firstly, we heard from experts and professors about the scientific dimension and various aspects of sustainability. Secondly, work ethics and how to cooperate with each other in groups, especially in a project that had challenges such as time and limited access to information.

Leandra Vanbaelinghem

As we started this project, I was apprehensive about working on Brandt's Creek because it had so little publicly available information. With my science background, I have always heavily relied on the literature, even for place-based research, so the thought of little access to foundational knowledge was new to me. While it was challenging, I was amazed at how our report developed and how many ideas everyone came up with. Brandt's Creek's current sustainability struggle made me understand what real-world challenges for action would look like and how lack of information, communication, clear sense of responsibilities and ownership and feeling relatively powerless are common sustainability barriers. Hence, I learned about knowledge mobilization and its impact on sustainability through experiencing this project, especially when we came across the water report, which was a steep learning curve.

Another aspect of this project that has helped me grow as a sustainability scholar was being exposed to the social factor of sustainability. I am grateful that I was able to work with such a diverse team that helped me understand better some areas of considerations in

sustainability that were still new to me. This applied to not only information from different disciplines, like economics and urban planning but also the skills, way of thinking and epistemic cultures involved. An example of this was the social aspect of sustainability in our system's approach, where we had to consider the influences and impacts of different communities. Specifically, I learned from my group members how to speak of various communities, acknowledge our place, and create space for these communities. I can walk away from this project, having truly grown as an interdisciplinary sustainability scholar because of my group members' insights.

It was also interesting to observe the different reliance on objectivity and subjectivity stemming from our group's diverse backgrounds. For example, when discussing communication pathways and what we should say about different interested groups of Brandt's Creek, we were conflicted about mentioning theoretical wishes and interests. Some of us thought it would not be okay to include groups and ideas we had not heard of and that we should keep this report purely objective. On the other hand, some of us thought it would be acceptable to do so to spark moving pieces of an idea. I felt some discomfort conforming to an opposing view, but it is part of growing in an interdisciplinary team, and accepting the differences in epistemic cultures. I learned that, ultimately, there is no single right way other than to clearly explain the limits and boundaries of our outputs and choose what is most beneficial to the intended audience.

Observing my group's and the other group's approach to this project made me reflect on how one of the main difficulties of addressing complex issues like sustainability is trying to comprehend how to determine where to start and where actions should be prioritized. Tools and analyses may help determine hotspots, but could there ever be two interdisciplinary sustainability team experts coming to the same conclusion and solutions? Probably not, which is beautiful but also restless in my systematic mind- yet to grow some more.

D.2: Reflections on Reflections

Anjali Desai

The similarity in the themes of the reflections posted by my group mates proves the consensus we have had through the project process of working on this report. Annie brings up an important point of having multidisciplinary knowledge on the subject to come up with a viable solution and the diversity in our group lived up to the requirement. Ilyas very well captures time management as a key strength of our group which helped us process the report in a timely manner. I agree with Hoda when she points out that it was a learning experience to work with a limited set of information and knowledge constraints.

Thomas brings our attention to an important point of focusing our attention on the sustainability of our local environment and initiatives not just being restricted to popular parks. Each of these local features play an important role like how Bradnt's creek has a potential to be a storm water collector in event of floods.The diversity in our backgrounds was accompanied by a significant difference in reliance on objectivity and subjectivity of various aspects of the project as highlighted by Leandra. The multiplicity of voices made it interesting to brainstorm and analyze the problem at hand from various lens which eventually led us to creating an in-dept and holistic report.

I am really grateful for the opportunity of working on a collaborative group project and thank the group for the continued support and understanding.

Annie Furman

I agree with much of what my groupmates have said in their reflections, and just wanted to take a moment to highlight a couple things in particular that resonated with me. From Anjali's reflection, the importance of learning from solving real world problems (instead of a situation fabricated for academic purposes) reminded me of how much more inspiring it is to work on a project that has the potential for immediate translation into our current community, and where we

might actually see some sort of progress over the rest of our time at UBCO. As Ilyas said, communication really is the key to a successful project in any discipline, but especially in an interdisciplinary project where we had to learn how to communicate between group members of so many different backgrounds. Trying to go through our final report and edit everyone's communication style into one cohesive whole was certainly one of the challenges of this project for me! I'd like to echo Tom's thanks for the other group's valuable feedback, as well as his distinction between "restoration" and "rehabilitation"—both words that I have been increasingly conscious of when and how I use after working with Brandt's Creek. I agree with Hoda as well that it was very interesting seeing how our two different groups in this class each handled the same issue. The different reports and recommendations our groups came up with were strong reminders about how much policy recommendations are shaped by the different backgrounds and expertises of the people involved in creating them. Even more reason to bring as many diverse voices as possible onto sustainability and resiliency projects! And finally, I really enjoyed what Leandra noted about the lessons she (and I think all of us) learned about social sustainability from working in our interdisciplinary group setting. I certainly learned a lot from my fellow groupmates over the course of this term and this project, and I'm grateful we all had the opportunity to collaborate together on the common ground of Brandt's Creek.

Ilyas Kanybek

I totally agree with my group mates that this project has truly been a learning experience for all of us. Anjali has rightly pointed out that not just our group but our class and the cohort and program in general are very diverse and interdisciplinary. We all come from different perspectives and backgrounds which makes communication with each other a novel experience but as Leandra pointed out we learnt the ways of knowledge mobilization in sustainability.

I believe we also learnt to do it on a topic that as Leandra said has little publicity. I agree that it was particularly difficult for us to have very little secondary data on the Brandts Creek and

here I should point out a great help of Annie's former knowledge and experience in relation to Brandts Creek. She correctly pointed out that she knows more than an average UBCO Graduate Student. I guess this was a good experience in a sense that we are used to working with secondary data a lot but here we had to go and seek out a lot of primary data from our guest speakers and walk around the Creek. In many ways this is important for people in graduate studies to learn to engage with primary data.

I also agree with Leandra that communicating, working together and getting to know group mates better. I learnt how different people see the same project, how their backgrounds shape this understanding. I learnt from Tom for instance the importance of being aware of indigenous peoples and their special and important role in studying not only the Brandts creek but the greater Okanagan in general. In that sense I think it is important and valuable to engage with people who are different from your typical professional and academic circle and get to see how others see the world.

Overall I was very lucky to have such a great group of people with excellent teamwork skills. People from very different backgrounds yet so special and valuable knowledge. In that sense interdisciplinary can indeed produce a great work.

Thomas Letcher-Nicholls

It was really wonderful to read these reflections; like the rest of the group, I am thankful for everyone's dedication, cooperation and hard work! One thing that we all shared in our reflections is the hope that this work will make a real difference here. I feel really grateful to have been in a team that was so invested in the work to improve the sustainability and resilience of Brandt's Creek, and I also hope very much that something of the work that both our groups in this course will one day contribute to sustainability interventions in Kelowna.

Specifically, I resonated with Anjali's reflection that it has been important and enriching

to do place-based work as a newcomer to Kelowna; I have really appreciated the opportunity to do work that engages intimately with the place where we live and work, and visiting the Sncewips Heritage Museum is one the highlights of my time at UBCO as a whole. I think this work has really helped me to learn about Kelowna and the Okanagan; and it has been important and moving to think about connections to the creek from First Nations groups and the unhoused community, which might go overlooked. I have been incredibly grateful for Annie's knowledge of Brandt's Creek and the riparian restoration project happening there, and I cannot wait to see that work come to fruition! I am energised by the way that Annie's art practice is so engaged with the community. I also share Ilyas and Hoda's reflections on the importance of teamwork, communication, and time management – and like Hoda, I am really proud of the way that our team overcame the challenges of the limited amount of information Brandt's Creek. And finally, I was really moved and humbled by Leandra's reflections on social sustainability and the differences in our disciplinary perspectives. She said that the outcome of this kind of interdisciplinary work can be beautiful, and I think that is the perfect note on which to end this project.

Hoda Pourpirali

First and foremost, I would like to express my gratitude to the exceptional group that I collaborated with in this course. Based on the reflections of my friends, it seems that our most significant commonality was the unique experience of diversity in fields of study and research, which strengthened and expanded our knowledge in areas outside of our own specialties. We complemented each other in this teamwork, and whoever had greater ability in a particular field would take the specific related part of work, and as Angelie mentioned, "we channelized our thoughts from different viewpoints."

Another point that Anjali, Annie, and others mentioned, and which it seems we all benefited from, is that through this project, we gained a better understanding of the city of Kelowna, particularly in terms of sustainability, and from now on, we will pay more attention to the environment around us with greater sensitivity, as a sustainability student. I also witnessed successful teamwork and scheduling in the conversations with Ilyas and Tom, and I am glad that this collaboration has been a good experience for them too.

Tom, as an expert in literature, made a very insightful reference to the issue of resilience and its difference from restoration and rehabilitation, which prompted me to revisit class discussions and read more about them, and I appreciate him for that.

In my reflection, I had addressed the two issues of limited access to data and the experience and different opinions of two groups regarding a specific and single topic, and I realized that these were exactly the things that were important and worthy of consideration for my friends as well as Leandra. In addition to scientific learning, the experience of cooperation and receiving different points of view from experts and friends was one of the valuable parts of this class for me.

Leandra Vanbaelinghem

I am thankful for everyone's positive experiences and takeaways. Specifically, I share Annie and Hoda's view that hearing from our speakers was very valuable, not only from presenters involved with Brandt's Creek but also from the speakers who shared the importance of their field's consideration in sustainability. This helped us consider all the relevant sustainability facets to analyze Brandt's Creek sustainability state, challenges and opportunities. Furthermore, Anjali mentioned the usefulness of our group members' differences in lived experiences, which I strongly second. For example, because some of Annie's family members are in education, Annie gave us insights on how teachers are more likely to incorporate new curriculum ideas if such

comes fully prepared, as they are usually swamped and underfunded. Hence, although this information did not stem from an academic background, it still considerably shaped our way of thinking about implementing our proposed citizen project.

Moreover, I agree with Ilyas that time management was one of our group's strengths. I am also proud of how our group bounced back from discovering the water report 2 weeks before our final presentation, as we approached with excitement another issue of focus for our project despite time constraints. Lastly, my experience was similar to Tom's, whereby I had thought much more about sustainability than resiliency in the past and I think focusing on stream health was a valuable way to explore the concept of resiliency more profoundly.

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