UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Assessing Access to Drinking Water at UBC

Andrea Cheng

University of British Columbia

APBI 497B

April 1, 2013

Assessing Access to Drinking Water at UBC

Andrea Cheng

April 2013

Table of Contents

Executive Summary

As the world faces multiple sustainability challenges such as a growing global population, climate uncertainty, rising fossil fuel prices, and a shifting economic landscape, water security is yet another dilemma that must be addressed. The distribution and popularity of single-use bottled water have been under much scrutiny as it poses many negative environmental affects. In addition to the waste it generates, the energy needed to produce and transport disposable polyethylene terephthalate (PET) plastic bottles is considerably higher than the energy needed to produce reusable water bottles and provide tap water.

Like the rest of Vancouver, the University of British Columbia's (UBC) Vancouver campus is striving to increase public access to drinking water and reduce the use of bottled water. A recent research project has determined public perceptions of the university's tap water and found that there is campus support to become a bottled-water-free campus. More recent projects have evaluated the environmental and economic viability of UBC's drinking water options. Based on the results and information gaps highlighted in these studies, this project will determine the baseline availability of drinking water options on campus and identify any deficiencies that are present. This project has the following objectives:

- To conduct a literature review of best practices regarding how other notable campuses manage drinking water provision

- To conduct a drinking water outlet inventory and evaluation to determine accessibility of tap water both within and outside of buildings. This involves a water fountain audit that completes the following tasks:
    - Identifies accessibility of water outlets, the condition of drinking water outlets, water pressure, water aesthetics (colour, smell, taste), type of outlet, proximity to washrooms, and whether the outlets can fill reusable water bottles
    - Maps the locations of water fountains, water filling stations, and kitchenette sinks accessible to students
    - Compares the water electrical conductivity and temperature of water between top and bottom floors of buildings and between 15-second flushes.

- To analyze collected data and identify:
    - Whether deficiencies exist in current drinking water access and develop associated recommendations
    - Whether other water delivery methods are needed to improve water provision on campus

In addition to the stated objectives, this report provides information on:

- Recent research on UBC's drinking water access
- UBC's water landscape
- UBC's water and safety
- UBC's technical guidelines regarding drinking water infrastructure

- UBC's Tap That campaign

Literature review of best practices

This section clearly outlines the procedures four Canadian post-secondary institutions have followed throughout their bottled water ban processes. It also identifies drinking water infrastructure and signage that other campuses use to provide free water to their populations. Effective informative tools such as webpages can clearly communicate institutional intentions and bottled-water policies, increase awareness of bottled water reductions, and address immediate inquiries from students and staff. Maps are extremely useful in informing the public of where drinking outlets are located on campus.

Drinking Water Outlet Assessment

The Drinking Water Outlet Assessment is the main component of this project, and encompasses an inventory and evaluation process of 197 drinking outlets from 59 buildings on campus. It provides a baseline representation of the availability, accessibility, functionality and appeal of UBC's drinking water sources. The inventory and evaluation yields the following results:

- Two thirds of the drinking water outlets evaluated are not visible from the main entrances of their respective buildings
- The majority of drinking water outlets evaluated are visible to passing traffic within their respective buildings
- 38% of drinking water outlets evaluated are situated within 5 meters of a washroom.
- 56% of water outlets are very clean and appear well-maintained
- 7% of drinking outlets are either dirty or have a substantial amount of residues on them.
- 2% of water outlets do not work
- 14% of water outlets have insufficient water pressure to avoid mouth contact with spigots
- 62% of water outlets have sufficient pressure to create an arch where drinking occurs mid-stream and easily allows for bottle filling
- Reusable bottles can be filled at 82% of the evaluated water outlets
- 42% of the 171 water fountains evaluated have goosenecks for bottles
- Water from 81% of the water outlets was colourless and free of air bubbles (initial flush)
- Water from 14% of the water outlets had colour or air bubbles in the initial flush that was absent in the second flush 15 seconds after. Air bubbles dissipate after 30-40 seconds.
- Water from 81% of evaluated water outlets had no unpleasant tastes upon initial flush
- Mean 1-Litre fill times decrease as water pressure increases
- Mean 1-Litre fill times of goosenecks are shorter than the fill times of spigots

In response to these results, the following goals are recommended to increase free drinking water accessibility on UBC's Vancouver campus:

Goal 1: Improve the infrastructure and maintenance as well as increase convenience of tap water usage available on campus

Goal 2: Increase awareness and promotion of tap water available on campus

Goal 3: Continue research on and monitoring of drinking water access on campus

Although drinking water infrastructure is highly available on campus, there are deficiencies in outlet maintenance and public awareness of free drinking water options. If the appropriate signage and informative tools are applied, the university's population will be empowered to make more ecologically responsible drinking water choices. Though the campus has made significant progress in adopting sustainable water consumption practices, there are still more milestones to be conquered on this journey to becoming a bottled-water-free community. The success of this vision will require the cooperation and open-mindedness of students and staff as well as the awareness that all members of the university's population have an important role to play in ensuring this vision is achieved.

Introduction

The University of British Columbia (UBC) is located on the west coast of Vancouver. As with other cities around the world, Vancouver faces multiple sustainability challenges such as a growing population, climate uncertainty, rising fossil fuel prices, and a shifting economic landscape. In 2009, the city launched its Greenest City 2020 Action Plan to engage citizens in building a strong local economy, vibrant and inclusive neighbourhoods, and a city on the leading edge of urban sustainability. The plan encompasses 10 goals that aim to minimize residents' ecological footprints and address other environmental dilemmas. The eighth goal is 'Vancouver will have the best drinking water of any city in the world'. To achieve this goal, the city has highlighted expanding public access to drinking water and reducing the use of bottled water as one of its highest priority actions. Vancouver aims to deploy more portable fountains, as well as install more permanent freeze resistant fountains and water bottle filling stations (City of Vancouver, 2012). Vancouver's drinking fountains are located in parks, community centers, public libraries, and along bicycle routes (Please refer to examples in Appendix A).

Like the rest of the city, UBC's Vancouver campus is also striving to increase public access to drinking water and reduce the use of bottled water. A recent research project has determined public perceptions of the university's tap water and found that there is campus support to become a bottled-water-free campus. More recent projects have evaluated the environmental and economic viability of UBC's drinking water options. Based on the results and information gaps highlighted in these studies, this project will determine the baseline availability of drinking water options on campus and identify any deficiencies that are present.

Background Information

About the Author

Andrea Cheng is in her fourth year of the Applied Biology program within Land and Food Systems at UBC. Her specialization is in Food and the Environment, which has allowed her to complete a wide variety of courses including Climatology, Agroecology, Oceanography, Geographical Information Systems, Sustainability by Design, Environmental Geography, Research Methods in Applied Animal Biology, and Environmental Impact Assessment. She has also been actively involved with Sprouts, a volunteer-run non-profit organization that makes local, healthy, organic food accessible and affordable to the UBC campus on a daily basis. She is completing this project through the UBC SEEDS Program to fulfill a directed studies requirement within her degree.

Project Stakeholders and Staff

SEEDS Program

The SEEDS (Social Ecological Economic Development Studies) Program is the first academic program in Western Canada to integrate students' energy and enthusiasm for sustainability with faculty members' research experience and staff members' expertise to increase campus capacity to function as a sustainable institution. UBC's SEEDS Program allows students to earn course-based credit working on sustainability projects, while receiving mentorship from faculty and staff. Students collaborate with faculty and staff to develop solutions for sustainability challenges on campus. To date, over 800 projects covering issues that involve materials, water, energy, transportation, land, food, climate, community and finance have been completed. The SEEDS Program Library allows the public to access all completed project reports and provides a historical record of sustainability at UBC (UBC Sustainability, 2013a).

Acting staff member:
Liska Richer, UBC SEEDS Program Coordinator

AMS Sustainability

AMS Sustainability is the sustainability office of UBC's Alma Mater Society. It has five employees and runs the $100,000 per year AMS Sustainability Fund as well as multiple ecological footprint reduction programs. These are achieved through their Lighter Footprint Strategy, which is informed through the UBC SEEDS Program.

Acting staff member:
Justin Ritchie, AMS Sustainability Coordinator

UBC Student Housing and Hospitality Services (SHHS)

UBC Student Housing and Hospitality Services (SHHS) provides accommodation for students, faculty and staff in eight residential complexes throughout campus. SHHS also encompasses the UBC Food Services Department, which is the primary food provider to the campus (UBC Student Housing and Hospitality Services, 2013). The AMS and SHHS have formed a memorandum of understanding (MOU), through which both parties have agreed to collaborate on the installation of 12 WaterFillz stations across campus (personal communication with Victoria Wakefield, Apr. 4, 2013)

Acting staff member:
Victoria Wakefield, Purchasing Manager

UBC's Waste Action Plan

UBC is developing a Waste Action Plan outlining waste reduction targets and the actions required to achieve those goals. UBC currently diverts about 44% of its operational waste from local landfills, a target that has been met partially through a range of successful waste reduction programs executed throughout the past decade and it is committed to further waste reductions in the future (UBC Sustainability, 2013b).

Acting staff member:
Bud Fraser, UBC's Water and Zero Waste Engineer

UBC Building Operations

UBC Building Operations is responsible for managing the university's built environment in a safe and sustainable way. It is dedicated to providing facilities maintenance, operations and renovation services to UBC's lands and various buildings as required (UBC Building Operations, 2013). UBC Building Operations provided information on water fountain locations for this project.

Acting staff member:
Greig Samodien, Facilities Manager

Supervising Professor

Dr. Mark Johnson conducts research through the Institute for Resources, Environment and Sustainability, and the Department of Earth and Ocean Sciences at UBC. He has research expertise in ecohydrology and watershed biogeochemistry as well as academic and professional experience in temperate, tropical and boreal climates, and in forested, agricultural, and mixed land use environments. The overarching goal of his research group is towards the development of more sustainable land use practices and urban systems (Ecohydro Lab, 2013).

Research on UBC's Drinking Water Access

Throughout the last three years, UBC students have conducted several studies to enhance sustainable water consumption and provision on campus. In 2010, two students (Sadowski and Willock) from the Global Resource Systems program in Land and Food Systems developed a social marketing plan to decrease bottled water consumption and increase access to free drinking water over the next four years. They conducted a survey to assess students' attitudes and perceptions towards water fountains and drinking tap water. The survey was completed by 534 people and yielded the following trends. Students do not think water fountains are widely available on campus and want more that are easy to use and well-maintained. Hygiene is a major barrier for students who do not drink from water fountains, where most students prefer the WaterFillz stations that have been installed in the Student Union Building. WaterFillz stations are roughly the same size as vending machines and dispense cold, filtered water into bottles or cups upon the press of a button (please refer to Appendix E: Types of water outlets at UBC). These machines also count and display how many water bottles have been filled. While many students trust the quality of campus tap water, there are still many who do not understand where the water comes from and whether it is safe to drink. Most students are supportive of banning the sales of bottled water and use a personal water bottle. Students prefer to drink cold, fresh-tasting water. From these major trends, Sadowski and Willock concluded that there is student support for sustainable drinking water options on campus. In order to facilitate the shift to sustainable drinking water consumption, Sadowski and Willock also suggested that effective awareness programs would need to be developed in addition to improvement of drinking water infrastructure (Sadowski & Willock, 2010).

Two research projects (*An Investigation into Sustainable Water Consumption* and *Assessment of Drinking Water at UBC: A consideration of water quality, energy and economic costs, with practical recommendations*) have evaluated the environmental and economic implications of bottled water use and UBC's chosen alternative drinking water solutions. The energy needed to produce and transport disposable polyethylene terephthalate (PET) plastic bottles is considerably higher than the energy needed to produce reusable water bottles and provide tap water from fountains or WaterFillz stations. Energy is also consumed when bottled water is processed, bottled, refrigerated, collected by waste management services and processed for recycling. Energy costs attributed to the use of reusable bottles stems mainly from bottle washing. Although the WaterFillz stations require a lot of energy to produce and cost about $10,000 each, the cost of production per unit of water decreases as more water is drawn into students' reusable bottles after installation (Kanda et al., 2010; Tran et al., 2012). Improved water outlets such as Brita Hydration Stations and Elkay EZH_2O fountains have lower initial costs ranging from about $1,200 to $4,000 (Kanda et al., 2010). On a longer-term basis of five years after installation, the WaterFillz stations have been found to be the most economical because their filters do not need to be replaced as often as other drinking water outlets (Tran et al., 2012). WaterFillz filters need to be changed every 6 to 12 months depending on usage and other water conditions (Kanda et al., 2010).

Tran et al. (2012) performed a water quality analysis on water samples from eleven buildings along with samples from Dasani bottled water and a WaterFillz station. They reported higher concentrations of copper and zinc in Totem Residence, and the Earth and Ocean Science (EOSC) Main. There were moderate concentrations of copper and zinc detected in Fred Kaiser, Geography, Buchanan A, and Scarfe. An elevated concentration of lead was found in EOSC Main. None of the results exceeded Canada's Drinking Water Guidelines. Tran et al. indicated that concentrations of trace heavy metals decreased as the week progressed and more water flushed through the pipes. Tran et al. also recommended potential locations where WaterFillz stations should be installed in the future. These recommendations were made based on water quality, building traffic and water fountain availability. Woodward and the Buchanan Lecture Halls had the highest building traffic and low levels of copper, zinc and lead. Geography, Scarfe, Totem Residence, and EOSC Main were suggested because of the moderate to high levels of trace metals found in their respective water samples. Henry Angus was suggested as a candidate because of the high level of traffic within the building. The following buildings were recommended because they had 0-1 water fountains and high levels of traffic: the Forest Sciences Building, the West Mall Swing Space Building, the Civil and Mechanical Engineering Building, the Mathematics Building, the Hugh Dempster Pavillion, and the H.R. Macmillan Building (Tran et al., 2012).

In June 2012, Justin Ritchie from Alma Mater Society (AMS) Sustainability and Victoria Wakefield from Student Housing and Hospitality Services (SHHS) conducted an inventory of 15 major academic buildings throughout the campus to gauge the availability of drinking water. These buildings were selected based on the recommendations that Tran et al. (2012) gave in their report. Drinking water outlets were counted and the buildings were either identified as having sufficient access to water or insufficient access to water. The West Mall Swing Space Building, Henry Angus Building, Geography Building and Mathematics Building had insufficient access to water. Ritchie and Wakefield also made recommendations to upgrade or retrofit fountains, and add signage to inform the public of where water outlets could be found. The AMS and SHHS have formed a memorandum of understanding (MOU), through which both parties have agreed to collaborate on the installation of 12 WaterFillz stations across campus (personal communication with Victoria Wakefield, Apr. 4, 2013).

A Commerce 468 project has also been completed in conjunction with this SEEDS project to develop a comprehensive marketing plan that promotes access to UBC's tap water. The marketing plan's main objectives were to analyze current customer awareness and support of UBC's sustainable drinking water sources. The project analyzed current customer attitudes towards sustainable water consumption and identified barriers that prevented the public from drinking tap water. A major component the project was the development of strategies to increase awareness of and participation in sustainable water consumption initiatives among non-tap-water users. It identified signage that was recognizable across language and cultural barriers, which would enable the UBC community to easily access drinking water locations on campus (personal communication with Liska Richer, April 19th, 2013).

UBC's Water Landscape

UBC has a broad selection of water sources including water fountains, WaterFillz stations, kitchenette sinks in academic buildings and student residences, and other commercial filtration units. There are currently no functional drinking water outlets or water fountains outside of buildings. Within the AMS, the Student Union Building (SUB) has two WaterFillz stations and six water fountains. Tap water is quite accessible within UBC's SHHS as well. Every residence has taps and main common lounges are equipped with water fountains. Some of the more recently built UBC Food Services outlets have water filling stations (personal communication with Victoria Wakefield, March 8, 2013).

Bottled water is available to the public in vending machines and food outlets maintained by the AMS and UBC Food Services (SHHS) as well as through catering services. Last year, the AMS made approximately $60,000 in revenue through bottled water sales from its 11 venues and catering services (personal communication with Justin Ritchie, March 12, 2013). AMS Food Services sells Pepsi's Aquafina and Nestlé Pure Life Water (Sadowski & Willock, 2010). UBC Food Services currently has 28 food venues and three mini marts at the Walter Gage, Vanier and Totem residences. Coca-Cola's Dasani bottled water can be bought at all these venues except at Starbucks locations, where Starbucks' Ethos bottled water is sold (UBC Food Services, 2013; Sadowski & Willock, 2010). Between September 2010 and August 2011, UBC SHHS made approximately $255,000 in revenue through bottled water sales from food service venues and vending machines (personal communication with Victoria Wakefield, April 26th, 2013). Both the AMS and UBC Food Services have non-exclusivity contracts with their respective bottled water suppliers (Nestlé, Pepsi and Coca-Cola) and UBC Athletics sells bottled water through their non-exclusive contract with Coca-Cola (Sadowski & Willock, 2010). Bottled water is also available through other locations on campus like the UBC Hospital, Shopper's Drugmart, UBC Village and Wesbrook Village.

Many faculties and departments have contracts with companies like Canadian Springs, who supply large water jugs and dispensers. There are more than 260 different departments at UBC that rely on commercial bottled water sources. In 2012, 260 departments had a total consumption of 1176 11-Litre jugs, 23570 18-Litre jugs, 102 sets of case goods, and 520 point-of-use water coolers. One case good includes 24 500-mL water bottles and point-of-use water coolers are filtered dispensers that are connected to UBC's water line. Canadian Springs supplies the campus with the largest fraction of commercial large-volume bottle water (personal communication with Liska Richer, April 18th, 2013).

The ability to access tap water on campus largely depends on whether students and staff own reusable water bottles. Reusable water bottles that vary in brand, size, material, design, lid type and price are currently sold at the Student Recreation Centre, the UBC Bookstore, Shoppers Drugmart, Save-On-Foods, the Village, Starbucks, the Outpost within the AMS, and at the various food outlets maintained by UBC Food Services (Sadowski & Willock, 2010; personal communication with Victoria Wakefield, March 8, 2013). Another factor that contributes to tap water consumption is the availability of water outlets on campus. The AMS and SHHS have installed two WaterFillz stations in the SUB, one at the West Mall Swing Space and one in the

H.R. Macmillan Building to increase water availability on campus and encourage sustainable water consumption.

UBC's Water and Safety

UBC's Vancouver Point Grey campus receives drinking water from Metro Vancouver's water system, which distributes its water from five hundred and eighty five square kilometers of mountainous land restricted to public access. The three reservoirs (Capilano, Seymour and Coquitlam) within this region collect water from rainfall, snowmelt, creeks and streams. Metro Vancouver tests water quality at the source, at treatment facilities and at various distribution points (UBC Risk Management Services, 2013). In 2010, Metro Vancouver started the construction of the Seymour-Capilano Filtration Plant, which treats water from the Seymour and Capilano watersheds. The project, scheduled to be completed this year, will ensure that Metro Vancouver's population is provided with high quality filtered drinking water by successfully addressing the following water quality concerns:

CONCERN	CAUSE	SOLUTIONS
Turbidity: Cloudy, coloured or dirty water from fine particles like clay or silt	Heavy rainfall causes landslides and erosion of stream banks in the watershed	Filtration of Seymour and Capilano source water will reduce turbidity Draw water from unaffected sources until turbidity levels have reduced
Waterborne parasites: Giardia and cryptosporidium	Parasites from animals in watersheds occur naturally in surface waters, at low levels	Watersheds are kept closed to the public Primary disinfection at source
Bacteria regrowth: in the distribution system between treatment plants and homes and businesses	Chlorine depletes along the distribution system Sediments settle out of water, creating an environment for bacteria to grow	Additional chlorine is added along the distribution system Flushing and cleaning programs of pipes and reservoirs eliminate silt
Corrosion: Staining of plumbing fixtures, health and environmental concerns, and economic impact	Natural acidity in water corrodes metal plumbing and piping and leaches copper into the water system	pH* adjustment (corrosion control) at facilities for all three water sources * where pH is a measure of acidity
Chlorination: Chlorination disinfection by-products	Produced by chlorine reacting with organic matter (e.g. tiny plant particles) in the water	Filter the water to reduce the level of organic matter. Use ozone and UV to reduce use of chlorine for treatment

(Metro Vancouver, 2013)

Drinking water is tested weekly at UBC's Point Grey campus. Water quality must be tested at the tap and/or drinking water fountains a minimum of two times per year within buildings throughout the campus (UBC Risk Management Services, 2013). The 12-16 sampling locations vary to ensure that different areas of the campus are adequately represented, and are determined based on land use and system configuration. Locations include residential areas, high-density areas, institutional areas, and the water source. Water samples from these locations are collected and are analyzed by laboratories approved through the Canadian Association of Environmental Analytical Laboratories. Each sample is analyzed for microbiological parameters (total coliforms, *E. coli*, turbidity), chemicals (lead, copper, arsenic, zinc, iron, vinyl chloride, aluminum, etc.) and physical parameters (pH, odour, taste, temperature) (personal communication with Greig Samodien, January 31, 2013). To mitigate the effects of piping on water quality, UBC Risk Management Services suggests that tap water be flushed for a minimum of 60 seconds, especially during summer months (UBC Risk Management Services, 2013).

UBC's Technical Guidelines Regarding Drinking Fountains and Stations

All buildings on campus must adhere to the British Columbia Building Code, but it doesn't have any specifications regarding water fountains and their location within buildings. The Technical Services Department within UBC's Building Operations is responsible for the following Technical Guidelines and applying them to new construction, building renewals and renovations. The UBC Technical Guidelines were first written in 2002. They have been revised since then and will continue to be altered as needed. These Technical Guidelines are strongly encouraged by the Technical Services Department, but it is not mandatory that they are followed (personal communication with Greig Samodien, Apr. 8, 2013). The most current version stipulates that:

Drinking water Fountains and Stations.

1. All buildings over 600 gross square metres shall have at least one accessible drinking water fountain, located in a public area. The drinking fountain should include an appropriate fixture for filling water bottles. An example of this might be the Elkay Drinking Fountain and Bottle Filling Station: http://www.elkayusa.com/cps/rde/xchg/elkay/hs.xsl/elkay-com-101698.aspx
2. All new buildings shall have drinking water fountains installed on the shortest dead leg possible off of a line that is flowing regularly. This line would preferably be serving a washroom.
3. The drinking water fountain shall NOT be cooled.
4. Drinking water fountains shall NOT have filters and hence no backflow preventers will be required.
5. Drinking water fountains shall only be located inside buildings at level-1 entrance lobbies and should be visible from the exterior.
6. Filtered water drinking stations for office-type areas are acceptable provided that a UBC Plumbing Permit is obtained. An approved backflow prevention device must be installed as per Section 15401 Backflow / Cross Connection Control to prevent water from being drawn

out of the filter system back into the water supply line. A regular filter maintenance program must also be in place as part of the service agreement with the filtration system vendor.

7. When retrofitting existing buildings, installation costs plus recurring filter changes are to be funded by the relevant Academic Department.

(UBC Technical Services Department, 2012)

UBC's Tap That Campaign

Common Energy is a student-run organization that aims to incorporate sustainability into all aspects of the UBC community. Its Tangible Solutions action team launched the Tap That: Bottled Water Free UBC campaign on January 28th, 2013. This campaign has increased awareness of the impacts of bottled water consumption and the benefits of drinking tap water from reusable bottles through its website, promotional videos, movie screenings, as well as through its Facebook and Twitter webpages. The main goal of the campaign is to gain public support for a petition that will encourage UBC President Stephen J. Toope to set a date by which the campus will become bottled water free. To date, the campaign has endorsements from eight campus organizations including the AMS, Sprouts and the UBC Bookstore, as well as from four undergraduate societies (Tap That UBC, 2013). The Tap That community on Facebook has 613 Likes. As of March 27th, 2013, UBC is officially committed to:

- The creation of a committee (modeled after the Waste Free UBC Committee) which will conduct research to determine the economic transition and phase-out plan for bottled water, and ultimately set the date by which the University will become bottled-water free.

- Following immediate next steps, which will ideally occur before September 2013:
    - Create a H_2O page on the UBC Mobile App, which will map all safe drinking water locations (including WaterFillz stations, taps, gooseneck taps, and fountains).
    - Incorporate a "safe water brand" into the new UBC Sustainability branding initiative to ensure that all WaterFillz stations, taps, gooseneck taps and fountains are easily identifiable and give consistent messaging.

(personal communication with Common Energy, Apr. 2, 2013)

Rationale for This Project and its Scope

This push to adopt more sustainable drinking water habits is separate from, but complimentary to, the campus' broader effort to conserve water and decrease the quantity of water consumed through process cooling and research, washroom facilities, irrigation and showers. The UBC Sustainability initiative is currently developing a Water Action Plan to help the campus achieve its goal of becoming a campus-wide closed loop water system. A Waste Action Plan is also being developed, which will outline UBC's waste reduction targets and the actions required to attain those targets (UBC Sustainability, 2013b). The life cycle of single-serve bottled water generates a considerable amount of greenhouse gases that contribute to climate change, and waste that is often discarded through garbage disposal or down-cycled into other disposable products (Sadowski & Willock, 2010). Therefore, cutting down campus bottled water consumption is a prudent step in meeting waste reduction goals.

This project is a continuation of research that has already been completed on UBC's drinking water access. The results from Sadowski and Willock's survey indicated that 56% of 505 respondents believed water fountains were either unavailable or difficult to access on campus. 21% out of 282 respondents claimed that water fountains were hard to find or that more needed to be installed on campus. The survey also showed that 83% of 517 respondents owned and used a personal reusable water bottle, and 79% of 268 respondents were supportive of a ban on the sales of bottled water provided that there would be adequate availability of alternative sources to clean, safe water on campus. Some people criticized water fountains for being unsanitary or for unsatisfactory water pressure. Most comments mentioned low pressure, where a few cited excessive pressure at certain water fountains. Tran et al. (2012) indicated that the functionality and overall condition of every water fountain on campus is unknown. It is also uncertain whether data provided by UBC Building Operations for this study was up-to-date. In response to these statistics and information gaps, this project has the following objectives:

- To conduct a literature review of best practices regarding how other notable campuses manage drinking water provision

- To conduct a drinking water outlet inventory and evaluation to determine accessibility of tap water both within and outside of buildings. This involves a water fountain audit that completes the following tasks:
    - Identifies accessibility of water outlets, the condition of drinking water outlets, water pressure, water aesthetics (colour, smell, taste), type of outlet, proximity to washrooms, and whether the outlets can fill reusable water bottles
    - Maps the locations of water fountains, water filling stations, and kitchenette sinks accessible to students
    - Compares the water electrical conductivity and temperature of water between top and bottom floors of buildings and between 15-second flushes.

- To analyze collected data and identify:
    - Whether deficiencies exist in current drinking water access and develop associated recommendations
    - Whether other water delivery methods are needed to improve water provision on campus

Methods

Literature Review of Best Practices

To determine drinking water provision practices at other institutions, a considerable amount of online research was performed. The relevance of findings was based on whether these institutions' population sizes were similar to UBC's population or whether they offered valuable insight about bottled water cutbacks. Particularly important information describes how institutions provide drinking water to their students, how they promote the use of drinking water outlets and how they successfully stopped selling bottled water at their campuses. Suggested practices that UBC should adopt will be included in the Discussion and Recommendations sections.

Water Outlet Inventory and Evaluations

Considering the trends noted in Sadowski and Willock's (2010) survey and the information gaps identified by Tran et al. (2012), a series of questions were chosen to represent how an individual would decided to regularly use a given drinking water outlet. The questions all assume that the individual owns a reusable water bottle and he or she will either choose to use the water outlet or purchase bottled water (or another commercial beverage) based on the responses to the questions. The following questions are meant to represent some of the key factors that encourage individuals to use or discourage individuals from using the drinking water outlets on campus.

1. Can I find the drinking outlet or is it accessible?
2. Do I know that the water from this outlet is safe to drink?
3. Is the outlet visually appealing?
4. Does the outlet work?
5. Can I conveniently fill my water bottle at this outlet?
6. Is the pressure or fill time adequate?
7. Is the water appealing (colour, smell, taste, temperature)?

These questions were used to construct a flow chart that either ended with the purchase of bottled water or another commercial beverage, or the regular use of the water outlet (please refer to the Diagram 1 in Appendix B). The questions were subsequently used to write a survey used to evaluate individual water outlets. The survey included the following components:

- The person conducting the survey
- Date and time of the survey
- The building in which the outlet was found
- The outlet's location (nearest room number or landmark) and floor number
- Whether the outlet was visible from a main entrance

- Whether the outlet was visible to passing traffic
- The outlet's proximity to a washroom
- The visual appeal of the outlet
- Whether a reusable water bottle could be filled at the water outlet
- The faucet type
- The water's colour
- The water's odour
- The water's taste
- The water outlet's pressure

The visual appeal, water colour, water taste, and water pressure were evaluated on a Very poor, Poor, Good, and Very Good scale. This scale was chosen, because it included an equal number of negative options and positive options, without providing too many options. The complete Drinking Water Outlet Assessment is included in Appendix B. Water taste, odour and colour involved an initial flush and collecting a second sample if the initial flush was not classified as Very good. The 15-second flush period was determined in collaboration with project staff. Although it is commonly suggested to flush water for about a minute to obtain the best quality of water, it was anticipated that most students and staff either do not flush water fountains before using them or flush them for a much shorter period. The survey was performed under these assumed circumstances.

The buildings included in the evaluation were determined in collaboration with UBC Building Operations and based on the high traffic locations Tran et al. (2012) identified. UBC SHHS also requested the evaluation of common blocks within seven residences (included as the List of Buildings with Zones in Appendix B). Other factors that were considered included: whether students commonly visited the buildings, whether the buildings were located on major campus corridors, and whether most areas of the main campus were represented. Since roughly one month was allotted to data collection and collection capacity was limited, the scope of the evaluations was set at approximately 60 buildings. The list of buildings was modified throughout the data collection process for various reasons. The Music Building was initially not included, but was added when a drinking water outlet was identified there. The Aquatic Centre, initially on the list, was not evaluated because of time constraints and decreased accessibility within the building. The West and South wings of the Biological Sciences Building were also removed from the list, as students do not commonly use them. Buildings were separated into six zones based on geography. This facilitated data collection and ensured efficiency and thoroughness (Map 1 in Appendix B).

The scope of the outlet inventory and evaluations was also set to include all water fountains, kitchenette sinks in common areas, WaterFillz stations, fixed dispensers at cafés, and point-of-use coolers within areas commonly used by students. The inventory excluded all laboratory sinks and the majority of washroom sinks with the exception of a few buildings where fountain spigots and bottle-filling goosenecks are found in washrooms. Sadowski and Willock (2010) identified that some of the people surveyed would not drink water from a sink tap, because they assumed "sink tap" referred to public washroom sinks. Public washrooms are typically perceived as unhygienic areas and were therefore not included in the inventory. Time constraints and data collection capacity were also considered when determining the scope of the inventory.

The data collection process was further facilitated through the recruitment of volunteers from Common Energy. Four volunteers helped conduct surveys and were shown the full Drinking Water Outlet Assessment beforehand. A few outlet evaluations were performed in groups to standardize survey responses. Once group surveys were consistent, pairs of volunteers were assigned one of the six building zones. Surveys were conducted on Mondays and Tuesdays to ensure that water conditions were similar throughout the entire process. Pictures were taken of all surveyed water outlets and organized into computer files that corresponded to each of the six zones. All the survey responses were analyzed using Excel.

Analysis of Water Electrical Conductivity and Temperature

Once the water outlet inventory was completed, a separate list of water fountains was compiled to analyze water electrical conductivity and temperature. One factor that affects whether or not individuals use a drinking outlet is the temperature of the water. The purpose of this analysis was to determine whether water collected on the top and the bottom floors of buildings exhibits temperature variations. Therefore, only buildings with water fountains on two or more floors were included (please refer to Electrical Conductivity and Temperature Data Table in Appendix B). A WaterFillz station, two commercial point-of-use water dispensers, a Brita Hydration Station, and a Dasani water bottle were also analyzed for reference. Electrical conductivity is the measurement of all ions present in the water, such as different salts, nitrates and nitrites, phosphates and other minerals. These measurements do not indicate specifically which ions are in the water, but may help determine whether building pipes are affecting water quality. Electrical conductivity was measured in 59 buildings and temperature was measured in 57 buildings. Measurements were all done on Tuesdays, using a Thermo Orion electrical conductivity meter (please refer to equipment section in Appendix B). Initial flushes and second samples were assessed after 15 seconds of flushing.

The data collection process was facilitated by volunteers who helped collect water samples from outlets. The results were entered into a spreadsheet and analyzed to produce bar graphs. Separate graphs were produced to compare minimum, maximum and mean values with results from a WaterFillz station and a Brita Hydration Station.

Analysis of Water Flow Rate

The water flow rate was measured from outlets classified in each of the pressure levels (Very poor, Poor, Good, and Very good). The time required to fill a water bottle is another factor that affects whether or not a drinking outlet is used. The purpose of these measurements was to determine whether pressure affected flow rate, and the difference between gooseneck and spigot flow rates. A list of 100 water outlets represented a wide range of buildings from the inventory list (please refer to Flow Rate Data Table in Appendix B). To measure flow rate, a water bottle and graduated cylinder were used to measure the volume of water dispensed in

5.2 seconds (± 0.2 seconds). If a water fountain had a gooseneck or bottle filler, the flow rates for both the drinking spigot and the gooseneck or bottle filler were measured. Data collection occurred on Thursdays, and was facilitated with the aid of one volunteer who helped collect water samples and measure water volumes. Once the data was entered into a spreadsheet, the mL/s flow rates and 1-Litre fill times were calculated for all the water sources. The 1-Litre fill time represents the time needed to fill a 1-Litre bottle at a given water source. The mean 1-Litre fill times for spigots and goosenecks at each pressure level are shown in the Water Flow Rate subsection of Findings and Discussion.

Literature Review of Best Practices

In the last five years, the movement to support safe and reliable public water infrastructure and decrease consumption of single-serve bottled water has grown across North America. Between the years 2009 and 2011, 15 university campuses across Canada publicly announced a commitment to phase-out the sale and provision of bottled water (The Council of Canadians, 2011). On March 15th, 2012, the Council of Canadians announced that 23 university campuses in the country were officially pro-tap (The Council of Canadians, 2012). In November 2011, the Portland State University Sustainable Drinking Water Task Force (PSUSDWTF) identified 35 Take Back the Tap (TBTT) campaigns across North America, 47 Think Outside the Bottle (TOTB) campaigns, and 30 additional campaigns not affiliated with TBTT or TOTB. The PSUSDWTF also compiled a list of 43 post-secondary schools with campus-wide water bottle bans, 11 post-secondary schools with department or area-specific bans, and 79 post-secondary schools with awareness or reduction campaigns (PSU's SDWTF, 2012).

In *Best Practices Guide on University Campus Sustainability*, Ashley Rensler (2012) compiled and documented best practices from other university campuses across Canada involving healthy food policies and practices, Styrofoam containers and water bottle bans for York University's President's Sustainability Council. This guide clearly outlines the procedures four Canadian post-secondary institutions followed throughout their bottled water ban processes. UBC could definitely learn from each of these cases as it gains momentum from Common Energy's successful Tap That campaign.

The University of Winnipeg's bottled water ban process lasted from January 2008 to March 2009. Throughout this period, the University of Winnipeg Student Association (UWSA) opened a water bottle free café and launched Polaris Institute's "Bottled Water Free Zones" Campaign. Polaris Institute is an organization that helps enable citizen movements and social change (Polaris Institute, 2013). Coalition meetings with local environmental groups were held to build a city-wide bottled water free action plan and the University of Winnipeg formed a Bottled Water Working Group. The working group met with University Administration and Administration agreed to principles of banning bottled water sales. The Canada Research Chairs and an expert on water toxicity performed a water safety audit on campus. During USWA elections, the following referendum question was asked: "Would you be willing to support an initiative led by the University of Winnipeg and USWA to gradually eliminate sales of bottled water on campus with increased access to clean and free drinking water?" Three quarters of respondents were in favour of the ban. The Canadian Federation of Students and the UWSA worked with campus administration to ensure that regardless of their existing pouring contract with Pepsi Co., the University would have the ultimate say in what products were purchased and sold on campus (Rensler, 2012).

Queen's University's bottled water ban process ran from June 2010 to September 2012. Throughout this period, a drinking fountain inventory and audit was conducted to ensure the campus had access to bottled water alternatives. Policies were also developed to establish the scope, inclusions, exclusions and provisions of the anticipated bottled water ban. There was an initial termination of bottled water sold in large volumes (591 mL or more) and free filtered tap water was advertised. The Queen's Sustainability Office and the Queen's Water Access Group increased general awareness and provided information about issues associated with bottled water and the ban. Drinking water fountains were enhanced through the additions of goosenecks to encourage more use of reusable bottles, and water fountains were installed in locations that previously lacked them. The distribution of bottled water within vending machines and retail food location also changed significantly. Vending machines that solely sold bottled water were removed throughout the campus. Bottled water in alternative vending machines were restocked and all advertising for bottled water was ceased throughout the campus. Queen's University also launched an awareness campaign that explained the reasons behind the bottled water ban and advertised newly enhanced access to public drinking stations through maps, lists and signage. Queen's University's pouring contract with Cola-Cola expired in August 2012 and at that time, regardless of whether a new contract was negotiated, the water bottle ban would still be in effect (Rensler, 2012).

The University of Toronto's bottled water ban process started in September 2011 and is anticipated to end in September 2013. The ban began on the St. George Campus and is destined to spread to the Mississauga and Scarborough campuses this year. Bottled water was eliminated from a wide range of locations on the St. George Campus including all vending machines on main contract, all Second Cup locations and all Starbucks locations. In contrast to the previous two campuses discussed, the University of Toronto received negative feedback to the bottled water ban referred to as "Ban the Bottle Backlash". Some students argued that there was no adequate transition period that allowed them to adjust to the absence of bottled water on campus. Students claimed that there were not enough water fountains and refilling stations to compensate for the lack of bottled water. A Facebook group named "Back Bottled Water and U of T" was created in an attempt to petition to bring back students' right to choose bottled water. The group only received 28 Likes and 5 posts. The arguments made by the group's administrators were not representative of the whole campus' stance on the ban (Rensler, 2012).

Ryerson University's bottled water ban process began in November 2009 and is expected to end sometime this year. It was initiated through the "Boycott the Bottle, Try the Tap" campaign in partnership with the Polaris Institute and Corporate Accountability International. Corporate Accountability International is a non-governmental organization that implements campaigns that challenge corporate control of water and food, as well as the use of tobacco (Corporate Accountability International, 2013). There was a collection of over 200 signatures in support of Ryerson going bottled water free and interaction with the student body through events on and off campus. A vote was taken at the Ryerson Student Union Semi-Annual General Meeting and overwhelming support for a bottled water ban was shown. A meeting with Ryerson University President was organized to discuss the bottled water ban and other steps were taken towards campaign building. On the First National Bottled Water Free Day, the President of Ryerson University and the President of Ryerson's Student Union signed Ryerson's Water Pledge committing to building a bottled water free campus by 2013. In 2012, Ryerson University's pouring contract with Coca-Cola continued the sale of bottled water in vending machines. The campus made a goal to eliminate bottled water in vending machines by 2013 and Coca-Cola communicated support of "sustainable campus initiatives". The elimination was supported because other Coca-Cola products would replace bottled water in vending machines (Rensler, 2012).

Ryerson University received mixed reviews from students regarding the bottled water ban. Comments both in support and against the ban were made and there was no indication of which side was more prevalent. Arguments against the ban included:

- "*Making water a human right doesn't solve the problem of equal access; bans limit consumer choice*"
- "*Justification in free access to tap water is insufficient – additional factors should be regarded (e.g. convenience)*"
- "*A ban takes away students' ability to choose*"

(Rensler, 2012)

In addition to Rensler's *Best Practices Guide on University Campus Sustainability*, other communication and promotion tools from universities were identified during online research. The University of Toronto and Queen's University are both considered Major Canadian Universities similar to UBC with populations of over 20,000 students. York University is classified as a mid-sized school (Universities in Canada, 2013). The University of Toronto, Queen's University and York University all provide printable and online maps that indicate where students can find water fountains and bottle-filling stations. Queen's University and the University of Toronto both have campus-wide water source signs that either show a man filling a bottle or a man drinking from a fountain. York University's map includes a list of the buildings with directions on where to find the water outlets within the buildings. These are all useful in helping students and staff find water sources on their campuses. The University of Toronto also has an interactive Google Map that includes different overlays corresponding to different types of water outlets. The map's users can choose to locate any or all of the following outlet categories: bottle filling stations, drinking fountains and food outlet taps. A second interactive Google Map shows the locations of wheelchair accessibility areas, bicycle racks, food outlets, parking lots, safety locations, student services, student spaces, washrooms and areas with wireless internet. Most of these layers also include sub layers that allow users to choose exactly what they want to locate.

All three of the previously mentioned universities have webpages dedicated to promoting the use of free drinking water outlets and provide direct links to their water maps. The University of Toronto's webpage is extensively informative. It provides information on its bottled water free policies and the steps the campus has taken to end the distribution of bottled water. The University of Toronto has defined "bottled water free" as having no sale or distribution of bottled water, except at special events where bottled water is the only possible source of hydration (University of Toronto Food & Beverage Services, 2013a). The webpage also provides a Media section with links to news coverage on the bottled water phase-out and a FAQ section that answers the following questions:

- Why did you ban bottled water at the University?
- Now that I can't buy bottled water, what should I drink?
- Who should I contact to request a water station in my building?

- Do the water fountains on campus dispense filtered water?
- Where can I get more information about Toronto tap water?
- What are bottle filling stations?

(University of Toronto Food & Beverage Services, 2013b)

These extra features are effective ways to clearly communicate the institution's intentions and policies, increase awareness of the bottled water ban, and address immediate inquiries from students and staff. Pictures of water fountain infrastructure and signage at other post-secondary institutions can be found in Appendix C.

Findings and Discussion

Through the qualitative analysis, 197 drinking water outlets were identified in 59 buildings on campus. All 197 outlets were mapped using Google Maps chosen for its interactive aspects. Users can specifically select which buildings they frequently visit and the map will indicate where to find the water outlets in selected buildings. When a building placemark is selected, a pop-up information box provides users with pictures of the water outlets and the nearest room numbers or landmarks. These details help users find outlets within buildings, showing users what to expect and what they need to look for. Each placemark is colour-coded based on the type of water outlet it represents. The legend found in the left side bar also facilitates building selection, especially if users are not sure where buildings are specifically found. The building list has been arranged in alphabetical order using building code names (please refer to Appendix D for a screenshot).

Map link: http://goo.gl/maps/ng5W4

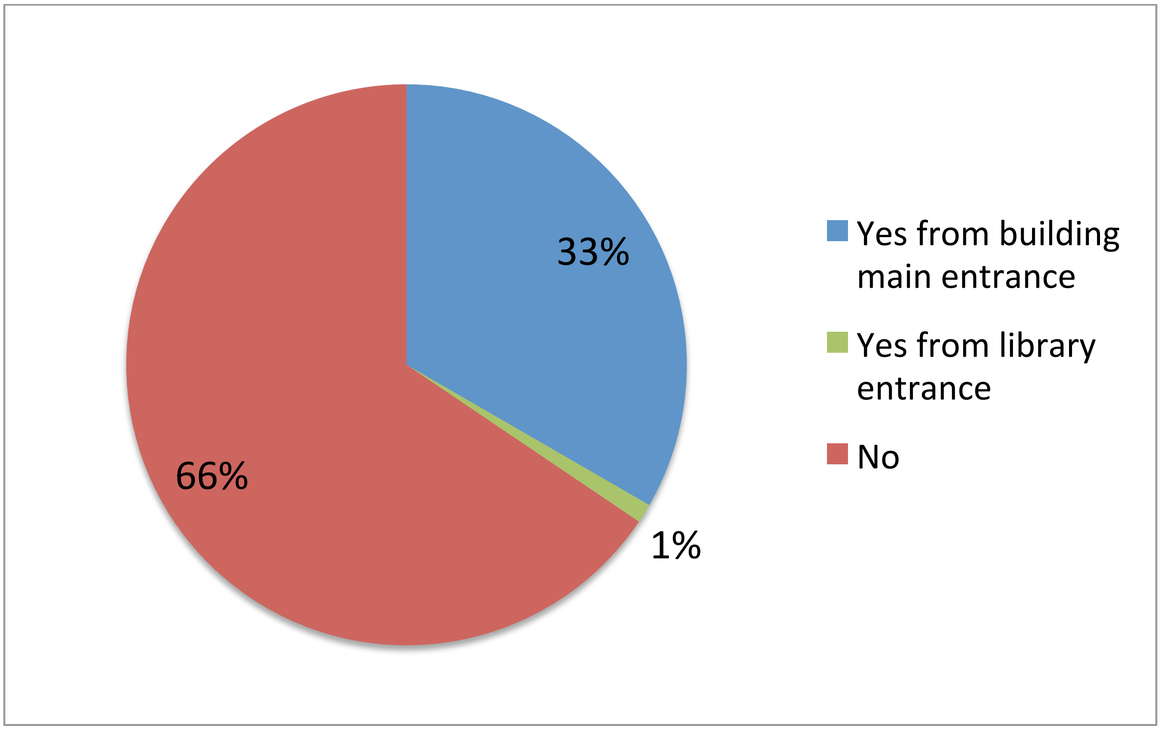
The following series of pages are structured to present the findings of the water outlet inventory and evaluations. Each section corresponds to one or two components of the qualitative survey, or a component of the quantitative analysis (flow rate, electrical conductivity and water temperature). Each section includes a brief introduction explaining the reason the component was included in the evaluations, diagrams that represent the evaluation results, a summary of those results, and discussion of the results.

Qualitative Analysis

Ease of access

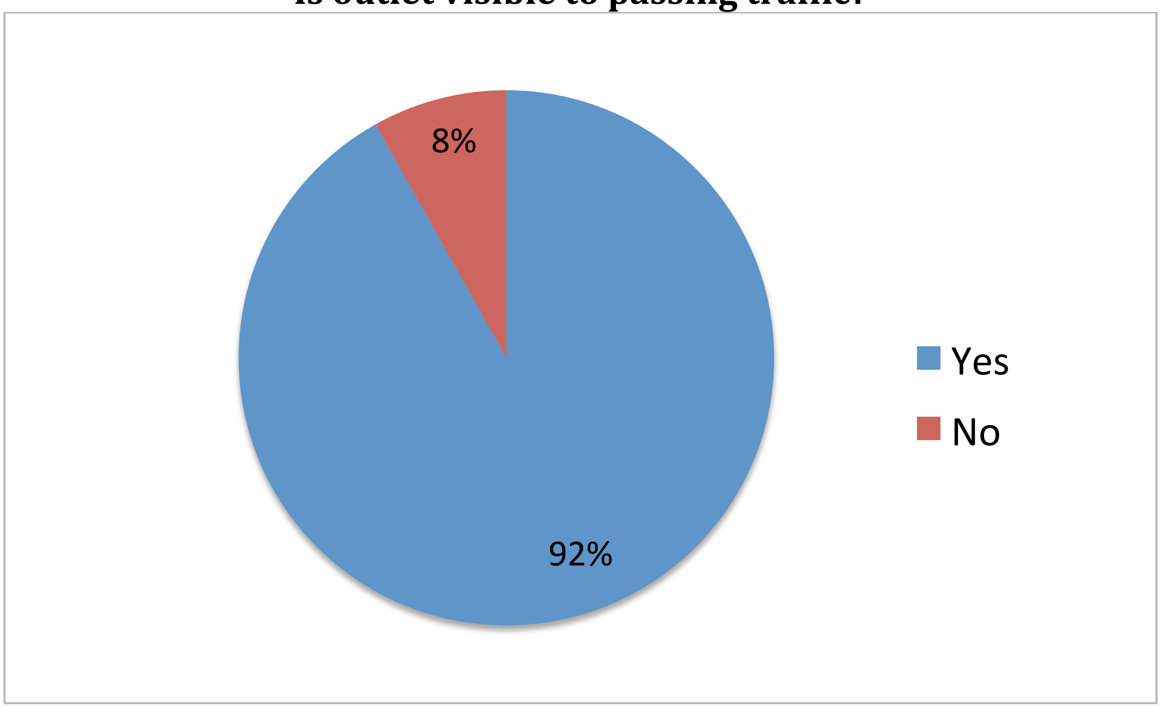
Visibility from building main entrances and to passing traffic was included in the evaluation to assess how easily an individual who was unfamiliar with each building could find the water outlets. Since the Technical Guidelines indicate that water fountains should ideally be located in lobbies and be visible from main entrances, this data was collected to gain a baseline understanding of how many buildings adhere to this guideline and where additional signage is needed.

Is outlet visible from a main entrance?



Subset of 90 outlets

Is outlet visible to passing traffic?



Sample size: 197 drinking water outlets

Summary:

- Two thirds of the drinking water outlets evaluated are not visible from the main entrances of their respective buildings
- 1% of water fountains are visible from library entrances within buildings
- The majority of drinking water outlets evaluated are visible to passing traffic within their respective buildings

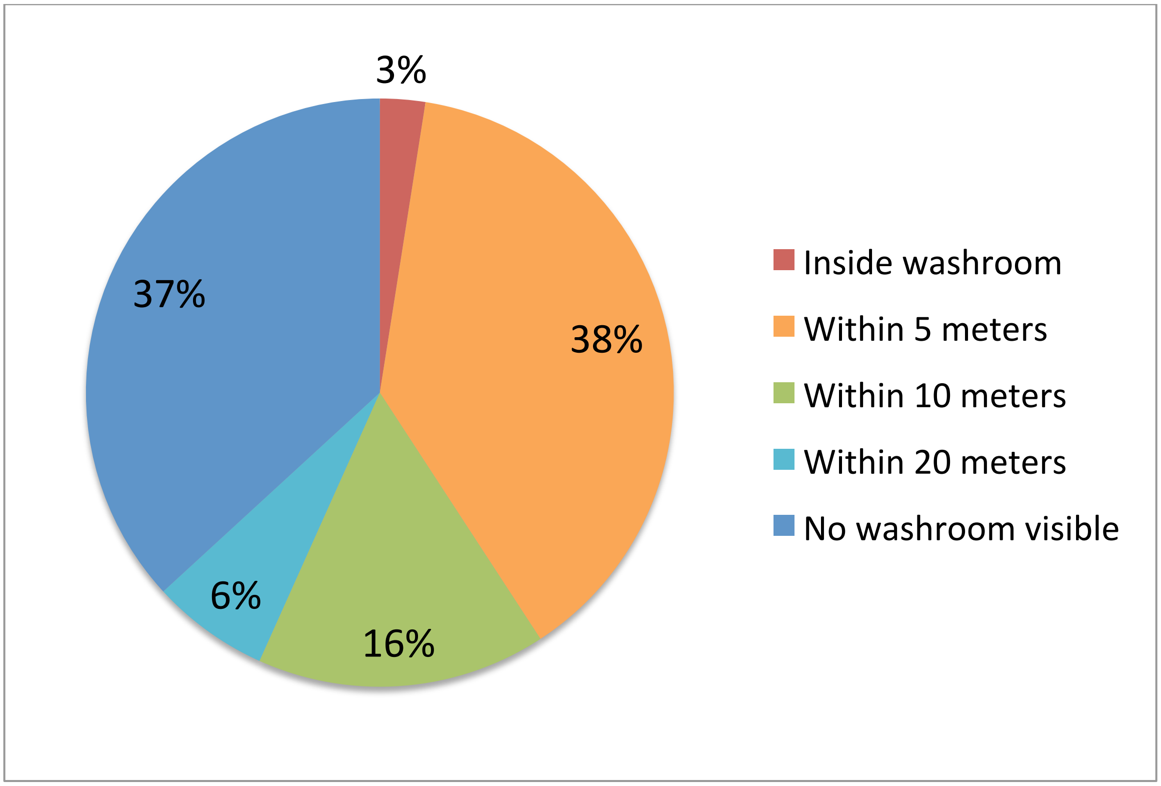
Discussion:

The subset of 90 water outlets assessed for visibility from main entrances reflects all first or main floor outlets and buildings that only have an outlet on an upper level. For example, the Music Building only has a WA-2 dispenser on the third floor and the Buchanan Tower's first water fountain is found on the second floor. Two thirds of the outlets that are visible from the main entrances of their respective buildings are found in buildings that have been built within the last 23 years. As the first draft of the UBC Technical Guidelines was written in 2002 after the majority of the buildings on campus were built (1930s to 1980s), it is no surprise that they do not adhere to the most current guidelines. It is also worthy to note that, though it does not appear that water fountains have ever been mandatory in buildings, the majority of the buildings do possess some form of water fountain. However, it is unclear of whether the fountains were installed when buildings were constructed or if they were added at later dates (personal communication with Greig Samodien, Mar. 21, 2013).

Since the majority of drinking water outlets from the subset are not visible from the main entrances of their respective buildings, the university's population needs to search for them once they enter the buildings. This is probably why there is the perception that water fountains are not adequately available on campus. Searching for water outlets in unfamiliar buildings probably deters people from fully committing to regular use. If informative tools and appropriate signage are available, the majority of the outlets could easily be found, as they are visible to passing traffic in major hallways. Signage is especially needed in buildings where water outlets are located in more secluded hallways and in corners. For example, in the Walter C. Koerner Library the water fountains on the fourth and fifth floors are in a corner near the Men's washroom. Although there is signage that indicates the general direction in which the water fountains are located, they are not evidently visible and somewhat misleading. Signage would be useful in libraries as bookshelves tend to block longer-range visibility. In other cases, water fountains are only visible to hallway traffic going in one direction because it is off to the side or around a corner.

Proximity to a washroom

Proximity to washrooms was evaluated because water outlets near washrooms are commonly perceived as being unhygienic. This data was collected to gain a baseline idea of how that perception may pertain to certain water outlets on campus and where additional information tools are needed.



Sample size: 197 drinking water outlets

Summary:

- 3% of drinking water outlets evaluated are situated inside a washroom.
- 38% of drinking water outlets evaluated are situated within 5 meters of a washroom.
- 37% of drinking water outlets evaluated are situated where no washroom is visible.
- 22% of drinking water outlets evaluated are situated within 10-20 meters of a washroom.

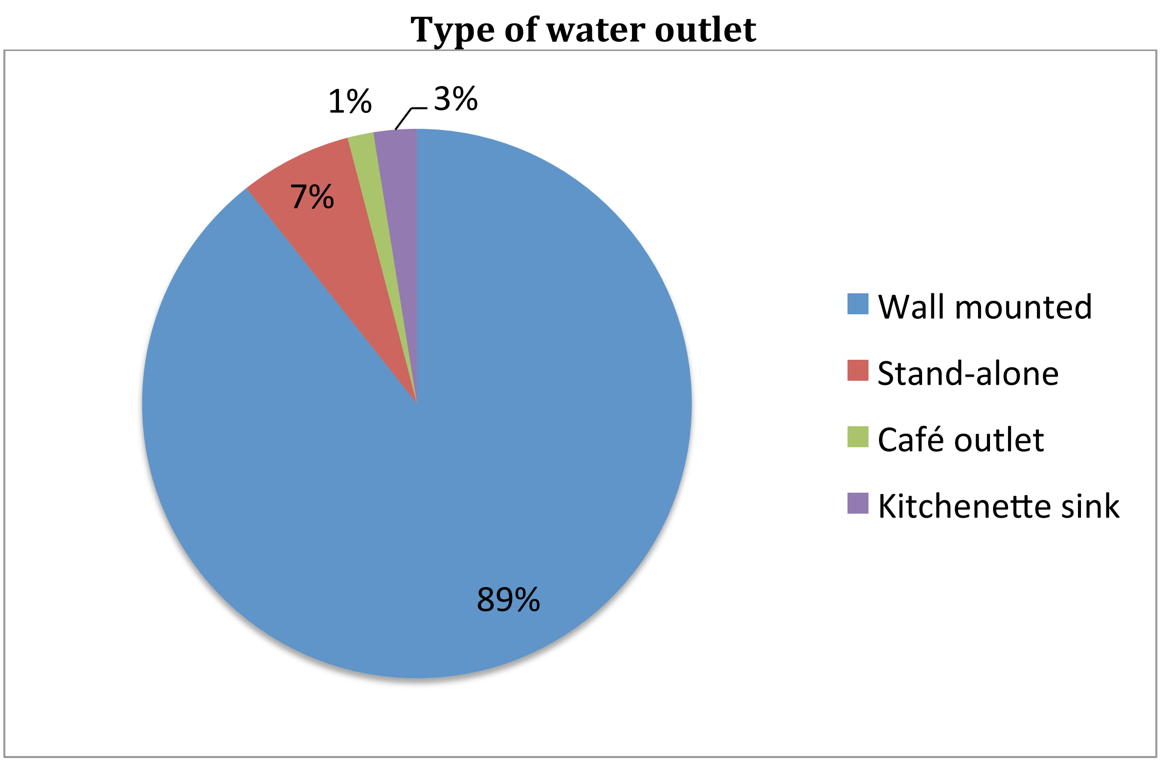
Discussion:

Interestingly, the percentages of water outlets within 5 meters of a washroom and with no washroom visible are almost the same. The three outlets that are located inside washrooms either have a spigot or gooseneck attached to a washroom sink. These are located in the Forest Sciences Building, Frederic Lasserre Building, and the Earth and Ocean Sciences Main Building. While outlets further away from washrooms may initially seem cleaner, they could be harder to find without appropriate signage. If custodians cannot find drinking outlets, they will be cleaned less frequently. Outlets that are in or near washrooms may have a better chance of being cleaned whenever the washrooms are cleaned. Water outlets near washrooms also have fresher water, because of the amount of flushing that occurs in the pipes. Unless a water fountain located farther away from a washroom is used frequently, the water tends to sit in the pipes longer and become stale.

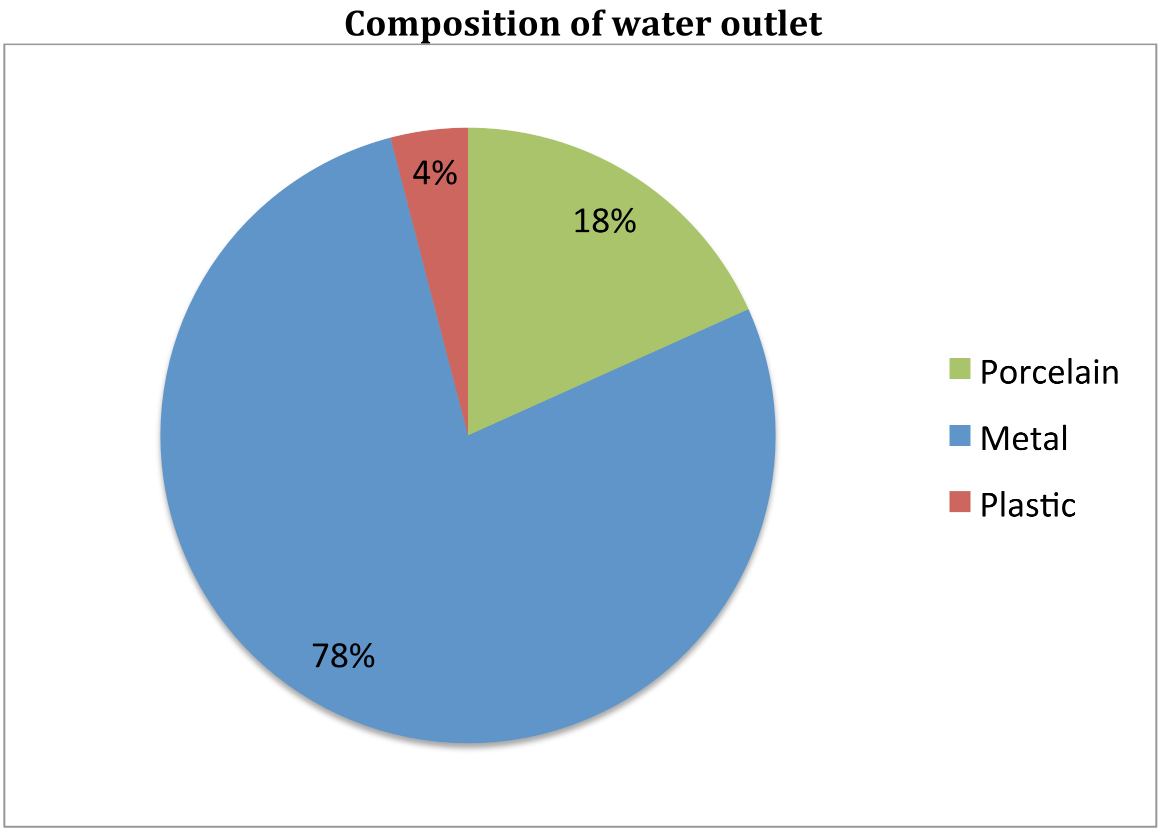
It would be beneficial to assess public perceptions of water outlets near washrooms and whether the public prefers water from outlets further away from washrooms. Once that data is collected, the full implications of this investigation's data will be clear. If the majority of the public perceives water outlets near washrooms as being unhygienic and will not drink from them, signage and other informative tools will be needed to ensure the safety and quality of water from 41% of the water outlets evaluated in this study.

Type and composition of water outlets

The type and composition of water outlets were evaluated in the survey to gain a baseline idea of how many different kinds of water outlets are available to students and staff on campus.



Sample size: 197 drinking water outlets



Sample size: 197 drinking water outlets

Summary:

- 89% of the evaluated water outlets are wall-mounted.
- 7% are free standing outlets with piping that connects to the building's water supply.
- 3% are kitchenette sinks accessible to students
- 1% are café outlets
- 78% of the evaluated water outlets are either completely metal or mostly metal
- 18% of the evaluated outlets are porcelain
- 4% of the outlets are plastic

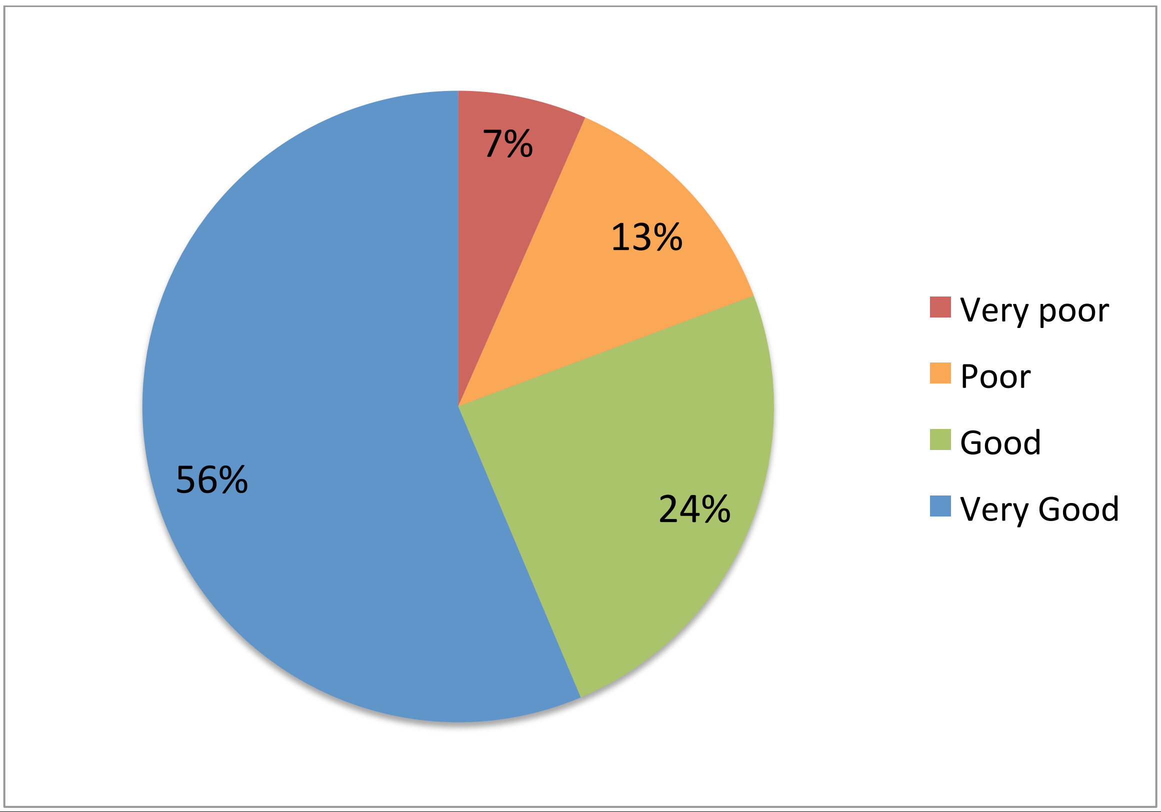
Discussion:

The majority of the evaluated water outlets on campus are metal wall-mounted water fountains. A unique water outlet that is also wall-mounted is the Brita Hydration Station in the Walter Gage Residence lobby. This outlet is solely for bottle filling and appears quite space-efficient. Free-standing outlets with piping encompass the new WaterFillz stations as well as any point-of-use coolers from private suppliers like Canadian Springs, WA-2 and Source H_2O by Van Houtte (Please refer to Appendix E for pictures of the different types of water outlets at UBC). Specific faculties finance these privately-owned dispensers and the suppliers service them whenever the filters need to be changed. Only kitchenette sinks that are accessible to students were evaluated. Other kitchenette sinks primarily accessible to staff and research personnel were also seen, but they were beyond the scope of this investigation due to time constraint and limited data collection capacity.

Further research should examine how many of these outlets are used on a regular basis and which ones the public prefers. There were at least 10 different types of water fountains seen on campus and further research would help determine which ones need to be upgraded in order to be used more frequently. It would also be beneficial to examine the life cycles of each of the evaluated outlet types to determine which ones are most cost effective and energy efficient in the long run.

Visual appeal of water outlet

Visual appeal was evaluated in the survey because it is one of the key factors that determine whether a water outlet is used. This data provides a baseline representation of which water outlets are clean and which ones need better maintenance.



Very Poor	Poor	Good	Very Good
Dirty outlet that has filth or residues	Moderately clean outlet that has filth or residues	Clean outlet that has minimal residues (only on a small portion of the outlet) or does not have filth/residues	Very clean outlet that does not have filth or residues. Looks very well-maintained

Sample size: 197 drinking water outlets

Summary:

- 7% of the drinking water outlets evaluated are either dirty or have a substantial amount of residues on them.
- 13% of the water outlets are moderately clean and have residues on them
- 24% of the water outlets are clean and either have minimal residues on them or do not have residues.
- Just over half the drinking water outlets evaluated are very clean and appear very well-maintained

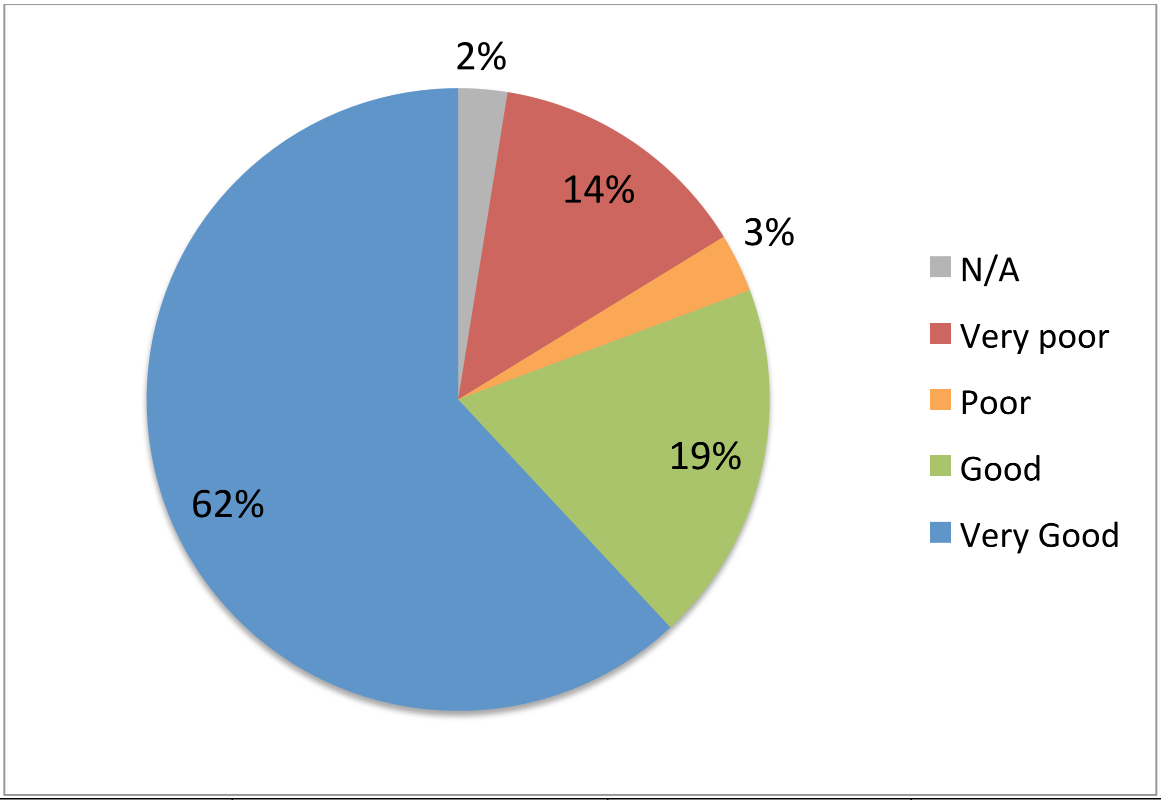
Discussion:

A key factor that determines whether or not an individual uses a water outlet is whether it appears clean and well maintained. Regardless of whether the outlet is fully functional, if the individual does not know or think that the water from an outlet is clean, they may not use it. UBC Building Operations have indicated that water fountains get serviced on a daily basis through the Building Operations custodial department, by scrubbing them with a neutral disinfectant. These results suggest that this is not the case for all water fountains on campus and there needs to be better maintenance on about 44% of the drinking outlets evaluated. If these water outlets are to be used by more people, they need to be kept clean on a daily basis.

Similar to the data regarding proximity to washrooms, the full implications of this data will be evident once public perceptions of outlets identified as Very poor, Poor, Good and Very good are assessed. This follow-up investigation would compensate for the most significant limitation of this component from the survey. Although the definitions of Very poor, Poor, Good and Very good were established before the surveys were conducted, personal interpretations of outlet cleanliness could have varied slightly between the people conducting the surveys. Due to time constraints and limited data collection capacity, one or two people assessed the majority of the water outlets at a given time. Having outlets classified by more people with the same parameters would have made this data more precise. In addition, standards of cleanliness vary from person to person. It is possible that a fraction of people on campus still would not drink from water outlets this investigation has classified as 'Good' or 'Very good'. Since the main objective of this data collection process was to gain a baseline idea of UBC's drinking water landscape, it was beyond its scope to assess public perceptions of its findings.

Water outlet pressure

Water pressure was evaluated because it is another key factor that determines whether a water outlet is used. This data provides a baseline representation of which water outlets have adequate water pressure and which ones need to be adjusted or fixed.



Very Poor	Poor	Good	Very Good
Insufficient water pressure to avoid mouth contact with fountain	Water pressure creates a sufficient arch, then decreases to an insufficient degree after a few seconds (~1 cm arch)	Sufficient water pressure to avoid mouth contact with fountain; placing mouth close to spigot may be required (~2 cm arch)	Water pressure creates a sufficient arch to easily place mouth in mid-stream and would allow easy filling of reusable water bottles

Sample size: 197 drinking water outlets

Summary:

- 2% of the water outlets do not work
- 14% of water outlets (all water fountains) have insufficient water pressure to avoid mouth contact with spigots.
- 3% of water outlets have insufficient pressure to maintain a water arch higher than approximately 1 cm.
- 19% of water outlets have sufficient pressure to avoid mouth contact with spigot.

- 62% of water outlets have sufficient pressure to create an arch where drinking occurs mid-stream and easily allows for bottle filling.

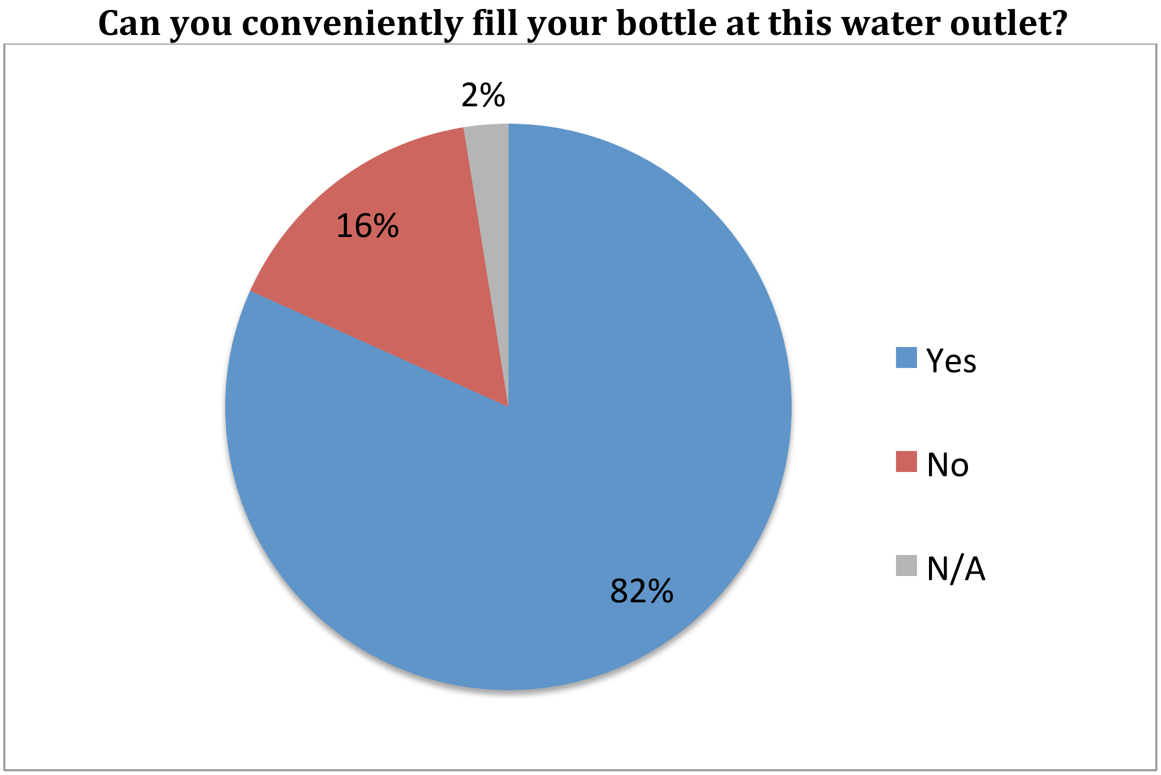
Discussion:

Another major determinant of water outlet usage is the outlet's pressure. If the pressure is not sufficient for an individual to avoid mouth contact with the fountain, it will likely be used less. Lower pressure also inhibits bottle filling from spigots and lengthens the bottle fill-time. This was further investigated in the water flow rate analysis. Some fountains had excessive pressure levels when their mechanisms were activated at full capacity, but it was generally easy to control the pressure after the initial spurt. These fountains generally splashed a lot or the water streams overshot the fountains themselves. Water pressure was slightly uneven at several water fountains and made it difficult to drink from them. Other water fountains' mechanisms had delayed responses and remained on a few seconds after they stopped being activated.

Ideally for optimal hygiene, drinking should occur midstream at least three or four centimeters away from the spigot. Further research could be done to gauge at which pressure most people start being deterred. Similar to visual appeal, different people most likely have varied standards for "adequate pressure". It is possible that some people on campus still would not drink from water outlets this investigation has classified as having 'Good' pressure, because they consider it inadequate.

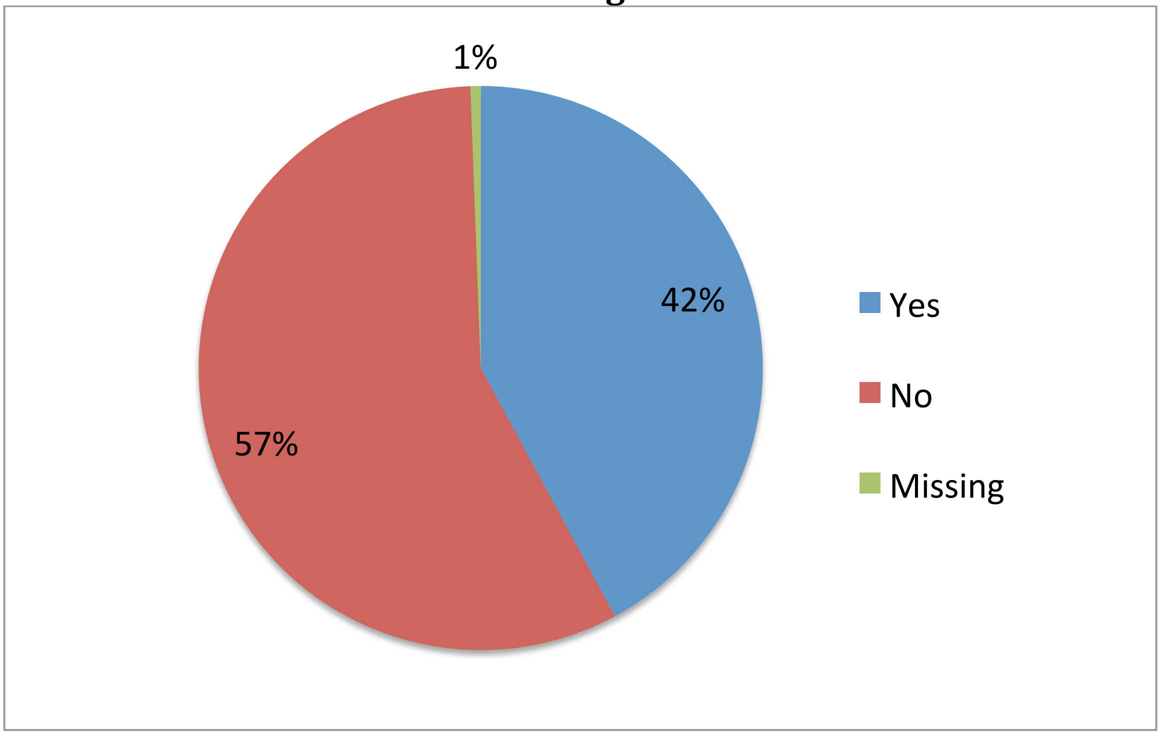
Compatibility with reusable water bottles

The ability to fill reusable water bottles and the presence of a gooseneck fixture were evaluated in the survey to assess how compatible the water outlets on campus are with reusable water bottles. This data was collected to gain a baseline idea of how many outlets are available and useful to students who own reusable bottles.



Sample size: 197 drinking water outlets

Does the water fountain have a gooseneck for water bottles?



Subset of 171 water fountains

Summary:

- Reusable bottles can be filled at 82% of the evaluated water outlets
- 42% of the 171 water fountains evaluated have goosenecks for bottles
- 2% of evaluated water outlets do not work
- 1 water fountain was missing a gooseneck (in Hennings near room 206)

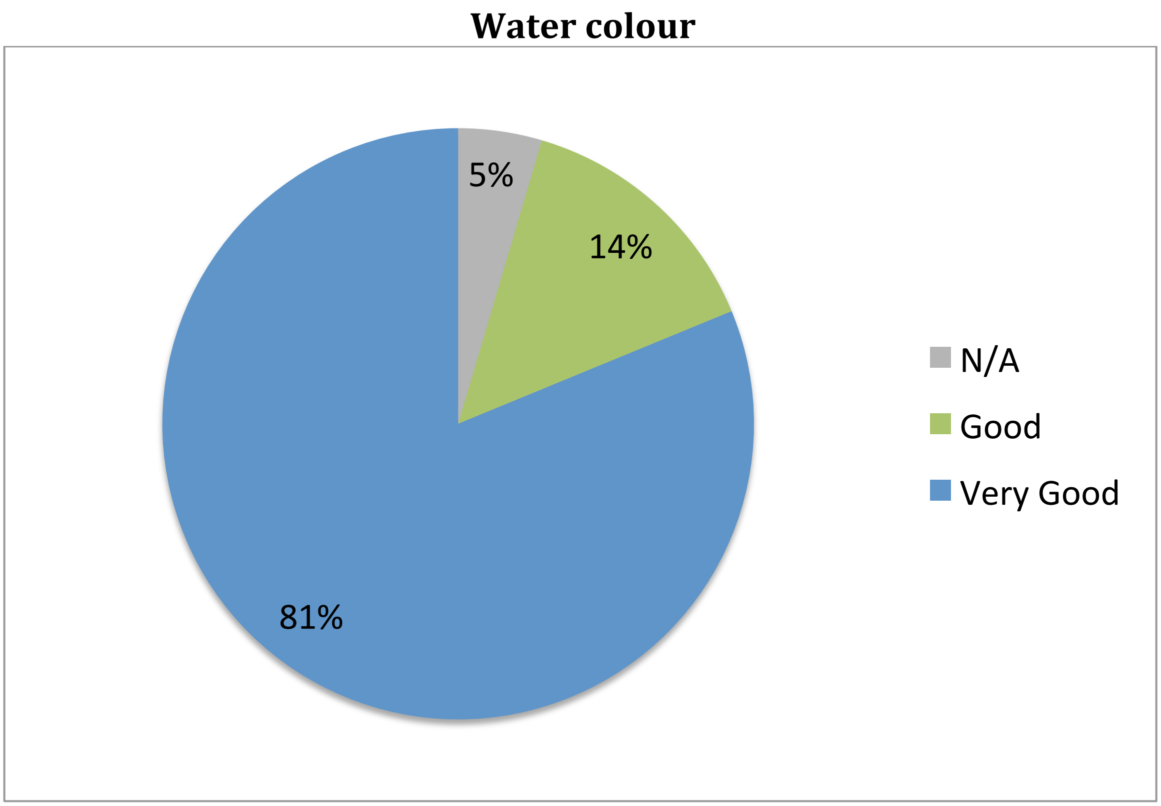
Discussion:

In Sadowski and Willock's (2010) survey, 83% of 517 respondents owned reusable water bottles. Assuming most students have reusable water bottles, they need to be able to fill them up when necessary. The public would be able to fill up reusable bottles at the majority of the water outlets evaluated regardless of whether they have goosenecks or not. Just under half of the water fountains evaluated have goosenecks, but that doesn't necessarily mean bottles cannot be filled at fountains without them. All 197 water outlets were assessed using taller water bottles with heights of either 20.5 cm or 21 cm, and any bottles equal to or shorter than those heights should be fillable. Water outlets that merited a "No" for bottle filling either did not work or had low pressure. For some outlets, lower pressure only allowed the test bottles to be filled halfway before the water started flowing out into the fountain. In these cases, the outlets also merited a "No" because the bottles could not be filled completely.

Observations on convenience and ergonomics were also collected. Though drinking from the spigot is possible at some older water fountains, bottle filling is not ergonomically favourable. In these cases, the mechanism usually needs to be activated with the same hand that would hold a water bottle. Other fountains that are embedded in the wall offer a very narrow space for bottle filling. Water outlets such as the WaterFillz stations, the Brita Hydration Station, café outlets, point-of-use water dispensers and goosenecks are quite easy to use. Further research could investigate which types of outlets the public prefers.

Water colour, odour and taste

Water colour, odour and taste were evaluated because they are also factors that determine whether people drink water from campus outlets.



Very Poor	Poor	Good	Very Good
Colour does not dissipate after 2 samples are assessed. Air bubbles do not dissipate after 5 minutes	Colour is present in first sample and is faint in second sample. Air bubbles dissipate after 2 minutes	Colour/air bubbles are present in first sample and are absent in second sample. Air bubbles dissipate after 30-40 seconds.	First sample is colourless and free of air bubbles

Sample size: 197 drinking water outlets

Summary:

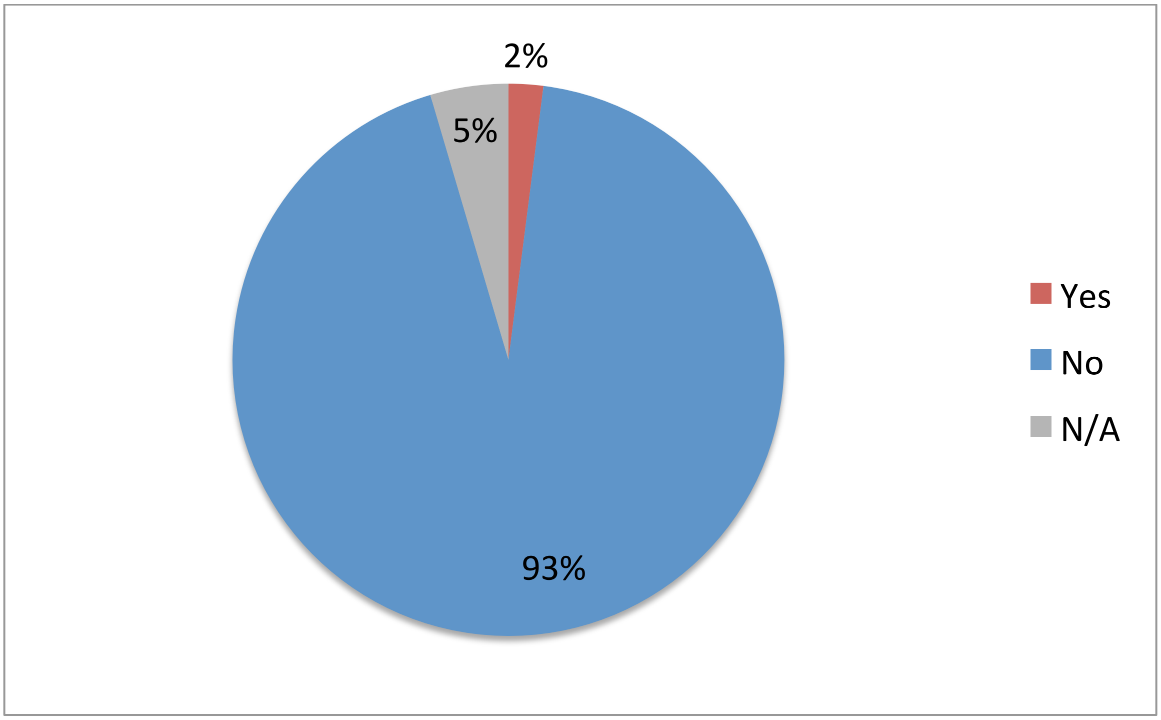
- Water from 81% of the water outlets was colourless and free of air bubbles (initial flush)
- Water from 14% of the water outlets had colour or air bubbles in the initial flush that was absent in the second flush 15 seconds after. Air bubbles dissipate after 30-40 seconds.
- 5% of the water outlets could not yield an adequate sample or did not work

Discussion:

Overall, water from the 197 evaluated water outlets was either classified as 'Good' or 'Very Good'. The outlets that yielded 'Good' water either had some visible impurities or a lot of air bubbles in the initial flushes. The only case where impurities were seen was on the third floor of the D.H. Copp Building, which most likely has older pipes that are not used very often. Other water fountains yielded cloudy water with a large quantity of air bubbles that dissipated within 30-40 seconds after the samples were drawn. This typically happens to cold water that sits in pipes for a while and warms up, because colder water holds more air than warm water. Air that is no longer soluble at the warmer temperature comes out of solution. Water pressure also contributes to adding air to the water. The water is pressurized in the pipes to transport it to buildings and out the water outlets. Water under pressure holds more air than water that is not pressurized. Once the water leaves a tap, spigot or gooseneck, the water is no longer under pressure, and the air comes out of solution in the form of tiny bubbles (USGS, 2013).

As this could pose issues from an aesthetic perspective, it is crucial that the public is aware that these occurrences are not harmful in any way. The campus needs to clearly communicate why people may see water bubbles in their water. It is suggested that people wait for 20-40 seconds until the bubbles disappear (USGS, 2013). Sometimes flushing the water for 15 seconds to one minute will ensure that colder water with more dissolved air is running through the pipes. If the bubbles do not clear up after three to five minutes, the public should be provided with contact information for UBC Building Operations, so that they can be notified.

Water odour



Sample size: 197 drinking water outlets

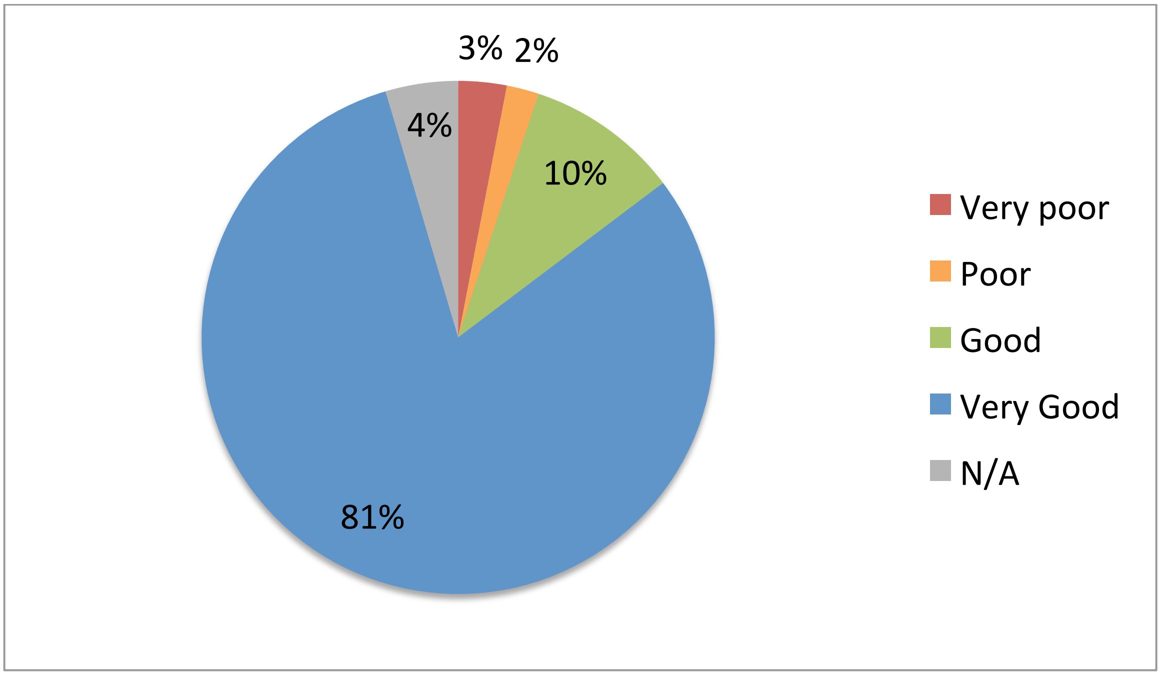
Summary:

- Water from 2% of evaluated water outlets had a slightly stale scent
- Water from 93% of evaluated water outlets did not yield any odours
- 5% of the water outlets could not yield an adequate sample or did not work

Discussion:

Generally, the tap water provided on campus does not have any strong odours. The 2% that did have a stale scent was in the same building (D.H. Copp Building) and the scent dissipated after flushing the water. These outlets had not been used in a very long time and water left in the pipes grew stale. If the usage of all the water outlets on campus was increased and more flushing occurred, water odours would be rare. Due to time constraints and limited data collection capacity, one or two people assessed the majority of the water outlets at a given time. Further research could examine whether several people can detect odours from certain outlets. Different people most likely have varied degrees of scent and some people may be more sensitive than others. It is possible that some people on campus can smell water odours that others cannot detect.

Water taste



Very Poor	Poor	Good	Very Good
Stale, metallic and other off-tastes that do not dissipate after 2 samples are assessed	Stale, metallic and other off-tastes detected in first sample and dissipate in second sample	Stale taste in first sample that disappears in second sample	No unpleasant taste is detected in first sample

Sample size: 197 drinking water outlets

Summary:

- Water from 3% of evaluated water outlets tasted stale or slightly metallic upon initial flush and after 15 seconds of flushing
- Water from 2% of evaluated water outlets tasted stale or slightly metallic upon initial flush and disappeared after 15 seconds of flushing
- Water from 10% of evaluated water outlets tasted stale upon initial flush and disappeared after 15 seconds of flushing
- Water from 81% of evaluated water outlets had no unpleasant tastes upon initial flush
- 4% of the water outlets could not yield an adequate sample or did not work

Discussion:

The water from the majority of the water outlets throughout campus tastes Very Good upon the initial flushes. Very Poor or Poor tasting water mainly came from water fountains that had not been used for a while. As a result, the water was left stagnant in the pipes and grew stale. Similarly to water odour, increased usage of water outlets and flushing will improve the taste of the water because it doesn't sit in the building pipes for very long. In most cases, flushing the water for a full minute is not necessary to get water that tastes Very Good. This investigation shows that flushing the water for 15 seconds is adequate. Since this study was done in the winter and spring, temperatures were generally cooler than in the summer time. It is expected that stale water could be encountered more frequently in the summer months because less people are on campus to use the outlets and less flushing will occur. Flushing is further discussed in the electrical conductivity and temperature section.

As has been previously stated in other data sections, the time constraints and limited data collection capacity only permitted outlet evaluations to be completed by one or two people. A follow-up investigation could involve a multi-disciplinary group that tastes the water from a set number of outlets on campus. The multi-disciplinary aspect would help ensure that data is less biased. Everyone who helped with data collection for this study was most likely accustomed to tap water already and therefore would have had different standards for taste than an individual used to drinking bottled water. More taste tests would increase the validity of this investigation's data.

Other Observations from Evaluations

- Objects like recycling bins, garbage cans, vending machines and desks were seen in front or beside some water fountains. This obstructs the water fountains and makes it inconvenient to use these outlets.

- It is apparent that some people like to use water fountains to clean their cups. When the water fountains in Woodward Library were evaluated, tealeaves had been left in two of the water fountains. This affects overall perception of a fountain's cleanliness. A sign next to the water fountain on the second floor of the Scarfe Office Block reads: "Please do not empty coffee cups into fountain!!!!!" On another floor of the same building block, a staff member was seen emptying his coffee mug into the water fountain and rinsing it out.

- Other water outlets were situated in dim or dark areas of buildings, which may deter some people from using them. A well-lit water outlet is more inviting and provides good visibility of the outlet's cleanliness.

- In addition to the 197 evaluated outlets, an outdoor water fountain was found in the space between Brock Hall and the Student Union Building. Although time constraints did not permit a full evaluation of this water fountain, it was noted that it does not work and does not appear to have been used in a while.

- Some water fountains drained extremely slowly or their drains seemed slightly clogged. This could affect overall perception of sanitation of these water fountains, because some people may be concerned about hygiene.

- In addition to privately owned point-of-use coolers that are connected to UBC's water line, water dispensers with 11-Litre and 18-Litre jugs were also seen throughout campus. These are financed through specific departments and offices.

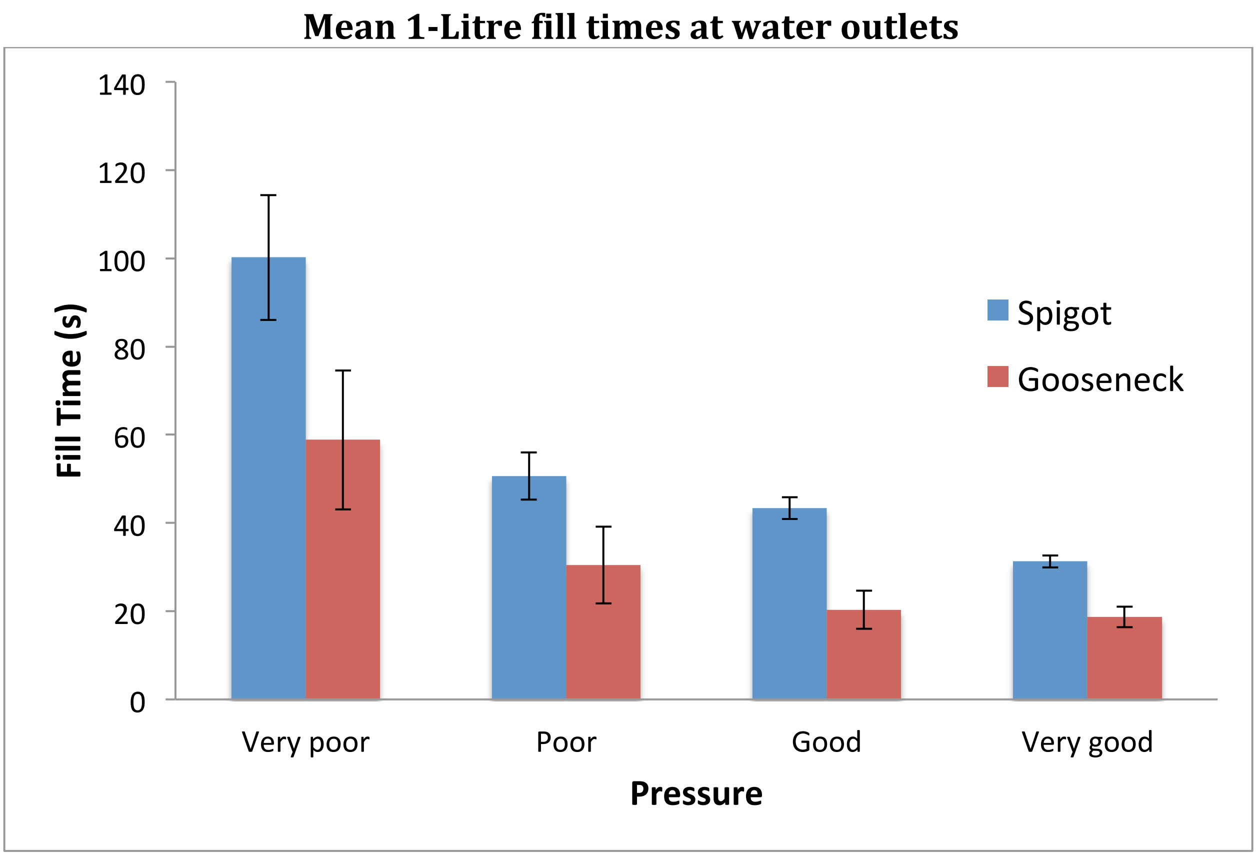
- At the WA-2 water dispenser in Milano (Henry Angus Building), wax cups are available, where 7-8 cups were used and disposed during the 10-minute evaluation. It would be better to offer the corn-based plastic cups instead of wax-coated cups and even more ideal to eliminate waste at these dispensers. Students should be encouraged to use their own cups and reusable bottles through limited access to wasteful options. This water station also has an advertising card that suggests that Metro Vancouver water is not safe to drink. It states: "Drinking water in Metro Vancouver often has taste and odour issues, contains chlorine and may harbour harmful contaminants". It prompts the public to be concerned about Metro Vancouver's water quality and to drink filtered water. Having advertisements for bottled water and commercially filtered water causes the public to question the quality of tap water available on campus.

- Glass water pitchers and tumblers are available in the Geography Lounge. Students and staff can freely borrow them for meetings and study sessions.

Quantitative Analysis

Water flow rate

Water flow rate was assessed to determine convenience implications of the water pressure results. This data indicates the times needed to fill a 1-Litre bottle at a given water source.



Subsets of: 14 9 5 4 22 11 59 23

Summary:

- The mean 1-Litre fill times decrease as water pressure increases
- The mean 1-Litre fill times of goosenecks are shorter than the fill times of spigots

Discussion:

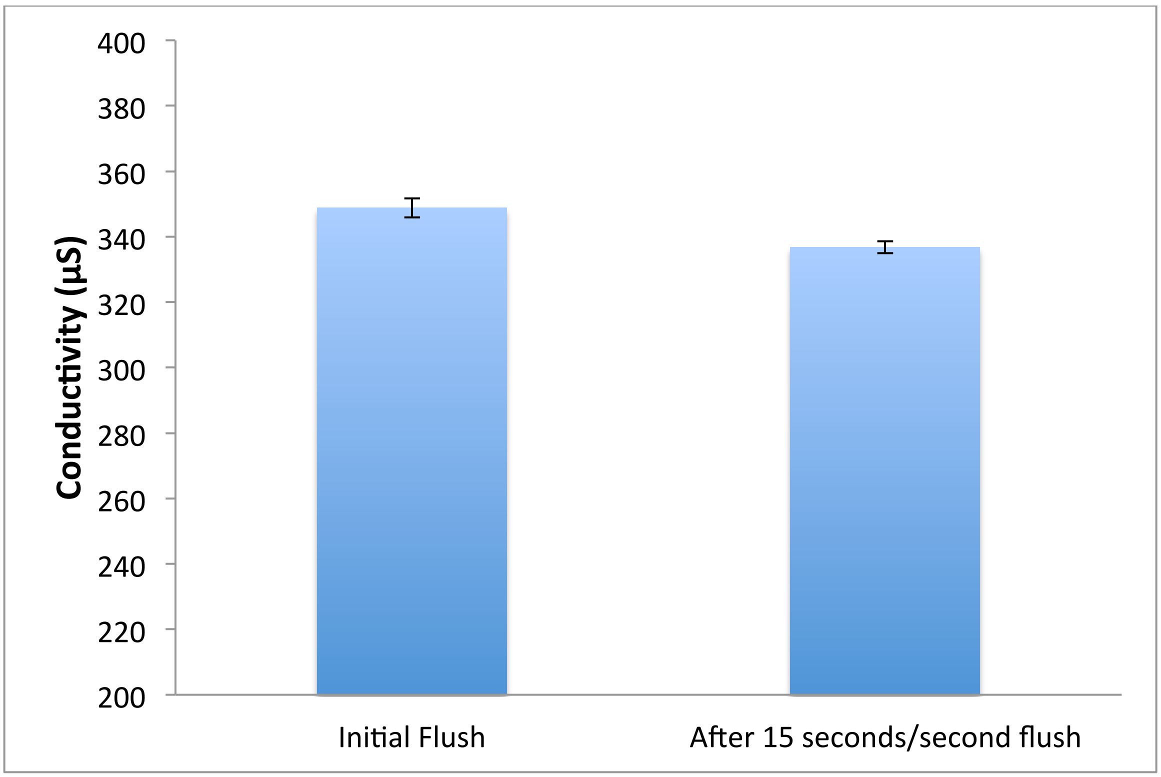
This water flow rate analysis emphasizes how water pressure affects water outlet usage. At outlets with 'Very poor' pressure, it takes an average of 100 seconds to fill up a 1-Litre bottle. In contrast, it takes an average of 31 seconds to fill up the same volume at outlets with 'Very good' pressure. Goosenecks further decrease those fill times to 58 seconds and 18 seconds respectively. Depending on how long people are willing to wait while their bottles are filled, some outlets may not meet their expectations. Assuming an individual owns a 1-Litre bottle and they prefer to wait about 30-40 seconds at any given outlet, they will tend to avoid outlets with 'Very poor' pressure, and spigots with 'Poor' and 'Good' pressure. This accounts for about one third of the initial 197 outlets evaluated depending on whether the outlets have goosenecks. The goosenecks have proven to be significant time savers and there is potential for more to be installed in compensation for lower pressure spigots. Often fountains whose spigots have lower pressures also have goosenecks with lower pressures. However, this is not always the case. In Allard Hall, a water fountain's spigot had a 1-Litre fill time of 226 seconds and its gooseneck had a fill time of 11 seconds. Further research could investigate which 1-Litre fill times people prefer and at what fill times people start being deterred.

Since there could be slight variations in how water pressure was initially interpreted, 1-Litre fill times could have been quite similar between categories. This is seen between outlets with 'Poor' pressure and 'Good' pressure. Their mean 1-Litre fill times differ by about 7 seconds and the standard error bars overlap for both spigots and goosenecks. Due to time constraints and unequal availability of outlets with different pressures, different subset sizes were assessed.

Electrical conductivity and water temperature

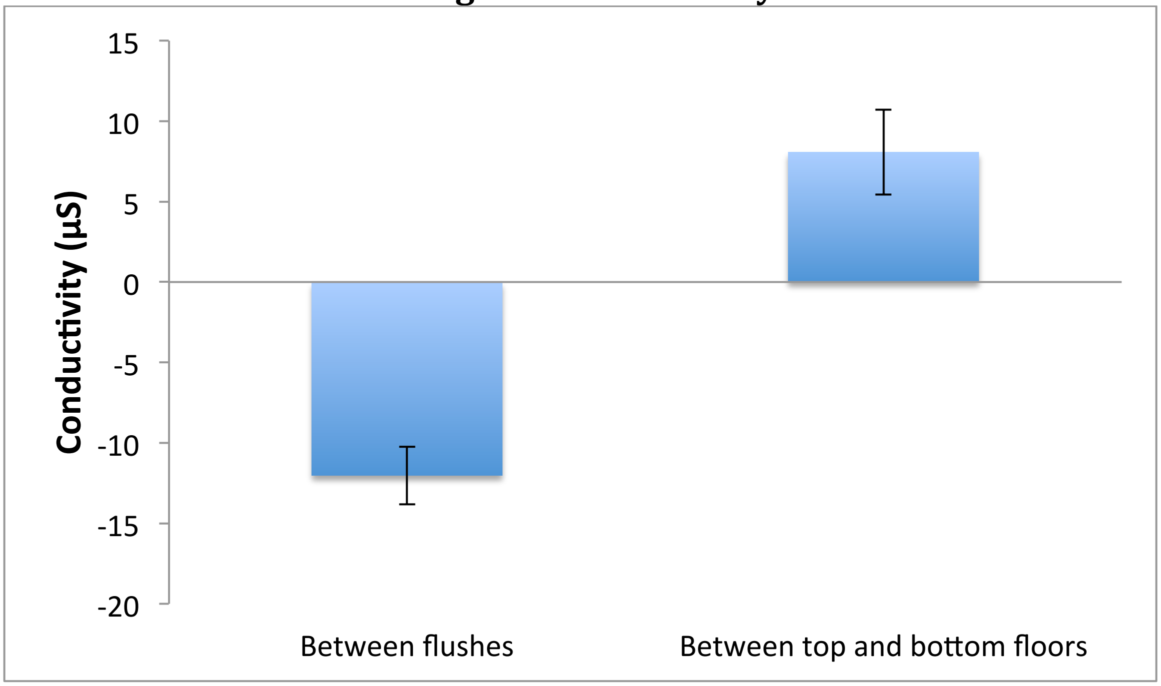
Electrical conductivity and water temperature were measured to assess whether building piping altered water quality. Most people prefer to drink colder water and this data provides a baseline representation of the mean water temperature from outlets on campus. Mean changes in water conductivity and temperature between initial and 15-second flushes as well as between top and bottom floors are compared. This data summarizes the benefits of flushing and how much building piping changes water conductivity and temperature. Three of the newest water outlet models (WaterFillz units, Brita Hydration Stations and Elkay EZH_2O fountain) were also compared to the water temperature minimums, maximums and means.

Mean conductivity values from water outlets at UBC



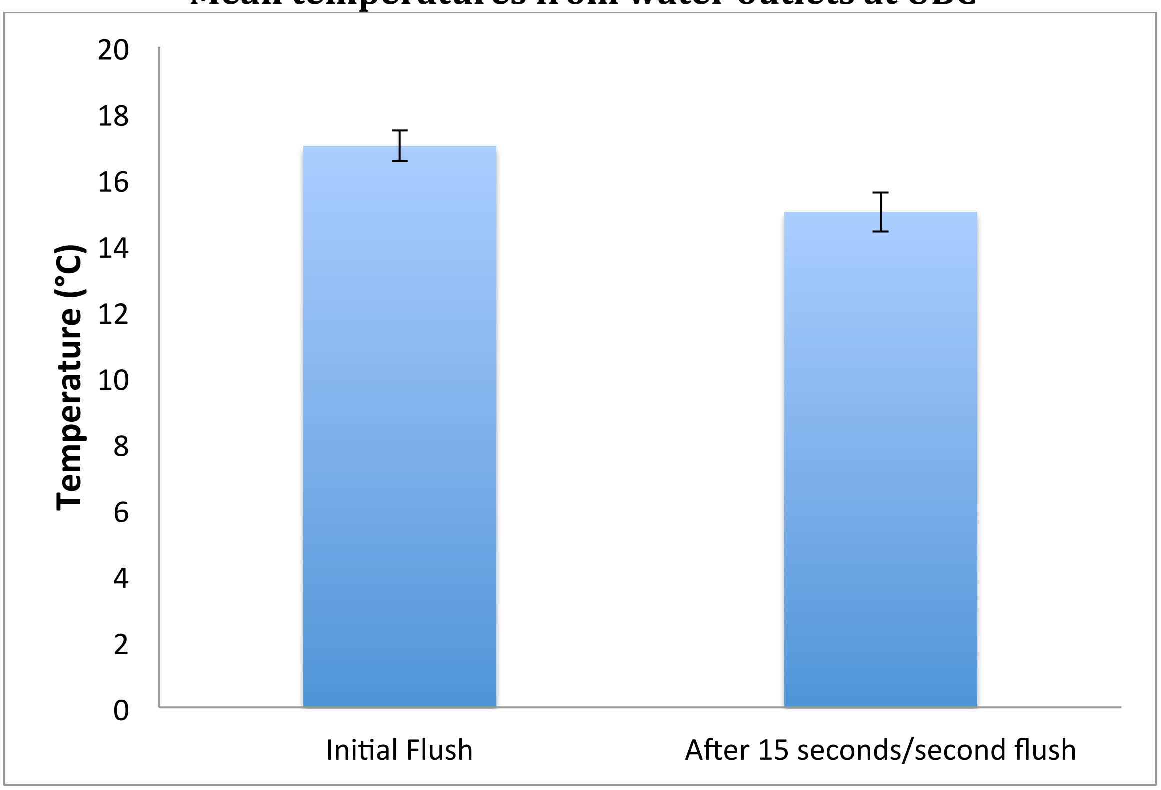
Subset of 59 outlets

Mean changes in conductivity values



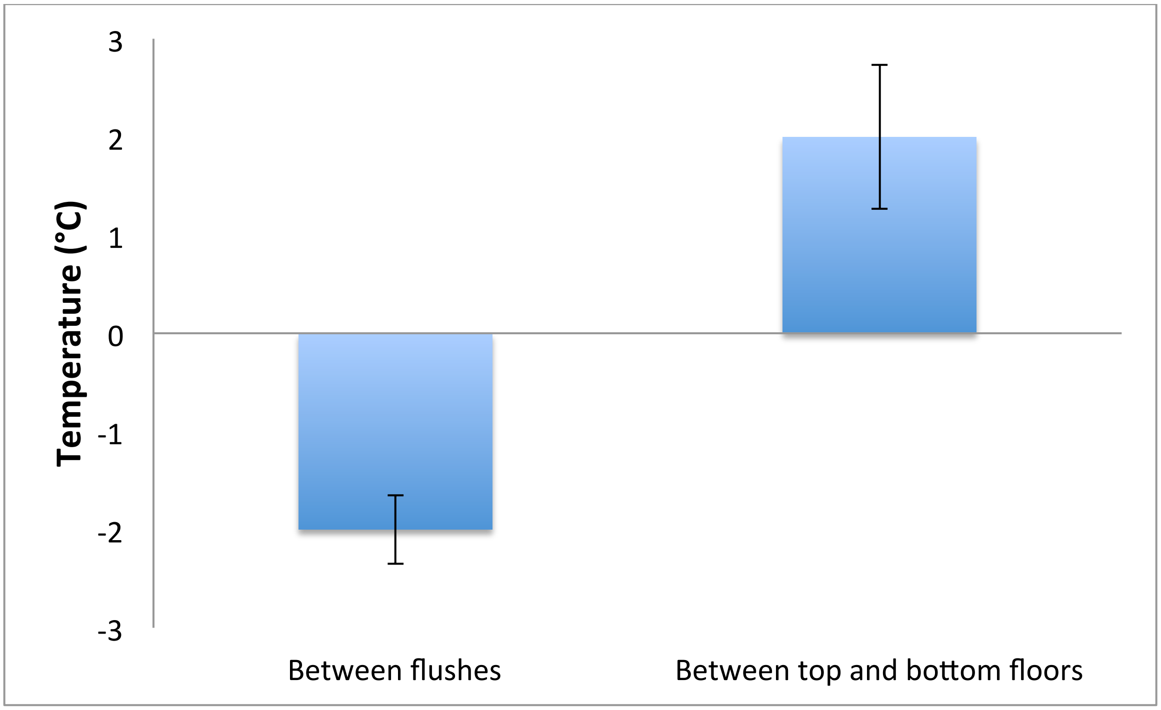
Subset of 59 outlets

Mean temperatures from water outlets at UBC



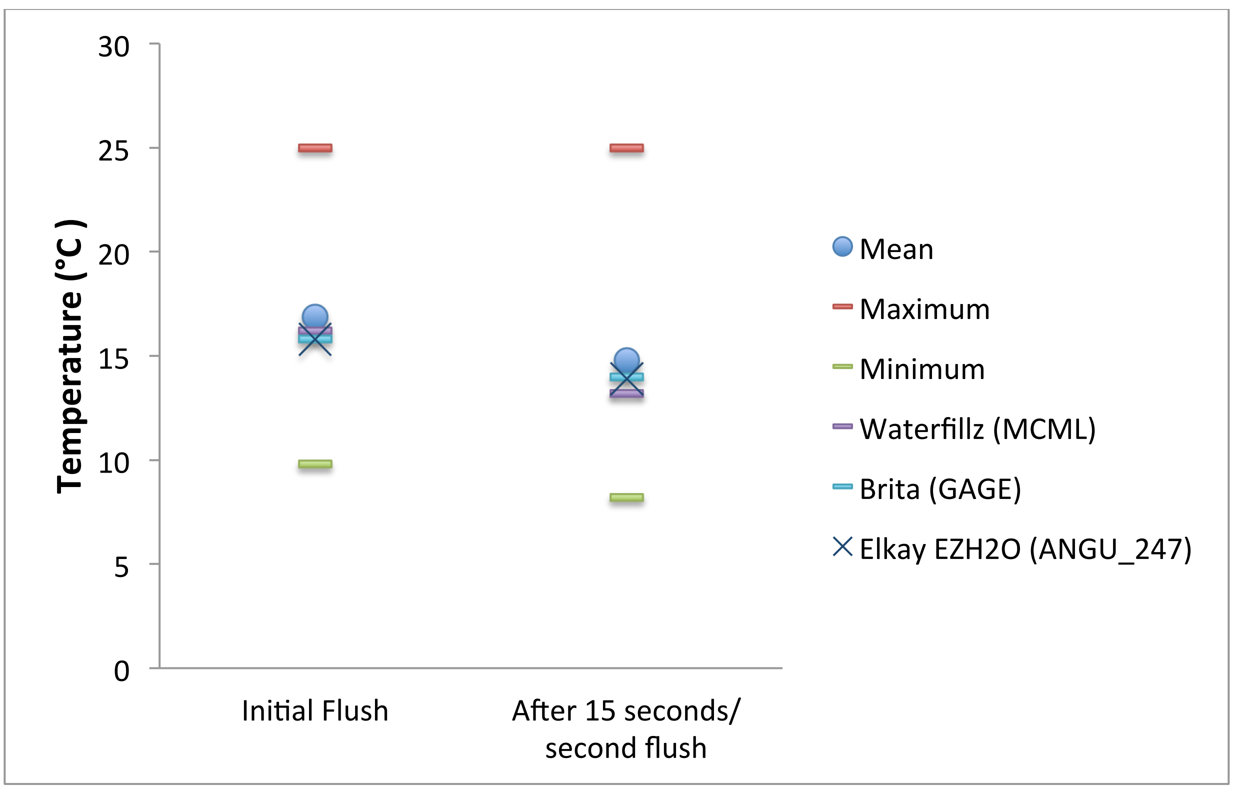
Subset of 57 outlets

Mean changes in water temperatures from water outlets at UBC



Subset of 57 outlets

Selected temperatures from water outlets at UBC



Subset of 57 outlets

Summary:

- The mean electrical conductivity at selected water outlets was 349 μS upon initial flushes
- The mean electrical conductivity dropped to 337 μS after 15 seconds of flushing
- The mean change in conductivity between flushes was -12 μS
- The mean change in conductivity between top and bottom floors was 8 μS

- The mean water temperature from outlets was 17°C upon initial flush
- The mean water temperature dropped to 15°C after 15 seconds of flushing
- The mean change in water temperature between flushes was -2°C
- The mean change in water temperature between top and bottom floors was 2°C

- The water temperature of the WaterFillz unit in MacMillan was 16.2°C upon initial flush and 13.2°C after 15 seconds of flushing
- The water temperature of the Brita Hydration Station in Gage Residence was 15.8°C upon initial flush and 14°C after 15 seconds of flushing
- The water temperature of the Elkay EZH_2O fountain near room 247 in Henry Angus was 15.8°C upon initial flush and 13.9°C after 15 seconds of flushing

Discussion:

The electrical conductivity of water is a widely used measurement of total dissolved solids that separate into ions. These solids are different types of salts, nitrates, nitrites, phosphates and minerals. Electrical conductivity is a general measurement of all the charged chemical species in the water and specific ions are not identified. Tap water conductivity values typically range from 50 and 800 microsiemens (μS) and overall, the conductivity readings from campus were within that range (California State Water Resources Control Board, 2004). Electrical conductivity values from UBC's drinking water outlets ranged from 315 μS to 438 μS. The water from a Dasani water bottle was also tested and it yielded a measurement of 593 μS. This is most likely because the company adds minerals to its water as extra nutrients and to adjust taste properties.

On average, electrical conductivity decreased by 12 μS after flushing the water for 15 seconds. It also increased by an average of 8 μS when water from top floors was tested and compared to water from bottom floors. These results indicate that, as water travels to higher floors, the conductivity minimally increases. Conductivity is affected by temperature and increases at higher temperatures. The results are reasonable because water usually warms up as it travels through building pipes. During this investigation, water temperature rose by an average of 2°C when water from top floors was measured and compared to water from bottom floors.

Water temperatures started out at an average of 17°C upon initial flushes and dropped to a mean value of 15°C after flushing the water for 15 seconds. The average change in water temperature between 15-second flushes was -2°C. According to Health Canada's Guidelines for Drinking Water the aesthetic objective for water temperature should be 15°C or less.

Temperature indirectly affects health and aesthetics through impacts on disinfection, corrosion control and formation of biofilms in the distribution system (Health Canada, 2012).

When water temperatures from three newer types of outlets on campus (WaterFillz units, Brita Hydration Station and the Elkay EZH_2O fountain) were compared, all of them yielded temperatures that were cooler than the overall means from the original data set of 57 outlets. Further research could investigate which one of these water outlet models are most cost effective and energy efficient. Water temperatures from older water fountain models fluctuate more because some of them aren't used as often. More flushing keeps cooler water moving through the pipes. In some cases flushing for more than 15 seconds may be required for cooler water. At the water fountain in Chemistry Block B near room 160, the water temperature started out at 19.5 °C and rose to 24°C after a 15-second flush. Water from the fountain on the fourth floor of the D.H. Copp Building started out at 22.7°C and rose to 25°C after 15 seconds of flushing. A few weeks later, a fountain on the third floor was revisited and water temperature decreased substantially after flushing the water for about one minute. Sadowski and Willock's survey indicated that most people prefer to drink water at a cold temperature. Further research could also specifically establish the public's standards of 'cold' and correspond temperatures to them.

It is crucial that the public is informed of the benefits of flushing the water at outlets. Flushing may initially be perceived as an inconvenience since the one-minute flush is commonly suggested. However, encouraging flushing for shorter periods like 15 seconds may be more appealing. In summary, flushing ensures that colder water is dispensed, it may decrease the amount of air bubbles, and it disposes of stale water left in piping. Further research could investigate how long people are willing to flush water at water outlets and environmental impacts associated with wasting water.

Recommendations

In response to the findings from the water outlet inventory and evaluation as well as the immediate follow-up steps to the Tap That campaign, the following goals and actions are recommended to increase free drinking water accessibility on UBC's Vancouver campus.

Goal 1: Improve the infrastructure and increase convenience of tap water usage available on campus

As the results from the water outlet evaluations show, some outlets require enhanced maintenance from the UBC Building Operations custodial services. It is recommended that water outlet cleaning procedures (mentioned under Visual appeal of water outlets in the Findings & Discussion section) are reviewed and revised to ensure that outlets are kept clean on a daily basis. The water pressure of at least 33 water fountains needs to be adjusted and eight water fountains that do not work need to be repaired. Various upgrades would also increase accessibility and reusable water bottle compatibility. Goosenecks or bottle fillers could be added to the water outlets in the following locations to increase convenience and decrease fill times. The list is arranged by priority according to level of traffic attributed to the buildings.

- Hennings near room 206 (needs to be replaced) – High student traffic
- Irving K. Barber Learning Centre and Library – High student traffic
- Walter C. Koerner Library (Levels 1-3) – High student traffic
- Hugh Dempster Pavillion – High student traffic
- Continuing Studies – Lower student traffic
- Institute for Computing, Information and Cognitive Systems/Computer Science – Lower student traffic
- Wayne and William White Engineering Design Centre – Lower student traffic
- Jack Bell Building for the School of Social Work – Lower student traffic
- Woodward Instructional Resource Centre (Levels 3 and 4) – Office space

(Tran et al., 2012)

Outlet model upgrades in the following buildings would improve visual appeal and increase convenience. The list is arranged by priority based on the traffic levels.

Visual appeal

- Chemistry Building – These fountains are quite old and need to be cleaned. Upgrading them to more current models would most likely increase usage. The Chemistry building has been identified as a building with high student traffic.

- Macleod Building – The majority of the water fountains in these buildings are porcelain. Some of them need to be cleaned and are not visually appealing. These upgrades are not highly urgent because each of these buildings has at least one newer water fountain with goosenecks. The Macleod Building has been identified as buildings with high student traffic.

- Robert F. Osborne Centre (Unit 1) – The porcelain water fountains in Osborne Unit 1 are quite old and not very attractive. Similar to the Chemistry Building situation, upgrading these fountains to more current models would probably increase usage. Since Osborne Centre is used for recreation, it is recommended that these water fountains be upgraded in the shorter term.

- D. H. Copp Building – These older porcelain water fountains are not very appealing and have not been used for a very long time. They are not ergonomically compatible with reusable water bottles. Replacing them with more modern models would improve visual appeal and increase usage. Similar to Buchanan Tower, upgrading may not be possible unless the building gets renewed. The urgency of these upgrades is also up for discussion, because water outlets are accessible within the Woodward Instructional Resource Centre and a WaterFillz unit will be added to Woodward IRC soon. This may be adequate in the short term, but longer-term upgrades should be discussed to increase convenience within the D.H. Copp Building itself.

Convenience

- Frederic Lasserre and Forest Science buildings – additional water outlets aside from these washroom outlets would increase free drinking water accessibility within their respective buildings. The Forest Sciences building has been identified as a building with high student traffic.

- War Memorial Gym – Only one water fountain was identified in this building, but it is not in a very obvious location. It is recommended that a second water outlet be installed in the lobby area, since it is a recreational building.

- Robert F. Osborne Centre (Unit 2) – The metal fountains in Osborne Unit 2 are aesthetically reasonable, but they are not ergonomically compatible with reusable water bottles. Since Osborne Centre is used for recreation, it is recommended that these water fountains be upgraded in the shorter term.

- Buchanan Tower – These water fountains need to be cleaned and are not ergonomically compatible with reusable water bottles. Upgrading may not be possible unless the building gets renewed. The urgency of these upgrades is up for discussion, because water outlets are accessible within the Buchanan classroom blocks and Stir It Up café. However, this is not a viable long-term solution as convenience will be an issue for the staff who work in the tower's offices.

- Food Nutrition and Health (FNH) Building – These water fountains are embedded into the wall and are not very compatible with reusable water bottles. Just like the Buchanan Tower and D. H. Copp Building cases, upgrading may not be possible unless the building gets renewed. The urgency of this upgrade may be higher because the building is further away from other buildings with more modern water outlets. The closest outlet would be the water fountain in Wesbrook Building, since the kitchenette sink in the FNH Building is only accessible to staff and graduate students.

- Marine Drive Residence (Commons Block)- This building did not have a drinking water outlet and installing one would increase water accessibility. However, the urgency of this upgrade is up for discussion as most of the resident units have their own kitchenette sinks.

- Hebb Building near room 9L – Upgrading this water fountain is not urgent, because newer outlets with goosenecks are available on subsequent floors.

(Tran et al., 2012)

The locations the proposed for WaterFillz unit installations are not confirmed and negotiations with Building Operations are still in progress. Aside from the one to be installed in Woodward IRC, another one has been put in the Fred Kaiser Building (personal communication with Justin Ritchie and Greig Samodien, April 4, 2013). When considering the installation of WaterFillz units or Brita Hydration Stations, it is important to consider whether there are other drinking water options within the targeted building. The majority of the following buildings that were shortlisted for WaterFillz units have other types of water outlets available, and require upgrades and/or appropriate signage and informative tools.

Buchanan A & D	Hugh Dempster Pavillion
Irving K. Barber Learning Centre	Life Sciences Building
Henry Angus Building	Geography Building
Neville Scarfe Building	Mathematics Building
ICICS/ Computer Sciences	

The Earth and Ocean Science Main Building has limited access to drinking water because its outlets are located in washrooms. However, water is accessible in the newly constructed Earth Sciences Building through its water fountain and Magma's café outlet. A water outlet upgrade or WaterFillz unit would increase free drinking water accessibility in the Forest Sciences building. It is recommended that a WaterFillz station be put in the Forest Sciences Building, because all its water outlets are in washrooms and it has been highlighted as a building with high student traffic. Since the H. R. Macmillan Building already has a WaterFillz unit, the upgrade is not extremely urgent. Other neighbouring buildings across Agronomy Road (ICICS and Hugh Dempster Pavillion) also have water fountains that are accessible. In the short term, the interactive water outlet map and informative tools would help inform students of tap water safety and alternative water access solutions. However, longer-term water access solutions for the Earth and Ocean Science Main Building and the Forest Sciences building should be discussed, as convenience will be an issue for the students and staff within these buildings.

It is also recommended that more extensive policies for drinking water outlets be developed in addition to the Technical Guidelines. The Technical Guidelines cover the planning and construction of new buildings, renewals and renovations. Additional policies could address issues like obstruction from desks and garbage cans, hygiene, cup rinsing, proximity to vending machines, drainage, visibility and lighting. Specific student-to-water-outlet ratios need to be established as well as whether it is better to have several water fountains within a building on multiple floors, or one more advanced filtration unit (WaterFillz or Brita Hydration Station) on the main floor of the building. Sadowski and Willock (2010) identified convenience as both a barrier to and a reason for using personal water bottles. Having water fountains on multiple floors of buildings would increase accessibility and convenience, because people wouldn't need to travel between floors.

Goal 2: Increase awareness and promotion of tap water available on campus

As discussed in the literature review and discussion sections, communication about where drinking outlets are located and other informative tools on water safety are necessary. They provide a metaphorical safety net that empowers the public to use the free drinking water outlets on campus and prevents the public from buying commercial bottled water every time they need drinking water (Please refer to the diagram in Appendix F). In addition to the intended H_2O page on the UBC Mobile App and safer water brand, there are other ways in which UBC could increase awareness of free drinking water access. As a follow-up project to the interactive Google Map component of this project, UBC could develop a campus-wide interactive map similar to the one that the University of Toronto provides. This map could be accessible from the UBC Sustainability website under the Water Initiatives section. The scope of the map could also be expanded to include kitchenette sinks in research buildings, the Aquatic Centre, and the Doug Mitchell Sports Centre. This campus-wide map could be a collaborative effort between campus management and future research projects from the SEEDS Program.

A complete webpage could also be accessible from the UBC Sustainability Water Initiatives section as well. This webpage would include a link to the campus-wide map and provide information about campus bottled water policies as well as campus water quality. Additionally, a FAQ section modeled after U of T's FAQ page could be written to address immediate inquiries from students and staff. A drinking water guide could also be developed through another SEEDS project to provide the campus with drinking water tips, to highlight the benefits of flushing and to raise awareness about air bubbles. A drinking water map could also be included in this guide and be found in brochures as well as the AMS student planner.

Another web feature, accessible from either of the UBC Sustainability Water Initiatives or UBC Food Services websites, could offer a similar service that Urbanspoon provides. Urbanspoon is a website where the public can rate and review restaurants, and others can refer to this information. For example, if the public can see that a given water outlet has already been used by 100 people and 95% of those people indicate that they like it, then other people will most likely be willing to try that same water outlet. Users can indicate what they like or do not like about specific water outlets through comments, and UBC Building Operations could further use this information to gauge where maintenance and upgrades are needed. The website would facilitate the outlet monitoring process and would also communicate which outlets are used more frequently. This idea could also be expanded to include food outlets on campus and used as a means to monitor general food preference trends.

Promotional videos made by student groups like Common Energy or through SEEDS projects could feature specific outlets on campus and provide drinking water tips. These videos could be viewed from the UBC Sustainability webpage and cover the following topics:

- Feature certain water bottles and why students choose to use them
- Challenge current negative perceptions of water outlets on campus
- Encourage life-cycle thinking when drinking water options are considered

Campus events on Imagine days, World Water Days and National Bottled Water Free Days could also be organized and sustainable drinking habits should be promoted to and by staff. However, the details of these two recommendations are beyond the scope of this project.

Goal 3: Continue research on and monitoring of drinking water access on campus

In response to this project, the public perceptions of these results need to be assessed. As previously mentioned in the discussion sections, the full implications of these results will be determined once public norms and attitudes are evaluated. Another SEEDS project could take the pictures taken during data collection and develop a visual survey. This survey would be offered online and by students completing the project. If only one person is completing the project, volunteers from Common Energy could also be recruited. The survey could feature a range of results from this project and ask questions such as: Would you drink from this outlet (show a picture of an outlet)? Would you drink this water (show a picture of cloudy bubbly water)? Which water outlet do you prefer (show pictures of two or more types of outlets and ask people to rank them)? What do you think of outlets within 5 meters of washrooms? This survey should be administered to students from a broad spectrum of faculties and in multiple locations on campus to ensure accuracy.

Since there are multiple types of water outlets available, further research could be done on the life cycles of each water outlet and which ones are most cost effective, energy efficient and durable. Brita Hydration Stations and Elkay EZH_2O fountains have lower initial costs ranging from $1200 to $4000 (Kanda et al., 2010). However, on a longer term basis of five years after installation, the WaterFillz stations have been found to be the most economical because their filters do not need to be replaced as often as other drinking water outlets (Tran et al., 2012). WaterFillz filters need to be changed every 6 to 12 months depending on usage and other water conditions (Kanda et al., 2010). These investigations could further be compared with other water outlets like the free-standing water coolers (with piping and with jugs) and café outlets.

As has been mentioned in previous sections, additional collaborative research projects could be done to develop a campus-wide interactive map like U of T's and a Sustainable Drinking Water Guide for brochures and the AMS student planner.

Conclusion

UBC has exhibited promising signs in its ability to mirror Vancouver's goal of expanding public access to drinking water and reducing the use of bottled water. Common Energy's successful Tap That campaign is undeniably a pivotal step in helping the university achieve this component of its waste reduction targets. In support of this campus movement, this project has successfully determined the current availability of free drinking water on campus and outlined how the institution can further improve accessibility. It provides staff and future research projects with baseline data on the distribution, functionality and appeal of 197 water outlets in 59 of the institution's major academic buildings. Although drinking water infrastructure is highly available on campus, there are deficiencies in outlet maintenance and public awareness of free drinking water options. If the appropriate signage and informative tools are applied, the university's population will be empowered to make more ecologically responsible drinking water choices. Though the campus has made significant progress in adopting sustainable water consumption practices, there are still more milestones to be conquered on this journey to becoming a bottled-water-free community. The success of this vision will require the cooperation and open-mindedness of students and staff as well as the awareness that all members of the university's population have an important role to play in ensuring this vision is achieved.

Acknowledgements

I would like to thank the following staff and stakeholders for their support and mentorship throughout this project: Victoria Wakefield from Student Housing and Hospitality Services, Justin Ritchie from AMS Sustainability and Bud Fraser from Campus Sustainability. I thank Greig Samodien from UBC Building Operations for providing all the necessary documents and information to conduct the water outlet inventory and evaluations. I want to thank Liska Richer, the SEEDS Program Coordinator, for managing logistics and providing support throughout the project. I also thank my supervising professor, Dr. Mark Johnson, and PhD student Ashlee Jollymore for their keen guidance during project planning and data analysis.

This project's results would not have been attainable without the help and enthusiasm from the following volunteers: Jenny Liu, Jason Farra, Umaima Baig and Laura Gauthier from Common Energy as well as Aaron Chan and Kimberly Ho.

References

California State Water Resources Control Board. (2004). *Electrical Conductivity/Salinity Fact Sheet*. Retrieved from http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/3130en.pdf

City of Vancouver. (2012). *Greenest City 2020 Action Plan*. Retrieved from http://vancouver.ca/files/cov/Greenest-city-action-plan.pdf

Corporate Accountability International. (2013). *What we do*. Retrieved from http://www.stopcorporateabuse.org/what-we-do

Ecohydro Lab. (2013). *Mark Johnson*. Retrieved from http://ecohydro.ires.ubc.ca/johnson

Health Canada. (2012). *Guidelines for Canadian Drinking Water Quality Summary Table*. Retrieved from http://www.hc-sc.gc.ca/ewh-semt/alt_formats/pdf/pubs/water-eau/2012-sum_guide-res_recom/2012-sum_guide-res_recom-eng.pdf

Kanda, K., Brar, T., Ho, R., & Yeh, N. (2010). *An Investigation into Sustainable Water Consumption*. Retrieved from UBC's cIRcle Library website: https://circle.ubc.ca/bitstream/handle/2429/34070/APSC261_SustainableWaterConsumption_Group03_clean.pdf?sequence=1

Metro Vancouver. (2013). *Seymour – Capilano Filtration Project*. Retrieved from Metro Vancouver's Publications website: http://www.metrovancouver.org/about/publications/Publications/SCFiltrPlant2010.pdf

Penn State Campus Sustainability Office. (2012). *Water Bottle Filling Stations at Penn State University*. Retrieved from http://www.green.psu.edu/psuDoing/CSO/HydrationStatBusinessPlanFinal.pdf

Polaris Institute. (2013). *About Us*. Retrieved from http://www.polarisinstitute.org/aboutus

PSU's SDWTF. (2012). *Report of the PSU Sustainable Drinking Water Task Force*. Retrieved from http://www.pdx.edu/planning-sustainability/sites/www.pdx.edu.planning-sustainability/files/SDW%20Task%20Force%20Report%20-%201.24.12.pdf

Queen's University Hospitality Services. (2013). *Queen's University is a bottled-water free campus*. Retrieved from http://dining.housing.queensu.ca/sustainable-u/bottle-free-campus/

Rensler, A. (2012). *Best Practices Guide On University Campus Sustainability*. Retrieved from http://www.yorku.ca/susweb/resources/documents/BestPracticesFinalGuidePDFDoc.pdf

Sadowski, R., & Willock, A. (2010). *Shifting to Sustainable Drinking Water Consumption at UBC: A Social Marketing Plan*. Retrieved from UBC Sustainability's SEEDS Program Library website: http://sustain.ubc.ca/sites/sustain.ubc.ca/files/seedslibrary/GRS_497E_ShiftingtoSust

ainableDrinkingWater_CLEAN_0.pdf
Tap That UBC. (2013). *Endorsements*. Retrieved from http://tapthatubc.com/endorsements/
The Council of Canadians. (2011). *Jurisdictions that ban bottled water*. Retrieved from http://canadians.org/water/issues/Unbottle_It/jurisdictions.html
The Council of Canadians. (2012). Backing the Tap: Campuses lead the way for Bottled Water Free Day 2012. Retrieved from http://canadians.org/media/water/2012/15-Mar-12-2.html
Tran, A., Li, B., McNicholl, D., Noble, J., Dijk, K.V., & Lee, N. (2012). *Assessment of Drinking Water at UBC: A consideration of water quality, energy and economic costs, with practical recommendations*. Retrieved from UBC's cIRcle Library website: https://circle.ubc.ca/bitstream/handle/2429/42338/Assessment_Drinking_Water_UBC.ENVR400_Report.pdf?sequence=1
UBC Building Operations. (2013). *UBC Building Operations*. Retrieved from http://www.lbs.ubc.ca
UBC Food Services. (2013). *Locations & Hours*. Retrieved from http://www.food.ubc.ca/locations-and-hours
UBC Risk Management Services. (2013). *Water Quality*. Retrieved from http://riskmanagement.ubc.ca/environment/water-quality
UBC Student Housing and Hospitality Services. (2013). *Student Housing*. Retrieved from http://www.housing.ubc.ca/vancouver
UBC Sustainability. (2013a). *SEEDS Program*. Retrieved from http://www.sustain.ubc.ca/courses-teaching/seeds
UBC Sustainability. (2013b). *Waste Action Plan*. Retrieved from http://www.sustain.ubc.ca/campus-initiatives/recycling-waste/waste-action-plan
UBC Technical Services Department. (2012). *UBC Technical Guidelines 2012 Edition*. Retrieved from http://www.technicalguidelines.ubc.ca/div_15_files/Division_15/2012_Division_15_Tech_Guidelines_Launch.pdf
Universities in Canada. (2013). *Major Canadian Universities and Mid-sized Canadian Universities*. Retrieved from http://www.university-canada.net
University of Toronto Food & Beverage Services. (2013a). *On Tap – Bottled Water Free*. Retrieved from http://www.food-beverage.utoronto.ca/policies/on-tap
University of Toronto Food & Beverage Services. (2013b). *On Tap FAQs*. Retrieved from http://www.food-beverage.utoronto.ca/policies/on-tap/on-tap-faqs
USGS. (2013). *Water Questions & Answers: Why does my drinking water look cloudy sometimes?*. Retrieved from The USGS Water Science School website http://ga.water.usgs.gov/edu/qa-chemical-cloudy.html

Appendix A: Vancouver's Water Fountains

Left: An outdoor water fountain near the Bloedel Floral Conservatory at Queen Elizabeth Park
Right: Water fountains and signage at Vancouver Central Library

Water fountains at the Hillcrest Community Centre

Outdoor water fountain at the intersection of Elliot Street and Ashburn Street near the North Arm Trail Bikeway

Appendix B: Water Outlet Inventory and Evaluation

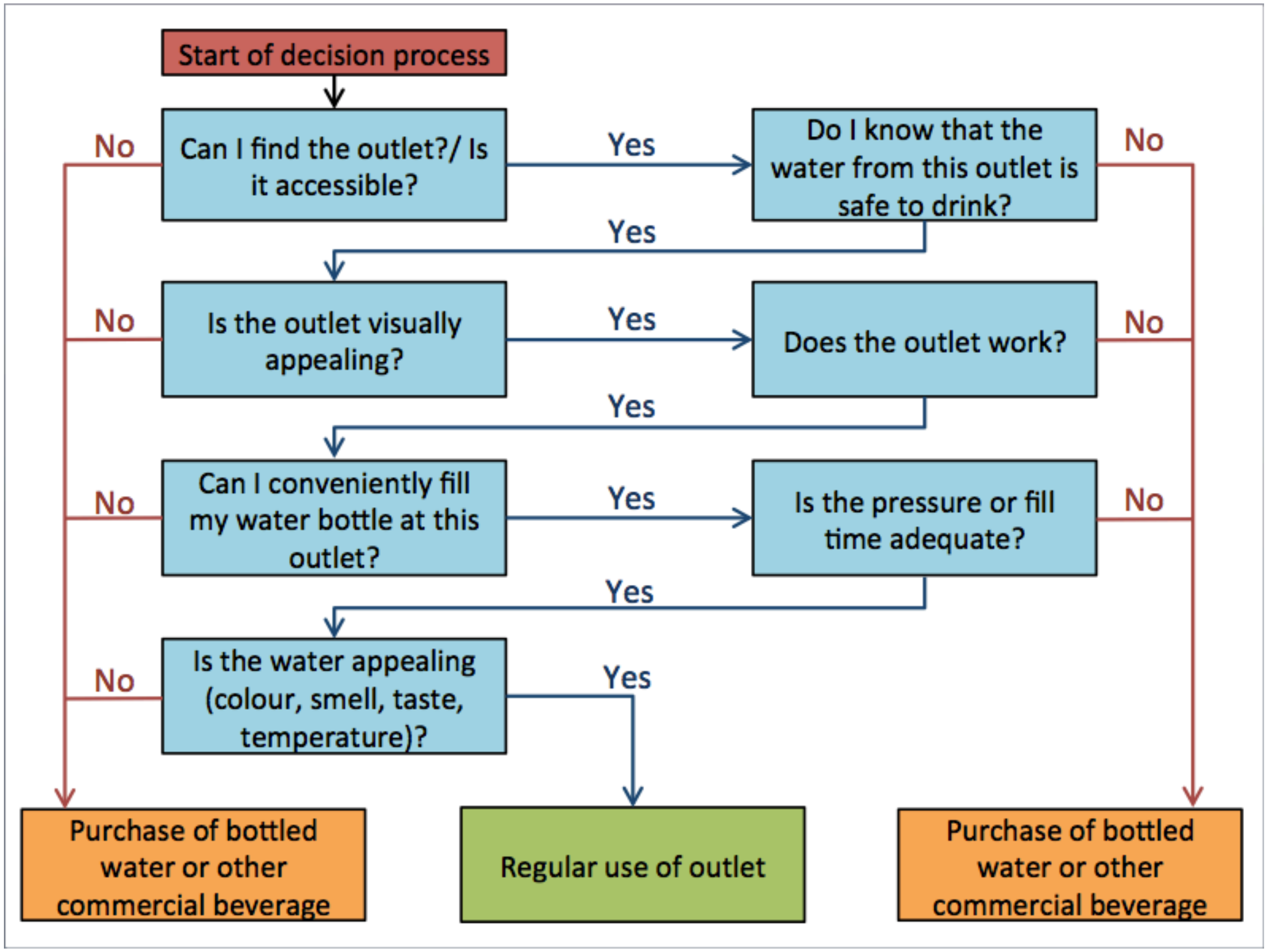


Diagram 1. This diagram portrays how each of the components from the water outlet evaluation plays a role in the decision process to regularly use a water outlet. It assumes that an individual owns a reusable water bottle and they will either choose to use the water outlet or purchase bottled water (or another commercial beverage) based on the responses to the questions.

Drinking Water Outlet Assessment

Scope of assessment:

- Will include all water fountains, kitchenette sinks in common areas, WaterFillz stations, and fixed dispensers at cafes in major buildings where students are mostly found
- Will exclude laboratory sinks
- Will exclude the majority of washroom sinks with the exception of a few predetermined of buildings where fountain spigots and bottle-filling faucets are solely found in the washrooms

	Very Poor	**Poor**	**Good**	**Very Good**
Visual Appeal	Dirty outlet that has filth or residues	Moderately clean outlet that has filth or residues	Clean outlet that has minimal residues (only on a small portion of the outlet) or does not have filth/residues	Very clean outlet that does not have filth or residues. Looks very well-maintained
Colour To assess colour, collect a sample in the cup provided and hold against a white piece of paper. If a distinct color observed, run water for 15 seconds minute and observe again.	Colour does not dissipate after 2 samples are assessed. Air bubbles do not dissipate after 5 minutes	Colour is present in first sample and is faint in second sample. Air bubbles dissipate after 2 minutes	Colour/air bubbles are present in first sample and absent in second sample. Air bubbles dissipate after 30-40 seconds.	First sample is colourless and free of air bubbles
Taste To assess taste, collect a sample in a cup and taste it. If it tastes stale, metallic or unusual, run water for 15 seconds and repeat.	Stale, metallic and other off-tastes that do not dissipate after 2 samples are assessed	Stale, metallic and other off-tastes detected in first sample and dissipate in second sample	Stale taste in first sample that disappears in second sample	No unpleasant taste is detected in first sample
Pressure To assess pressure, turn on fountain and observe stream of water	Insufficient water pressure to avoid mouth contact with fountain	Water pressure creates a sufficient arch, then decreases to an insufficient degree after a few seconds (~1 cm arch)	Sufficient water pressure to avoid mouth contact with fountain; placing mouth close to spigot may be required (~2 cm arch)	Water pressure creates a sufficient arch to easily place mouth in mid-stream and would allow easy filling of reusable water bottles

Building: ___________________________ Your name(s): _________________________________

Date (YYYY-MM-DD)__________________ Time: ___________________

Location Floor:	**Location (Nearest room number/landmark):**
Is outlet visible to passing traffic? ☐Yes ☐No	
Is outlet visible from a main entrance? ☐Yes ☐No	
Proximity to a washroom: ☐Within 5 meters ☐Within 10 meters ☐No washroom visible	
Visual appeal of outlet ☐Very poor ☐Poor ☐Good ☐Very Good Comments/Notes:	
Can you conveniently fill your water bottle at this water outlet? ☐Yes ☐No Height of bottle _______________	
Faucet type ☐Wall-mounted ☐Stand-alone ☐Porcelain ☐Metal ☐Plastic Comments/Notes (indicate if it is a WaterFillz unit, kitchenette sink, or other source):	
Water colour ☐Very poor ☐Poor ☐Good ☐Very Good Comments/Notes:	
Water odour ☐ Musty, mouldy or other off-odours detected ☐ No odour detected Comments/Notes:	
Water taste ☐Very poor ☐Poor ☐Good ☐Very Good Comments/Notes:	
Water pressure ☐Very poor ☐Poor ☐Good ☐Very Good Comments/Notes:	
Other comments/observations:	

List of Buildings with Zones

Zone 1
- Chan Centre
- Buchanan Tower
- Buchanan A,B,C,D,E
- Irving K. Barber Learning Centre
- Frederic Lasserre Building
- C.K. Choi Building for The Institute of Asian Research
- Music Building

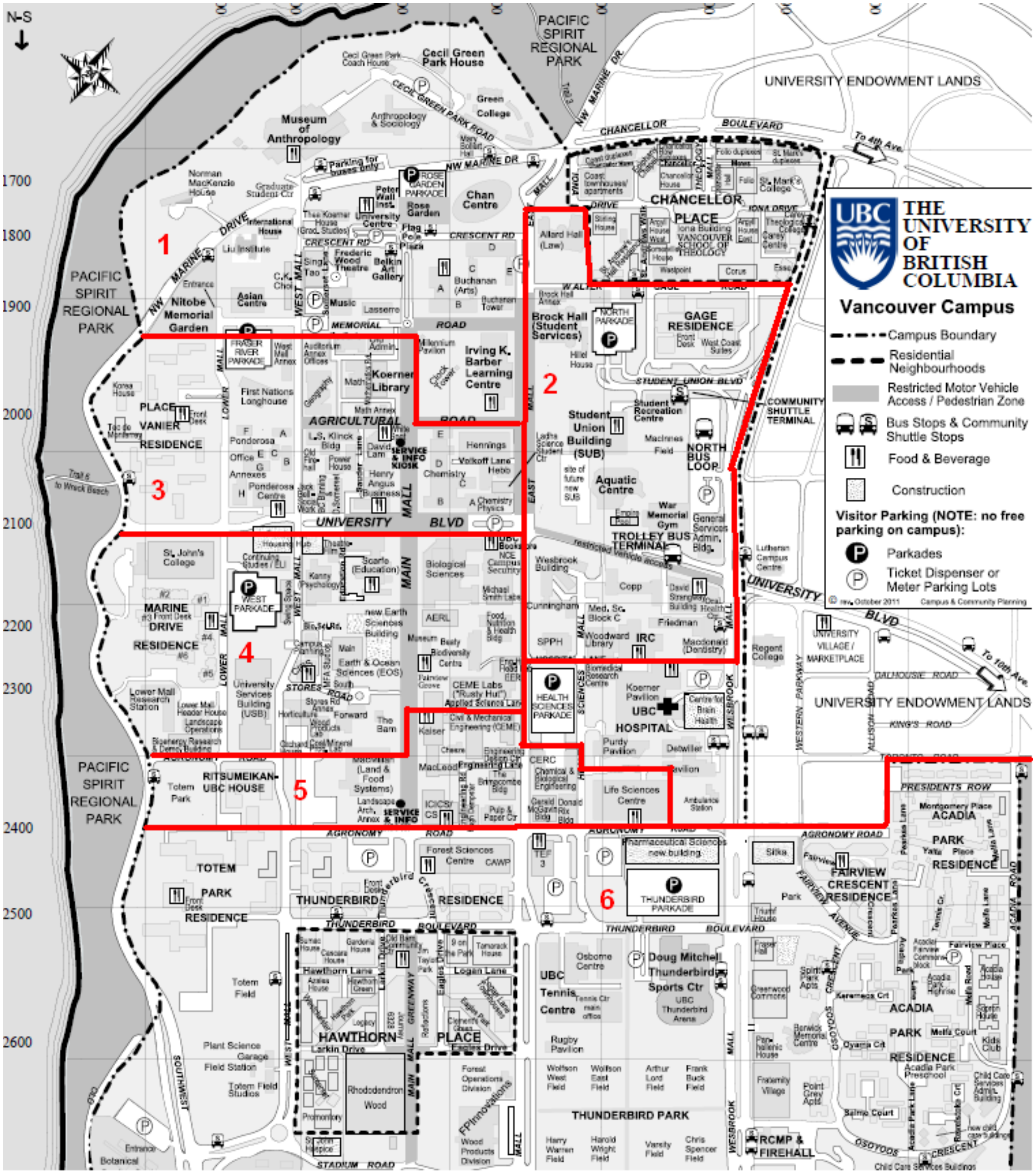
Zone 2
- Allard Hall between
- Brock Hall
- Gage Residence
- Student Union Building
- Student Recreation Centre
- War Memorial Gym
- Wesbrook Building
- D.H. Copp Building
- Woodward Library
- Woodward Instructional Resources Centre

Zone 3
- Place Vanier Residence (common place)
- First Nations Longhouse
- Geography Building
- Mathematics Building
- Mathematics Annex
- Walter C. Koerner Library
- L.S. Klinck Building
- David Lam
- Henry Angus
- Jack Bell Building for the School of Social Work
- Chemistry A, B, C, D
- Hennings Building
- Hebb Building

Zone 4
- Marine Drive Residence (common place)
- Continuing Studies Building
- Swing Space Building
- CIRS Building
- Horticulture Building
- Earth and Ocean Sciences – Main
- Earth Sciences Building
- Neville Scarfe Classroom Block
- Neville Scarfe Library
- Neville Scarfe Office Block
- Biological Sciences (North)
- Food Nutrition and Health Building

Zone 5
- Ritsumeikan UBC House (common place)
- H. R. Macmillan
- Fred Kaiser Building
- Civil and Mechanical Engineering
- Wayne and William White Engineering Design Centre
- Brimacombe Building
- Chemical and Biological Engineering Building
- Life Sciences Centre
- Hugh Dempster Pavillion
- Institute for Computing, Information and Cognitive Systems/Computer Science
- Macleod

Zone 6
- Totem Park Residence (common place)
- Thunderbird Residence (common place)
- Forest Sciences Centre
- Robert F. Osborne Centre (Units 1 & 2)
- UBC Tennis Centre
- Pharmaceutical Sciences & Centre for Drug Research and Development
- Acadia Park/Fairview Crescent Residences (common place)



Map 1. The campus was divided up into six zones to facilitate data collection and ensure that it was performed efficiently and thoroughly.

Electrical Conductivity and Temperature Data Table

Fountain	EC (μS)	Temp (°C)		After 15 Secs	EC (μS)	Temp (°C)
BUCHA_A103						
BUCHA_212						
BUTO_297						
BUTO_1297						
IBLC_156						
IBLC_455						
ALRD_B111						
ALRD_472/473						
COPP_1203/1205						
COPP_3203/3205						
COPP_4203/4205						
Gage_Brita						
IRC_Basement						
IRC_Ground Level						
IRC_4th floor						
SRC_Main						
SRC_Elevator						
SUB_Lobby North						
SUB_200 North						
WOOD_Basement						
WOOD_3 Elevator						
ANGU_247						
ANGU_457						
CHEM B_160						
CHEM B_362						
GEOG_148						
GEOG_246						
HEBB_9L						
HEBB_55A						
HENN_206						
HENN_310						
MATX_1110						
MATX_1212						
WCKL_Level 1						
WCKL_Level 5						
BIOL North_0512						
BIOL North_3514						
CIRS_2321						
CIRS_4321						

Fountain	EC (µS)	Temp (°C)		After 15 Secs	EC (µS)	Temp (°C)
CONT ST_B210G						
ESB_Magma						
FNH_130						
FNH_Basement						
SCRF Class_1013						
SCRF Class_1320						
SCRF Office_1						
SCRF Office_6						
BRIM_115						
BRIM_412						
CEME_1214						
CEME_2208						
CHBE_106						
CHBE_304						
MCLD_148						
MCLD_448						
MCML_WaterFillz						

Equipment

The graduated cylinder and a water bottle were used to measure water flow rates.

The beaker was used to examine water colour

The plastic tumbler water used to measure water electrical conductivity and temperature

This Thermo Orion electrical conductivity meter was used to measure water electrical conductivity and temperature. In this picture, the apparatus reads 272 μS and 16.0°C.

Flow Rate Data Table

Fountain/Outlet	Volume (mL)	Time (s)		Gooseneck?	Volume (mL)	Time (s)
BUCHA_1WR						
BUCHA_Stir it up						
BUCHA_212						
BUCHB_303						
BUTO_697						
BUTO_1297						
CHAN_SE						
CHAN_NW						
CKCHOI_Entrance						
IBLC_255						
IBLC_455						
Irving CTLT_214						
Irving Lib_4						
ALRD Lib_2						
ALRD Lib_4						
ALRD_107						
ALRD_372/373						
ALRD_B111						
BROCK_2 (either)						
COPP_3203/3205						
COPP_4608						
Gage_Lobby						
IRC_Basement						
IRC_Ground level						
IRC_334						
IRC_400-414						
SRC_2 Elevator						
SRC_2 Ladies WR						
SRC_Main						
SUB_200 North						
SUB_200 South						
SUB_215						
War Mem_303						
WESB_1						
WOOD_2 NE Stair						
WOOD_3 Elevator						
ANGU_247						
ANGU_457						
CHEM B_160						

Fountain/Outlet	Volume (mL)	Time (s)		Gooseneck?	Volume (mL)	Time (s)
CHEM B_362						
DLAM_1246						
DLAM_246						
GEOG_148						
GEOG_246						
GEOG_Lounge						
HEBB_9L						
HEBB_15F						
HEBB_45A						
HENN_206						
HENN_310						
LONG						
LSK_100						
MATH_122						
MATH_Men's WR						
MATX_1110						
Vanier_Caf						
WCKL_Level 2						
WCKL_Level 5						
BIOL North_3514						
CIRS_3321						
CIRS_Loop						
CONT ST_B210G						
ESB_1016/1018						
ESB_Magma						
FNH_130						
FNH_Kitchen						
HORT_101						
SCRF Class_1013						
SCRF Class_1123						
SCRF Lecture_2						
SCRF Lecture_9B						
SCRF Lect_205A						
SCRF Lect_300A						
SCRF Lect_310						
SCRF Office_1						
SCRF Office_6						
SCRF Lib_1						
SWNG_WaterFillz						
BRIM_115						
BRIM_215						
CEME_1005						

Fountain/Outlet	Volume (mL)	Time (s)		Gooseneck?	Volume (mL)	Time (s)
CEME_1214						
CEME_2027						
CHBE_140						
CHBE_312						
DMP 108						
LSC_1.416						
MCLD_112						
MCLD_214						
MCLD_254						
MCML_Agora						
MCML_WaterFillz						
Osborne Unit 1						
Osborne Unit 2						
PHARM_1104						
Tennis Centre						

Appendix C: Water Outlets and Signage From Other Institutions

(Penn State Campus Sustainability Office, 2012)

An Elkay EZH_2O water fountain currently at Pennsylvania State University and corresponding signage

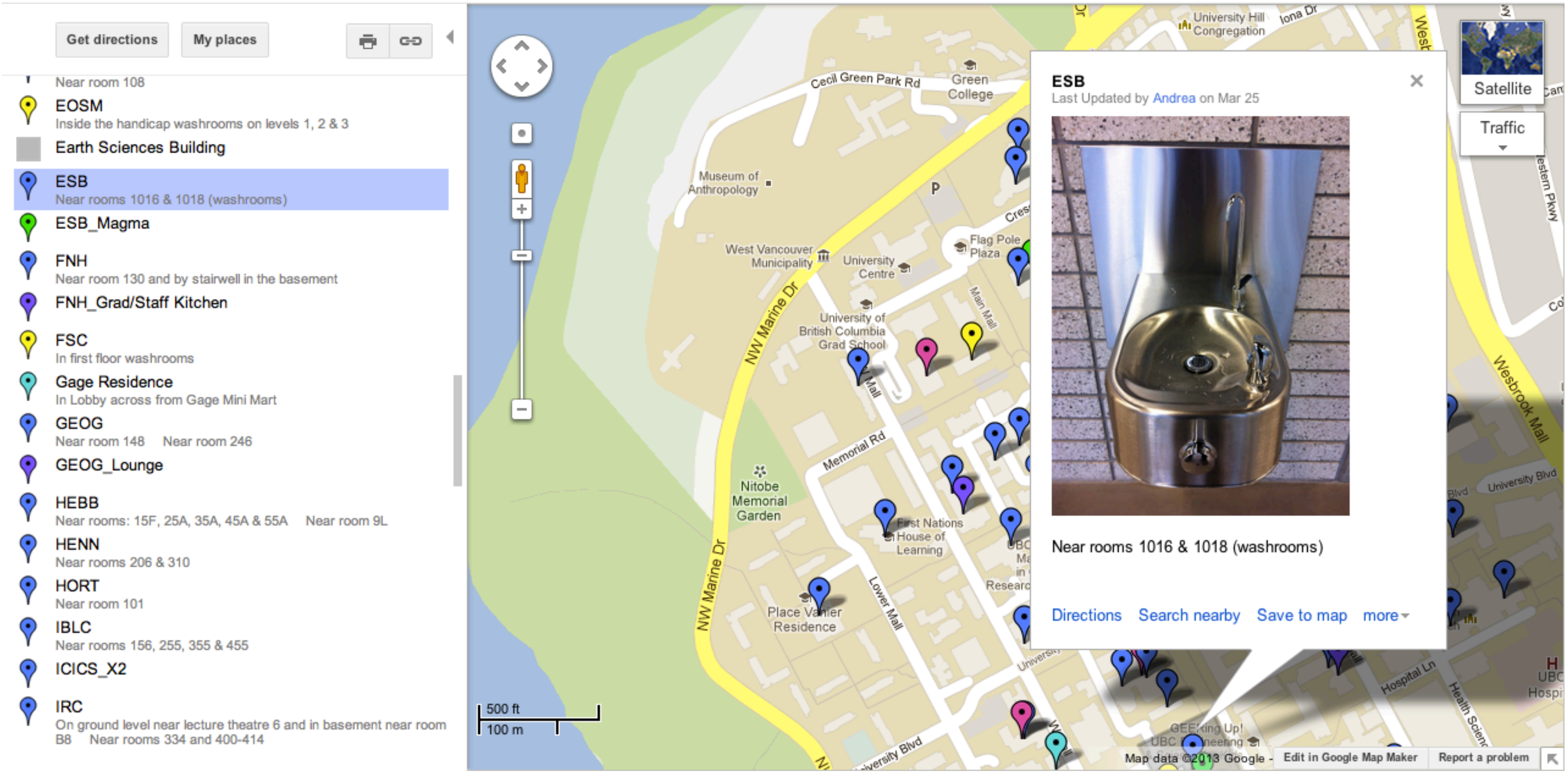
(Queen's University Hospitality Services, 2013)

(PSU's SDWTF, 2012)

Top left and right: A water filling station at Queen's University and corresponding signage/imagery

Bottom left: A Brita Hydration Station currently installed at Portland State University

Appendix D: Interactive UBC Water Outlet Map



Screenshot of Interactive UBC Water Outlet Map made on Google Maps

Appendix E: Types of Water Outlets at UBC

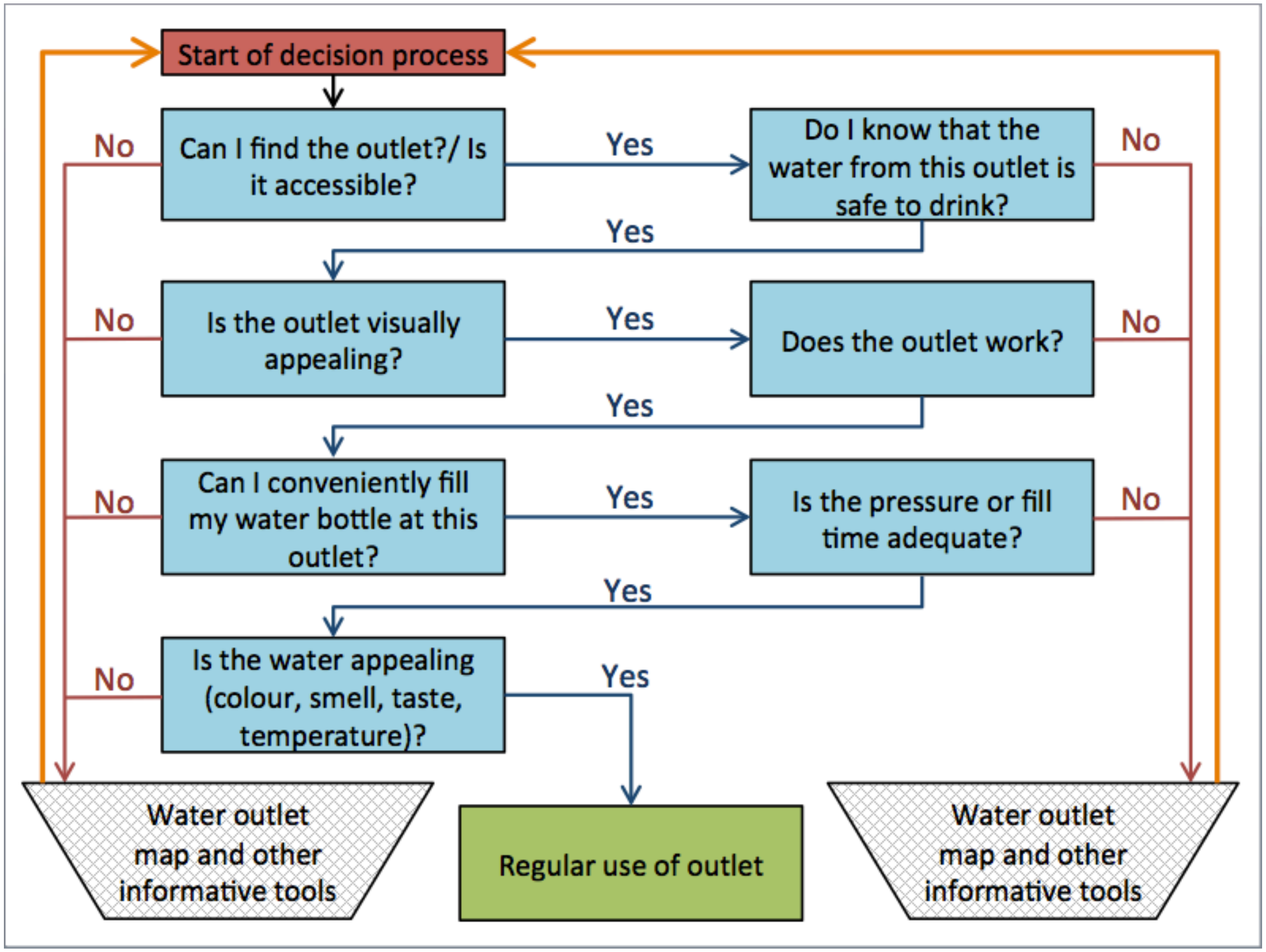


Left: Water fountain and gooseneck at Allard Hall Library
Middle: Café outlet at Magma in the Earth Sciences Building
Right: Kitchenette sink in the Centre for Interactive Research on Sustainability

Left: WaterFillz station at the H. R. Macmillan Building
Right: Brita Hydration Station in the lobby of the Walter Gage Residence

Left: WA-2 Station in the Music Building
Right: Van Houtte's Source H_2O ion dispenser in the Continuing Studies Building

Appendix F: Modified Decision Flow Chart



This diagram, modified from the diagram in Appendix B, shows how a water outlet map and other informative tools serve as a metaphorical safety net that empowers the public to use the free drinking water outlets on campus and prevents the public from buying commercial bottled water every time they need drinking water.