UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Sustainable Water Consumption

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Abstract

With the increasing global demand of plastic bottled water, additional unsustainable resources are required to support this demand. The University of British Columbia (UBC) is planning to construct a new Student Union Building (SUB) and the AMS would like to investigate and compare the environmental, social, and economical impacts of alternative drinking water solutions. Three methods will be compared; plastic bottled water, WaterFillz units, and improved water fountains. Each method was closely investigated with surveys and online research. A recent survey of UBC students conducted for the UBC Seeds project showed that 15% of UBC students required filtered water while 37% preferred. The survey highlighted UBC students concern of not enough clean available drinking fountains around campus. With 77% positive feedback on the newly installed WaterFillz unit at the SUB, the introduction of viable alternatives to bottled water around campus will change students drinking habits.

The purchase cost of a WaterFillz unit is $10,000, while a similar two-stage water filtration system would cost significantly less. Both WaterFillz and commercial water filtration units require replacing their water filters every six months, with the addition that WaterFillz require to replace a UV filter every year.

The results of the environmental, social, and economical impacts for each method of delivering drinking water to students showed that plastic bottled water is not a solution the AMS should consider. Instead in the interest of students, the AMS organizers need to perform more analysis on alternative drinking fountains and comparing them to the WaterFillz units.

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1.0 Introduction

This report on sustainable water consumption for the new Student Union Building (SUB) at UBC investigates the feasibility of different methods to deliver drinking water to students. Currently students have the option to purchase single use plastic water bottles or fill their reusable bottle from a regular water fountain. A propose solution is to use tap water filtration units to filter water for students. This will then decreases the consumption of single use bottled water. Since the bottled water consumption is increasing continuously in both developing and developed regions, the issue of energy consumed to produce bottled water was carefully investigated. The energy to produce bottled water involves processing, packaging, and transportation. In British Columbia, manufacturing, filling, transportation and distribution of plastic water bottles requires 49440 to 64005 barrels of oil per year.

The AMS has invested in two WaterFillz units to trial student's interest in reusuable bottle fill up stations and its influence on plastic bottled water sales. The goal of this project is to combine is to be part of the New SUB goal of achieving Leadership in Energy and Environmental Design (LEED) Platinum design.

In order to compare the WaterFillz Units and plastic bottled water, a triple bottom line analysis was completed to investigate each method in terms of its environmental, social, and economical impacts. This report also details UBC student perspective on the sustainable water consumption and other alternatives to WaterFillz Units.

2.0 Research Strategies

This report details a triple bottom line analysis that was conducted by performing a literature review of journal articles from online databases. The databases used for research of this project include Compendex, Web of Science, and Pubmed central. AMS members in charge of the new SUB also provided information used in this report. A surveyed performed for the UBC Seeds program provided information on UBC Students perspective of this issue. The manufacturers' websites for drinking water fountains and fill up stations provided product specifications, energy consumption, and purchase cost of different models.

3.0 Plastic Water Bottles

A triple bottom line assessment was completed to determine the footprint caused by the use of plastic water bottles. This involved analyzing the economic, environmental and social impact from the generation, consumption, and disposal of plastic water bottles. Research was focused on gathering data specifically from BC and UBC.

3.1 Environmental Impacts

Plastic water bottles are manufactured from polyethylene terephthalate (PET). The process to produce a bottle involves melting plastic resin pellets, injecting this into a preform and then blowing it into the desired shape. The bottle is either filled on site or shipped to another plant to be filled. According to Toxic Free Canada [1], during the creation of the plastic resin pellets workers are exposed to a number of harmful carcinogenic chemicals, including antimony trioxide. Harmful toxins from manufacturing are also released into the atmosphere. The effect of these toxins on the population is hard to gauge. Figure 1 below shows the overall process flow involved in making plastic water bottles.

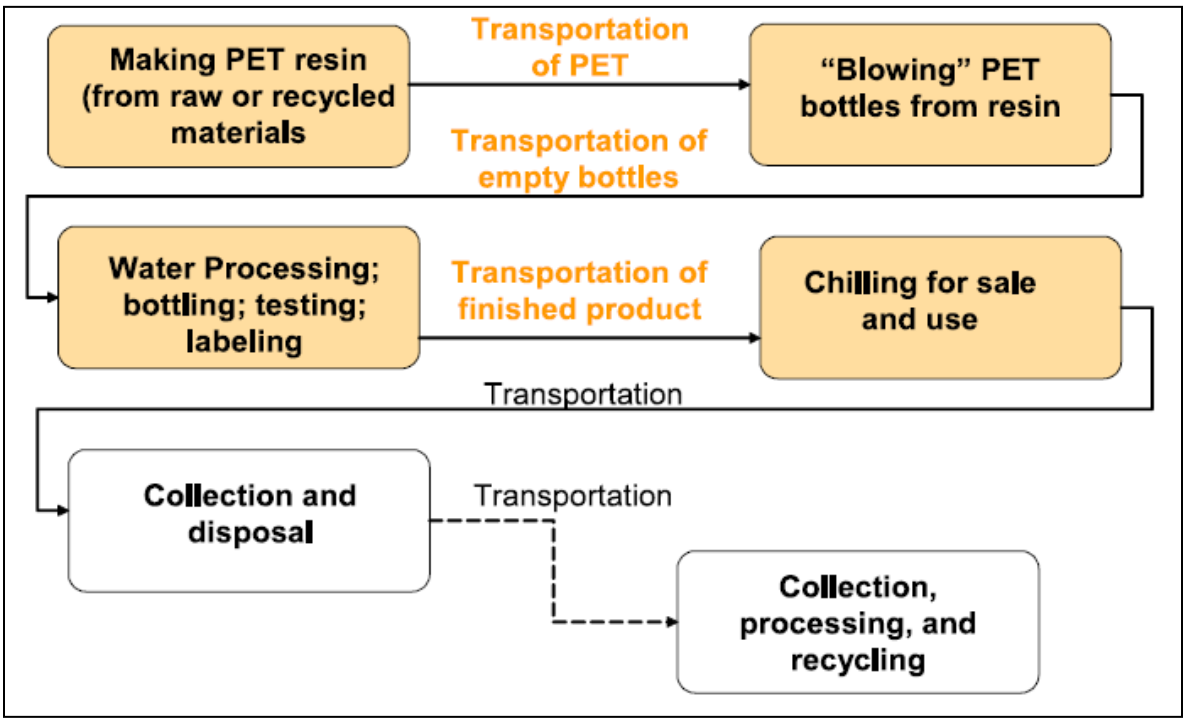

Figure 1: Bottled water process flow- Source: Energy Implications of Bottled Water [2]

Transportation of raw materials and finished products is also an important factor that contributes to the energy usage increasing the carbon emissions. Water bottles produced and distributed locally have lower environmental impact than those being imported from foreign countries. In British Columbia, 95% of water bottles are produced and distributed locally. Table 1 below shows the market share of bottled water companies in BC.

Table 1: Plastic water bottle companies in BC- Source: TFC, 2009 [1]

Company	Share	# of bottles	Distance
Nestlé	37%	46,791,615–60,659,127	150 km (Hope)
Dasani	14%	17,704,935–22,952,102	30 km (Coquitlam)
Aquafina	16%	20,234,212–26,230,974	27 km (Delta)
Others, local	28%	35,409,870–45,904,204	14 km (Richmond, Bby)
Int'l, France	4.5%	5,690,872–7,377,461	5343 sea; 4903 rail
Int'l, Fiji	0.5%	632,319–819,719	9446 sea

Natural Resources Canada Data handbook 2006 and US Department of Energy 2007 [1] provide figures for energy consumed in different transportation modes. Transportation by rail uses 0.22MJ/tonne-km; trucks use 2.31 to 7.56MJ/tonne-km and by sea requires 0.37MJ/tonne-km. Assuming the weight of plastic water bottles to be between 520g to 700g, it is calculated that transportation of water bottles to British Columbia consumes 30,000-40,000 GJ of energy every year.

Currently the UBC SUB sells Dasani and Aquafina water bottles through vending machines, while Nestlé water bottles are sold over the counter. All three companies are local distributers in BC and require less transportation to distribute water bottles to UBC.

Based on Encorp Pacific's results [1] in 2007, it is estimated that approximately 125.5 to 164 million PET water bottles were sold in British Columbia in 2007. It requires 21,370 MJ to manufacture 10,000 plastic bottles. Water treatment, filling and labeling of bottles requires additional 107MJ for 10,000 plastic bottles.

All energy figures can be expressed as barrels of oil to determine the complete carbon footprint of water bottles. One barrel of oil can produce 6100MJ based on National Energy Board. Therefore, manufacturing, filling, transportation and distribution of plastic water bottles in British Columbia requires 49440 to 64005 barrels of oil per year according to [1].

Canada is known for promoting sustainability through recycling and reusing. Recycling of plastic water bottles recovers only 60% of total energy used to produce them. People in BC have a notion that most of their plastic beverage containers are recycled as recycling trends are increasing. However, according to the study from Encorp Pacific [1], each year more plastic beverage containers end up in BC landfills. About 23-30 million PET water bottles went to Metro Vancouver landfills in 2007. Figure 2 below shows the increasing trend of plastic containers going to BC landfills from 2002-2007.

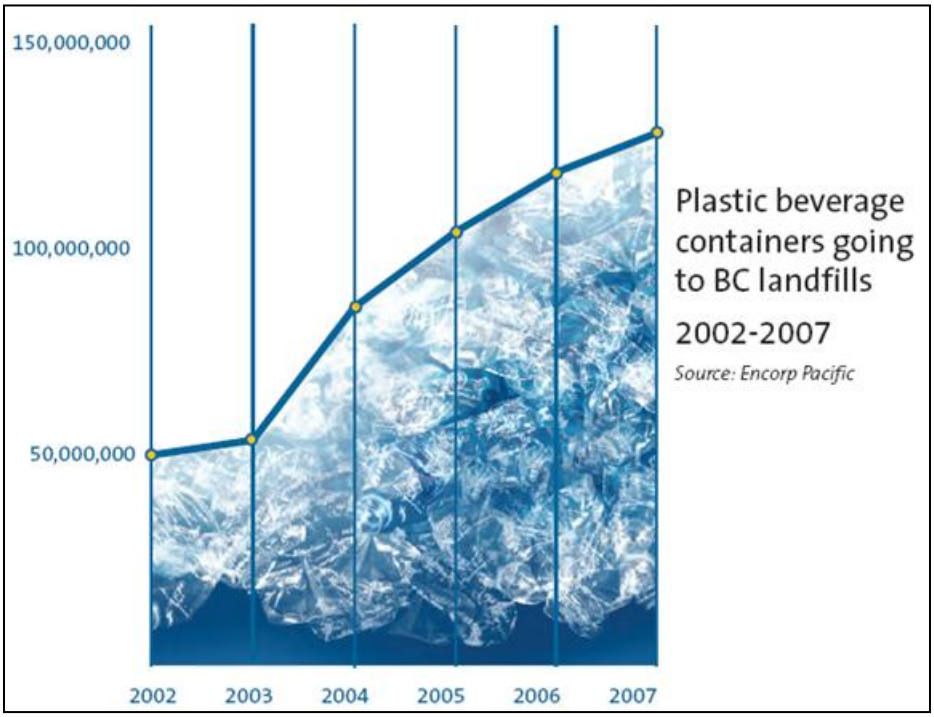

Figure 2: Number of plastic beverage containers going to BC landfills- Source: TFC, 2009 [1]

3.2 Economic Impacts

In 2011, the global bottled water market is expected to have a value of $86,421.2 million according to [3]. This is an increase of 41.8% since 2006. According to the market overview from [4], un-flavored water bottle sales in US proved the most important for the US bottled water market in 2009. It generated total revenues of $15.4 billion that is equivalent to 90.2% of the market's overall value.

Following the global trend, in British Columbia bottled water sales rose by 67% from 2003 to 2005 according to [1]. This is because 30% of Canadians use bottled water as the main source of drinking water. A 591ml water bottle in British Columbia has an average cost between $1.50 and $2.00. If a moderately active student were to consume the average recommended daily intake of 3000 ml [5] of water only through bottled water from the SUB, it would cost them $3,243 per year. This number was calculated using an average 591 ml bottle cost of $1.75. If the student were to consume only through tap water, it would total a yearly cost of $0.88 at $0.0008/L supplied by Metro Vancouver. Simply drinking tap water instead of bottled water can place students in a better financial position, without affecting the health of the student.

Sales data on the number of plastic water bottles sold by the AMS at the current SUB is not fully known. However, to be able to make a proper comparison on the economic and environmental impact these plastic water bottles have on the world, an estimate was produced. We do know that the student union building generated $70,000 in sales profit [Justin Richie, UBC AMS] from over the counter water bottle sales in 2009. The sales revenue from vending machine sales is not known, however for this study we will assume that their sales will not be impacted by the WaterFillz units installation but the over the counter sales will be eliminated.

Assuming an average price of a water bottle was $1.75/bottle and the AMS profits with a 25% of total revenue, this represents 160,000 bottles sold. It takes 23,548 MJ to produce and transport 10,000 average sized PET water bottles [1]. This translates to 374,000 MJ (61.2 barrels of oil) of energy consumed in the water bottles that the SUB sells over the counter.

If the WaterFillz prove successful enough to eliminate the sales of over the counter plastic water bottles the SUB will lose $70,000 in profit/year. This money goes directly into the funding of

AMS clubs. A possible solution to recover this money is for the AMS to sell reusable stainless steel water bottles.

According to a journal for academic labor [6], the Coca Cola bottling company had a ten year contract with Alma Mater Society (AMS) of UBC in 1995. The contract provides UBC with $844,260 annual sponsorship fee for each of the contract's 10 years from August 1995 and August 2005. UBC also receives 23% commission of net revenues from vending machines each month. The contract required UBC to sell the minimum volume commitment of 3,360,000 cans or Coke beverages including water by August 2005. Although, it is not known if UBC has a similar contract currently with Coca Cola or other beverage companies, it can be observed that UBC makes substantial amount of revenues from bottled water sales and are encouraged to sell this product.

3.3 Social Impacts

According to a discussion paper by C. Ferrier [7], about 54% of Americans drink bottled water everyday. The global bottled water consumption is shown in figure 3 below.

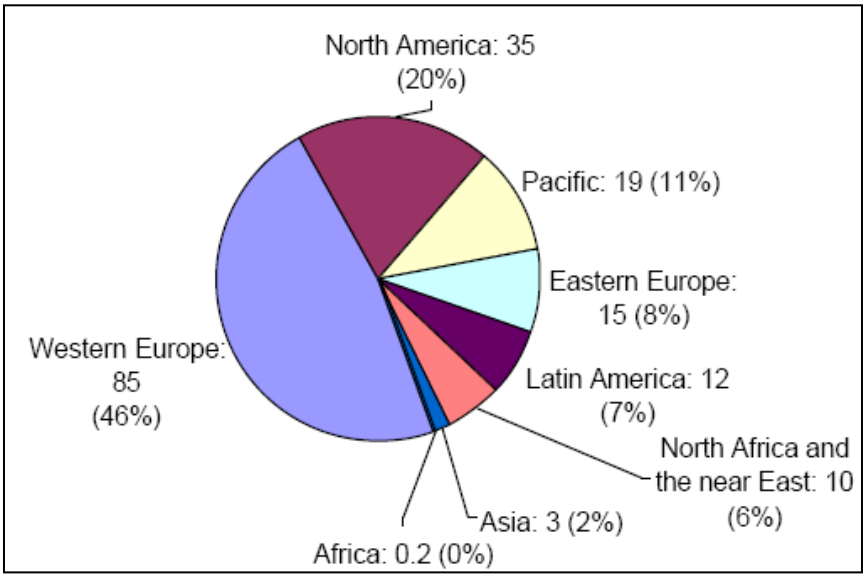

Figure 3: World bottled water consumption in 1999, in liters/year/person [7]

The consumption of single use plastic water bottles has also been a growing trend in British Columbia. Consumers prefer the non chlorinated taste of bottled water compared to tap water. Bottled water is also perceived as being cleaner and safer to drink than tap water. It is a

convenient source to quench thirst for users that want to avoid unhealthier drinks like soda and juice beverages.

According to an internet e-mail survey by Ipsos-Reid [8], 71% of Canadians drink bottled water because of convenience, 15% claimed to prefer the taste while 14% have health concerns with their tap water. It was also observed that majority of students think that colder water tastes better. It is important to recognize that if bottled water was not easily available many students would choose an unhealthy beverage over a tap water alternative. The importance of balancing student health and the environment needs to be considered.

4.0 UBC Student Perspective

A recent study [9] conducted for the UBC SEEDS project shows that the trend of choosing plastic bottled water over tap water is now shifting in the other direction. Students were asked questions related to their water consumption use and also their feedback on the recent installation of the WaterFillz unit at the SUB. The study involved online and in person surveys of UBC students across campus. Approximately 500 students responded to each question which represents ~1% of the UBC population.

The results showed a large concern of the availability of clean and ergonomically friendly water fountains around campus. When students were asked if the water they consumed needed to be filtered, 15% said it was required, 37% preferred, and 48% had no preference. When asked if students would drink water from a sink tap on campus 74% responded with a yes. Students were in strong favor of supporting a ban of plastic water bottle sales on campus if adequate safe drinking alternatives were provided. With over 77% positive feedback on the new WaterFillz units, the stats are showing that UBC students are breaking the existing trend of increasing plastic water bottle consumption. If clean drinking water was easily available and accessible on campus, students will use this option over plastic. A large percentage of UBC students already use refillable water bottles on campus.

5.0 Metro Vancouver Tap Water

Metro Vancouver supplies UBC with some of the world's safest tap water. Water from rain and snowmelt is stored in Capilano, Seymour and Coquitlam reservoirs. It is then filtered by a state

of the art filtration system and sent to UBC at a cost of $0.0008/L. Energy requirements for water filtration vary considerably with different water treatment techniques. Table 2 below shows energy requirements for different water treatment techniques.

Table 2: Energy requirements for water treatment techniques- Source: Energy Implications of bottled water [2]

Treatment technique	Energy use (kWh_e/million liters)
Ozone	
Pre-oxidation (pre-treatment)	30
Disinfection	100
Ultraviolet (UV) radiation (medium pressure)	
Bacteria	10
Viruses	10–50
Microfiltration/ultrafiltration	70–100
Nanofiltration (source TDS = 500–1000 ppm)	660
Reverse osmosis	
Source TDS = 500 ppm	660
Source TDS = 1000 ppm	790
Source TDS = 2000 ppm	1060
Source TDS = 4000 ppm	1590
Seawater desalination (reverse osmosis)	2500–7000

6.0 Alternatives

There are large energy consumption and significant environmental impacts that goes into the production and consumption of plastic water bottles. Due to the shifting trend in the habits and perception of clean drinking water by UBC students, we recommend increasing the availability and improving the ergonomics and appeal of consuming tap water. WaterFillz units will be compared with each other to possible alternative solutions.

6.1 WaterFillz Units

WaterFillz is a water dispenser that provides free clean drinking water. Taking water from Metro Vancouver mains, it filters, disinfects and chills the water. It is advertised as an environmentally friendly solution for drinking water at schools, workplaces or various events. Students can refill their own reusable water bottles with clean filtered drinking water for free. This provides an alternative to consuming single use plastic bottled water, which as discussed previously, is an unsustainable way of providing drinking water. There are currently two WaterFillz units installed

in the SUB as a pilot project to determine whether they are a viable solution to sustainable water consumption.

The WaterFillz works through a 4 stage process. The first stage is the prefilter. Its job is to remove any sediment, particulates or any contaminants which have been dislodge from the pipes. The second stage is the charcoal filter. It removes the chlorine that is added to city water, and potentially harmful manganese, copper, lead and mercury. At this point, the water is free of any tastes that people often associate with regular tap water; however, it still contains natural minerals and salts. The charcoal filter is the same type of filter used in Brita filters that are found in home applications. The third stage is the refrigeration unit, which chills the water to 5 degrees Celsius. The last stage is the UV light. It eradicates any micro-organisms that were missed by the previous filters and the chlorine in city water. The WaterFillz Company admits that the chance of micro-organisms being initially present is extremely small. The UV light therefore, is not a crucial part of the process.

The WaterFillz is a very large unit with approximately the same dimensions as a conventional vending machine. Producing the WaterFillz unit would require a large amount of energy. Steel production is an extremely energy intensive process, requiring approximately 121 to 143kWh per metric ton of sheet metal [10]. Estimating the amount of energy required to form metal into final products is very difficult, as there are many variables in the processes. The majority of its overall environmental impact would consist of its life during production. The energy consumption during operation is relatively small in comparison.

The initial cost of the machine is quite high at $10,000. The WaterFillz requires a filter change every 6 to 12 months depending on usage and water condition. The UV light filter needs to be changed every year.

6.2 Improved Water Fountains

There are many other existing products in the market right now with the same or similar features of the WaterFillz unit with a lower purchase cost. Many conventional water fountains on the market have integrated filters and refrigeration units much like the WaterFillz. Free standing units with a bottle filling spout, filtration and refrigeration systems can be found for $1,200-$4,000, considerably cheaper than WaterFillz units. Examples of such units include products

made by Elkay[11] and Brita[12], see figure 4. These are three general bottle fill up stations available in the market. They have a wide range of specifications and are customizable to include different options (i.e. refrigeration unit). Although the energy to produce these water fill up stations is unavailable, it is reasonable to assume that it would be less than that of the WaterFillz due to the significantly larger size of the WaterFillz unit. The maintenance cost is less due to the absence of the unnecessary UV light. If an unrefrigerated unit is used, the cost of electricity would be 0, as it draws no electricity. A study could be done to determine the drinking water temperature preference. A refrigeration unit may not be necessary as the ground water temperature is cool and remains relatively constant even in the summer.

Figure 4: Alternative drinking filling stations, Elkay Deluxe Floor Cooler (left), Elkay EZH2O Cooler Kit **(middle), Brita Hydration Station (right)**

Water fountains often suffer from a poor public image. They are often installed when the building is built, and are often in poor and unsanitary conditions. Water from old units is unfiltered and has an undesirable taste due to the chlorine in the water and contaminants from old piping. They are also difficult to fill reusable water bottles due to its awkward orientation and low water pressure. WaterFillz overcomes this poor public image by deliberately making their machines large with colorful graphics showing how the water has been treated. This gives the impression that the water coming from this machine is pure and has been treated by a high tech and complicated process, even though our research has shown that the filtration process is very simple and conventional, used in many home applications.

The image of water fountains could easily be improved by using the same tactics as used in the WaterFillz units. Various signs, banners, or other promotional material could be present around the water mountain to explain the filtering process of the water fountain and educate people on sustainable water consumption. The goal is to give the public an impression that the water from the fountain has been properly treated for drinking, and is pure and free of undesirable contaminants.

Comparing between proposed water fill up stations and the WaterFillz, the water fill up stations are the best alternative to plastic bottled water, if implemented properly with an attractive appearance and proper signage. These fill up stations require less energy to manufacture and offer significant savings in initial cost and operation.

7.0 Conclusion and Recommendations

This report uses a triple bottom line analysis on single use plastic bottled water, WaterFillz, and proposed water fill up stations. The researched showed that plastic bottled water is unsustainable. It is energy intensive to produce, the bottles end up in landfills and it financially impacts the students. For the AMS to promote a sustainable image, it is not recommended that the AMS consider single use bottled water as a major option in the new SUB building.

The survey conduct for UBC Seeds project shows that UBC students are open to alternatives to plastic water bottles. The WaterFillz units that the AMS proposes do promote the image of sustainability and have received positive feedback from students. However, the AMS should perform an assessment on the proposed Elkay and Brita water fill up stations comparing them to the WaterFillz units. The purchase costs of these models are significantly lower than the WaterFillz units at $1,200-$4,000. The filtration systems are also simpler and easier to maintain in these models. These units are smaller and easier to implement into buildings. The AMS should perform a thorough assessment on the energy implications of these units and should not consider plastic water bottles as an option.

References

[1] S. Griffin, "The Toxic Footprint of PET-Bottled Water in British Columbia," Toxic Free Canada, 2009. Available HTTP: http://www.toxicfreecanada.ca/pdf/TFC%20bottled%20water%20report_final.pdf

[2] P H Gleick and H S Cooley, "Energy Implications of bottled water," Environmental Research Letters, Vol. 4.1, letter 4 014009, 2009
Available HTTP: http://iopscience.iop.org/1748-9326/4/1/014009/
UBC Science and Engineering Library- GREENR online resource

[3] "Bottled Water," Wikipedia- free online encyclopedia [Online document].
Available HTTP: http://en.wikipedia.org/wiki/Bottled_water

[4] "Bottled Water in the United States," Data Monitor- Bottled Water Industry Profile, April 2010.
UBC Library- Print and Electronic Journals

[5] "Daily Water Intake Calculator," calculatorslive.com [Online calculator].
Available HTTP:
http://www.calculatorslive.com/Daily-Water-Intake-Calculator.aspx

[6] Sean Cook and Stephen Petrina, "Changing Tastes: Coca-Cola, Water and the Commercialization of Higher Education," Workplace: A Journal for Academic Labor 2005, Vol. 7:1, pp. 96-111, November 1, 2005
Available HTTP:
http://docs.google.com/viewer?a=v&q=cache:xHM_P3KRH_wJ:cust.educ.ubc.ca/workplace/issue7p1/pdfs/cookpetrina.pdf+ubc+beverage+contract&hl=en&gl=ca&pid=bl&srcid=ADGEESiUn8DbZjQiRAllxiTIFbf0owFz0duooIFnpRjMqWG82Ow9tSj2jPqbpkLn34NqiebFEp-mP6CCzAm5Vzu1E_wf55DdswG70sCKPz5gz9P-R4cPOM1pHBu3yonHTpsOLwZ51N_n&sig=AHIEtbQa7XAaPQ2tZXc0h1KzIO0meSnTYw

[7] Catherine Ferrier, "Bottled Water: Understanding a Social Phenomenon," [Discussion Paper], April 200. Available HTTP: http://civil.colorado.edu/~silverst/cven1317/bottled_water%20ferrier.pdf

[8] Diane P. Dupont, "Tapping into Consumers' Perceptions of Drinking Water Quality in Canada: Capturing Customer Demand to Assist in Better Management of Water Resources," Canadian Water Resources Journal, Vol. 30.1, pp. 11-20, 2005 UBC Science and Engineering Library- Compendex Online Journal Search

[9] Angela Willock and Rosalind Sadowski, UBC Seeds Project, Survey

[10] "Iron and Steel Overview: Energy Consumption," Metals Processing Advisor Website [Online document]. Available HTTP: http://www.energysolutionscenter.org/heattreat/metalsadvisor/iron_and_steel/overview/energy_consumption.htm

[11] "Deluxe Cooler," Elkay Products Website [Online document]. Available HTTP: http://www.elkayusa.com/cps/rde/xchg/elkay/hs.xsl/elkay-com-1300.aspx

[12] "Brita Hydration Station'" Brita Hydration Station home page. Available HTTP : http://www.britahydrationstation.com/buy/