Name

Caitlin Piccirillo-Stosser

Email address

caitlinps702@uchicago.edu

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The Use and Efficacy of Water Bottle Filling Stations as a Sustainability Initiative for Reducing Environmental Impact

Project description
My research examined how water bottle filling stations contribute to improving sustainability and reducing plastic waste at The University of Chicago (UChicago). A station inventory was created using information provided by Facilities Services and by visiting all campus buildings. To understand station usage, station meter (green ticker) data was recorded over a two-week period, a questionnaire was distributed to students, and station observations were conducted. It was found that filling stations are widely used and positively viewed by students. Cost-benefit analysis indicated that there is a large net benefit for installing additional filling stations at UChicago. Recommendations for further decreasing UChicago's reliance on plastic water bottles and waste generation at minimal costs include improving filling station records, installing additional stations on campus, and reducing plastic water bottle sales and distribution. This research will assist UChicago in reducing its carbon footprint and serving as a model for other institutions to follow.

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Name and Department of course instructor/faculty supervisor for project

Dr. Sabina Shaikh, Director of the Program on the Global Environment

The Use and Efficacy of Water Bottle Filling Stations as a Sustainability Initiative for Reducing Environmental Impact

Caitlin Piccirillo-Stosser
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Public Policy Studies, The University of Chicago
First reader: Yaqub Hilal
Second reader: Dr. Sabina Shaikh

Abstract

This research examines how water bottle filling stations contribute to improving sustainability and reducing plastic waste at The University of Chicago (UChicago). A station inventory was created using information provided by Facilities Services and by visiting all campus buildings. To understand station usage, station meter (green ticker) data was recorded over a two-week period, a questionnaire was distributed to students, and station observations were conducted. It was found that filling stations are widely used and positively viewed by students. Cost-benefit analysis indicated that there is a large net benefit for installing additional filling stations at UChicago. Recommendations for further decreasing UChicago's reliance on plastic water bottles and waste generation at minimal costs include improving filling station records, installing additional stations on campus, and reducing plastic water bottle sales and distribution. This research will assist UChicago in reducing its carbon footprint and serving as a model for other institutions to follow.

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I. Introduction

Americans have long expressed concerns about the health and safety of their drinking

water. In 1974, the Safe Drinking Water Act was passed with the intention of increasing the

accountability of public water providers and ensuring that all Americans have access to safe

drinking water (U.S. Environmental Protection Agency 1999). This was a groundbreaking piece

of legislation, as the Environmental Protection Agency (EPA) was given the authority to

establish requirements such as maximum levels of contaminants in water believed to be safe for

consumption (U.S. Environmental Protection Agency 1999). More recently, many individuals

have begun to express consternations about the negative effects that the water industry has on

the environment. Plastic disposable water bottles in particular pose significant environmental

problems. As a result, efforts have been made to transition away from plastic bottled water

toward sustainable alternatives in hopes of reducing waste and environmental impact. The

adoption by many cities of bans on plastic bottled water distribution, coinciding with an

increased consumer preference for cheap, environmentally-friendly options, has led to a large

increase in the reusable water bottle market (Chiu 2014; Transparency Market Research 2016).

At a valuation of $7.04 billion in 2015, the reusable water bottle market is expected to rise to

$10.19 billion in 2024 (Transparency Market Research 2016). To accommodate the changes in

both laws and consumer behavior, many institutions have begun to install water bottle filling

stations in their facilities. This research aims to understand how water bottle filling stations

contribute to reducing environmental impact at The University of Chicago (UChicago).

Plastic bottled water was first introduced in 1947, and since then, it has been the cause of much debate. The disparity of bottled water availability across socioeconomic groups and different areas of the world has often been a point of criticism, as the expense of bottled water has prevented it from being accessible to many poorer communities (Hawkins et al. 2015). The health and safety of bottled water have also come into question. While the quality of bottled water is expected to be better than the quality of tap water, this is not always true; in some cases, bottled water can contain just as many chemicals as tap water (Sullivan et al. 2005). In fact, a study conducted in 1999 by the Natural Resources Defense Council (NRDC) found that one-third of the 103 brands of bottled water tested contained elevated levels of bacteria, inorganic chemicals, and/or organic chemicals, leading the NRDC to conclude that bottled water was not necessarily safer than tap water (Olson et al. 1999).

In addition, the plastic bottles themselves frequently contain chemicals that can have potentially harmful health consequences. One such chemical, biphenol A (BPA), is a hormone-disrupting chemical that has been shown in animal studies to be associated with reproductive abnormalities (Natural Resources Defense Council n.d.). The possibility of BPA having adverse health effects has led manufacturers of plastic packaging and containers to gradually phase out its use (Tavernise 2012). In addition, in 2012, the U.S. Food and Drug Administration issued a ban on the use of BPA in the production of baby bottles and cups (Tavernise 2012). Even BPA-free water bottles may present health risks. Some of the chemicals that have replaced BPA in plastics, such as fluorine-9-bisphenol (BHPF), have also been correlated with reproductive abnormalities in animal studies (Wilson 2017). If BHPF has the same properties in humans as it does in other animals, it has the potential to cause fertility problems in humans. The existence of these chemicals in plastic bottles and other food and drink containers thus poses significant

health concerns. Still, during disasters such as the Flint water crisis when the safety of public water sources is questioned, bottled water is often purchased as a "safe" alternative to tap water (Stack 2017).

Bottled water has also become a serious environmental concern because it contributes to the critical issue of plastic waste. A recent study found that of the 8.3 billion metric tons of plastic that have been produced, 6.3 billion metric tons have become plastic waste, and of that, 91% has not been recycled (Parker 2017). The vast majority of plastic waste ends up in landfills, the natural environment, or the oceans, where it can take approximately 700 years for the plastic to decompose (Demszky n.d.). In addition, humans purchase about one million plastic bottles per minute, and in 2013, the recycling rate for plastic water bottles was only 23% (Nace 2017; Demszky n.d.). In the U.S., the 50 billion plastic water bottles that are used annually require 15-30 million barrels of oil, which is equivalent to fueling between 100,000 to 2 million cars for one year (Demszky n.d.). The production of bottled water annually generates 12 billion pounds of carbon dioxide emissions, contributing to global warming and climate change (Demszky n.d.). Further, approximately 2,000 times more energy is necessary to produce bottled water than tap water. While bottled water costs between $1.22-$7.50 per gallon, tap water only costs about $0.0004 per gallon (Demszky n.d.). It is evident that alternative solutions to plastic bottled water are necessary to reduce plastic waste and harmful environmental impacts.

Fortunately, many organizations and individuals have recognized the negative effects of plastic bottles on the environment. City authorities in particular have taken the lead in prohibiting the distribution of bottled water to reduce their carbon footprints. In 2013, Concord, Massachusetts became the first U.S. city to go entirely bottled water free, as the law prohibits the sale of non-sparkling, unflavored drinking water in single-serving plastic bottles of one liter or

less (Chiu 2014). In 2014, San Francisco began transitioning away from the sale and distribution of plastic bottled water on City property (Chiu 2014). Many cities and states have imposed taxes on bottled water. As of January 1, 2008, the City of Chicago has enacted the Chicago Bottled Water Tax, which levies a tax at the rate of $0.05 per bottle that must be paid by the purchaser (City of Chicago 2008). This tax is intended to discourage individuals from purchasing plastic water bottles, and can directly influence students' consumption preferences with regard to plastic bottled water.

Efforts have been made at UChicago to reduce the prevalence of plastic water bottles on campus. In 2011, UChicago Students Against Bottled Water (SABW), a subgroup of the former registered student organization (RSO) Green Campus Initiative (GCI), led a successful campaign to remove plastic water bottles from the student-run cafes (Slezkine 2011). Student Government supported this campaign and passed a resolution advocating for the gradual elimination of plastic water bottles on campus (Slezkine 2011). The café in the basement of Swift Hall (the Divinity School), Grounds of Being, although not a student-run café, joined in this effort by phasing out the sale of bottled water in the café and instead selling custom-printed BPA-free stainless steel refillable water bottles (Chatterley 2011). The efforts by SABW also helped to reduce the number of plastic water bottles provided at Convocation from 40,000 in 2010 to just over 6,000 in spring 2012 (Perrera 2012). However, SABW's campaign was led six years ago, neither GCI nor SABW exist in their original forms anymore, and few efforts on the part of the administration have been made to reduce plastic water bottle sales and distributions since then. While the ban on student-run campus cafes selling plastic water bottles is still active, disposable water bottles are available for purchase in vending machines, campus convenience stores, and some cafes on campus.

As a result of these policies and campaigns, as well as an enhanced understanding of climate change and human impact on the global environment, there have been increasing efforts across the U.S. for individuals to move away from the reliance on plastic water bottles and toward the use of refillable bottles. Reusable water bottles present a more environmentally-friendly option, as they do not contribute to the accumulation of plastic waste. It should be acknowledged that reusable plastic bottles could potentially pose health risks, since they also can contain chemicals like BPA. For example, previous research has shown that BPA can be released at higher rates from hard, polycarbonate bottles when exposed to boiling water (University of Cincinnati 2008). However, researchers have demonstrated that when BPA-free reusable bottles are used according to the manufacturers' recommendations, they are suitable for use and consumption (Cooper et al. 2011).

This trajectory toward using reusable water bottles instead of disposable plastic bottles is supported by the development of technologies, such as enhanced filtering systems, that improve the quality of tap water as a drinking water source. Water bottle filling stations are one particular technology that many institutions have been turning to in order to ensure safe drinking water while considering potential environmental impacts. Elkay is one of the leading innovators in manufacturing sustainable bottle filling stations, and currently has approximately 50 models of filling stations on the market (Elkay 2017a). Some of the other most prominent manufacturers of bottle filling stations are Halsey Taylor, Haws, and Oasis. While there are slight differences across brands and models, nearly every bottle filling station comes with a "filter monitor," with green, yellow, and red lights to indicate the filter status (Elkay 2017c). A filter is approaching the end of its life when the monitor is yellow, and filter replacement is necessary when the monitor is red (Elkay 2017c). In addition, each filling station contains a "green ticker," a meter that

informs users of the number of 20 oz. plastic water bottles that have been saved from waste (Elkay 2017c). In other words, the green ticker counts up how many bottles have been filled (in 20 oz. increments) as a means of highlighting to the station user the impact made by using the station rather than buying plastic bottled water. Currently, filling stations are still fairly expensive. Depending on the color, model, material, accessories, and other features included, such as whether the station is in-wall/standalone or attached to one or more drinking fountains, filling stations can range in price from approximately $700 - $7,500 (Elkay 2017c; Halsey Taylor 2017). While this clearly represents a wide range of prices, the most important aspects of the filling station, including the filter and cooling system, are featured even in the less expensive models. Further, all stations serve the purpose of helping to significantly offset plastic waste.

Water bottle filling stations are becoming increasingly more popular amongst consumers of reusable water bottles, and in response, numerous hospitals, schools, athletic facilities, and office buildings have installed filling stations (Elkay 2017b). In addition, to accommodate travelers who can no longer bring through security containers with fluids exceeding three ounces, and to reduce the number of plastic bottles going to landfills, airports across the United States have been more widely installing filling stations (Brockman 2017). With the reusable water bottle market expanding exponentially, the number of bottle filling stations and other technologies that improve the quality of tap water and support sustainability is expected to continue to grow over the next several decades.

UChicago has several filling stations on campus. However, the effectiveness of these stations in reducing UChicago's plastic waste generation has yet to be fully elucidated, as the stations are poorly documented by UChicago administration and green ticker data are not currently tracked. I located all filling stations on campus and understood how the campus filling

stations are used by distributing a questionnaire to students, tracking green ticker data, and

conducting station observations. As it is outlined below, stations are extensively used and

positively viewed by students, but there is ample room for improvement. I recommend that

additional stations be installed on campus and that a ban on plastic water bottles be implemented

to reduce UChicago's overall environmental impact.

II. Review of Literature

A small body of literature has evaluated different universities' and other institutions'

sustainability initiatives. Few studies have examined the efficacy of water bottle filling stations,

and, of those that have, the majority have examined water bottle filling stations as a means to

provide healthier water sources rather than as a strategy for reducing plastic waste. However,

some universities have installed water bottle filling stations on their campuses in hopes of

increasing the use of reusable water bottles and reducing environmental impact.

IIa. Sustainability Initiatives at Universities

Many universities around the world are taking great strides in adopting techniques for

reducing their environmental impacts and becoming "green" (McMillin and Dyball 2009).

Universities, including UChicago, have formed Offices of Sustainability that are responsible for

collaborating with campus and community partners to foster a culture of sustainability through

projects and practices (The University of Chicago Environmental Research and Sustainability

n.d.). UChicago and other universities have developed sustainability plans that outline both the

goals and achievements of the university with respect to enhancing sustainability on campus. The

UChicago Sustainability Plan Baseline Report highlights nine areas in which the Office of

Sustainability is focusing its sustainability goals (The University of Chicago Office of Sustainability 2016). While the report identifies waste reduction as one of these nine key areas, mentioning that 41% of the waste produced at the Hyde Park campus was diverted from landfill in 2015, the report does not mention water bottle filling stations as an element used to reduce campus waste (The University of Chicago Office of Sustainability 2016).

One of the most common efforts that universities make to improve sustainability on their campuses is to transition to more efficient sources of energy to power some or all of their buildings. Many universities are striving to obtain Leadership in Energy and Environmental Design (LEED) certification for their buildings, which entails complying with standards for healthy, highly efficient, and cost-saving green buildings. For example, the University of Wyoming (UW) is committed to reducing carbon emissions and incorporating renewable energy where possible in their facilities (Filho et al. 2015). Several of UW's new building projects have received LEED gold and LEED platinum ratings as a result of including innovative designs, such as a "living roof," that emphasize sustainable materials, low water use, insulation, and renewable energy. UChicago currently has 14 LEED certified buildings on its campus, and the University has recently adopted a policy that requires all new construction projects costing more than $5 million to be LEED certified (The University of Chicago Facilities Services). However, while projects have focused widely on development and technological innovation, few universities have undertaken other sustainability projects, and there has been a lack of large-scale recycling and waste reduction efforts.

Table 1: Advantages of Campus Greening (Filho et al. 2015).

Items	Advantages
Visibility	Campus greening activities showcase what an institution is doing and promote it—locally, regionally and internationally
Students' engagement	Campus greening efforts are inclusive and may engage students in practical implementation
Demonstration nature	Innovative approaches, methods and projects can be tested and demonstrated
Documentation	Activities on campus offer a permanent or semi-permanent record of what an institution is doing
Economic gains	Initiatives in campus greening often leads to decreases in wastage and hence saves money
Curriculum link	Many subjects can be taught and many principles can be illustrated via suitable campus greening schemes
Mobilization of students and staff	Academic staff and students tend to get equally mobilized in campus greening schemes

Campus greening has been shown to have additional significant positive effects aside from the direct environmental benefits from implementing more sustainable practices (Table 1). Consequently, many universities have developed sustainability centers in order to facilitate the integration of sustainability into the institutions' research and curricula. Soini et al. found that, as of 2017, there were 44 established university-based sustainability centers worldwide, which were defined as research centers that use sustainability or sustainable development concepts as their main frameworks; 31 were established between 2006-2016, but only 12 were in the United States (2018). These centers can be crucial in expanding sustainability research and the introduction of environmentally friendly practices both at universities and in surrounding communities. However, the fact that few of the existing sustainability centers are in the U.S., coupled with the authors' conclusion that the goals of a majority of the centers were solution-based rather than focused on understanding various environmental problems, may result in a large gap between the research and actual implementation of successful sustainability practices at universities.

McMillin and Dyball observed that many universities tackle sustainability in a compartmentalized manner, with sustainable education, research, and campus operations often very detached from each other (2009). They suggest a "whole-of-university" approach to sustainability, and encourage institutions to recognize that students learn from their entire university experience, which can be done by offering research- and project-based courses. At Australian National University (ANU), the 12-month trial of an in-vessel organic waste composting unit provided an opportunity for the integration of research and operations into student curriculum, while observing real effects from the composting unit (McMillin and Dyball 2009). Limitations to implementing sustainable practices or holistic methods as such include perceived costs to universities, as well as the time and commitment required for these projects (Filho et al. 2015). Therefore, this research hopes to identify water bottle filling stations as a low-cost and simple method for improving student engagement in minimizing UChicago's waste and carbon footprints. It will also be necessary to incorporate filling stations into UChicago's Sustainability Plan, especially with respect to waste reduction and sustainability water practices.

IIb. Water Bottle Filling Stations

Little research has investigated the use or efficacy of water bottle filling stations, likely because they are a fairly new technology and only recently has the trend to install filling stations begun to accelerate. Many hotels are switching to water bottle filling stations instead of standard water fountains in both front and back of house areas. Hilton San Francisco Union Square reported that they avoided 200,000 plastic water bottles over a span of ten months from eight filling stations (Hasek 2016).[1] All employees at the Hilton are given reusable water bottles, and

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[1] This number was determined by the green tickers that indicate the number of bottles saved at the hotel's stations.

individuals attending meetings and conferences at the hotel are encouraged to use filling stations rather than plastic water bottles. In addition to being sustainable and reducing plastic waste, hotels are using filling stations as an opportunity to increase revenue by selling reusable water bottles in hotel gift shops (Hasek 2016). While filling stations have been mentioned positively in hotel reviews, there is still little known about the consumer perspective of using bottle filling stations.

A recent study by Patel et al. examined the efficacy and cost of two different water delivery systems, water dispensers and bottleless water coolers, in increasing middle school students' access to and intake of water (Patel et al. 2016). The researchers found that students who were provided with these non-traditional water dispensers increased their water intake by 20% as compared to students who only had access to traditional drinking fountains. While neither of these water delivery systems are the subject of the current research, the evaluation of consumer behavior in a school setting contributes critical insights. The research suggests that individual behaviors toward water consumption can be adjusted based on the availability of different types of water dispensers. Thus, the provision of numerous bottle filling stations in a university setting may encourage individuals to use the stations to fill up reusable water bottles and transition away from consuming plastic water bottles.

Many of UChicago's peer institutions have initiated campaigns to reduce plastic waste on their campuses. Some have installed water bottle filling stations and have begun to advocate extensively for their extensive use. Cornell University has made filling stations available for reservation to be used at campus events. It was found that over 33,000 plastic water bottles were consumed during Cornell's end of year "Slope Day" celebration, costing over $20,000 in purchases alone, not even taking into account the costs of waste removal or subsequent

environmental impacts (Cornell Sustainable Campus n.d.a). Therefore, Cornell emphasizes to its students how much money and waste could be saved if all events used filling stations rather than buying bottled water for distribution. Duke University installed 50 filling stations on its campus between January 2014 and October 2015, which contributed to saving approximately 400,000 plastic water bottles in that time (Roth 2015). Further, to encourage the use of filling stations and the minimization of Duke's carbon footprint, the university provides every first year student with a reusable water bottle.

Princeton University launched a "Drink Local" campaign to encourage students to drink tap water and use campus filling stations. Like Duke, since 2009, Princeton has distributed complimentary water bottles to first-year students during move-in, which helps ensure students' ability to use the filling stations (Demszky n.d.). The Drink Local project has assisted in securing the installation of more than 190 bottle filling stations on its campus (bringing the total number of stations to more than 250) (Demszky n.d.). These stations have been installed in dorms, athletic buildings, and academic and administrative buildings across campus (Demszky n.d.). With the help of the Drink Local campaign, Princeton has observed positive responses to the filling stations from the students, as filtered tap water offers a cheaper option than bottled water and yet has no discernable taste difference. Interns on the Drink Local project have made several key recommendations for how to reduce the monetary and environmental costs associated with plastic water bottles at Princeton. These include an increase in the number of filling stations on campus and an end to the sale of bottled water in cafeterias, campus stores, and vending machines (Demszky n.d.). Princeton, Cornell, and other UChicago peer institutions such as the University of Pennsylvania, Columbia University, and Harvard University have created extensive inventories and maps of the locations of all the bottle filling stations across the

university campuses; these are available for viewing on each university's respective

sustainability website (Sustainability at Princeton n.d.; Cornell Sustainable Campus n.d.b.; Penn

Sustainability 2016; Columbia University Housing n.d.; Harvard University Sustainability n.d.).

These resources help provide easy access to and encourage more widespread use of these

stations.

UChicago also has numerous filling stations on campus, but unlike Princeton, there is no

campaign whose efforts are strictly focused on connecting students and faculty to these stations

and increasing their use. While UChicago's Office of Sustainability has exerted significant

efforts to improving campus sustainability through various initiatives and programming, it is

evident that little has been done regarding the bottle filling stations on campus. The inventory

maintained by the Office of Sustainability that details the campus filling station locations is

incomplete, which hinders administration and Facilities Services from locating the stations when

they are in need of repair or replacement. UChicago administration may also not know which

buildings could benefit from the installation of additional stations. Transparency to students,

faculty, and other campus-goers is limited as well, as UChicago has yet to make this inventory,

or a map, of the campus filling stations available for viewing online. Students and faculty may

not know all of the locations where they can fill up their water bottles, which prevents the

amount of plastic bottles saved from reaching its full potential. In addition, the green ticker data

is not currently tracked, recorded, or otherwise managed by any UChicago personnel. Thus, this

research aims to provide a more holistic understanding of water bottle filling stations at

UChicago and to investigate how filling stations can be used as a sustainability initiative for

reducing plastic waste and other harmful environmental impacts. While I acknowledge that

plastic soda bottles and other plastic containers also contribute significantly to the problem of

plastic waste, I chose to focus on water specifically because tap water, particularly from bottle filling stations, offers a cheap, healthy, and readily available alternative to plastic bottled water.

III. Methodology

In order to elucidate the role of water bottle filling stations in the reduction of plastic waste and in student participation in sustainability practices, this research was conducted in five phases. First, a complete inventory of the filling stations at UChicago was created, compiling materials provided by the Office of Sustainability and information gathered by visiting all campus buildings. Second, green ticker data (the number of plastic water bottles a station saves) from a selection of ten representative stations were collected and recorded for a two-week period. Third, a questionnaire was distributed to UChicago students via Facebook to gain an understanding of students' use of reusable water bottles, use of filling stations, and preferences regarding filling stations, among other key pieces of information. Fourth, three campus stations were selected for observations of students' interactions and behaviors with filling stations. Fifth, the data collected from the previous phases was used to conduct a cost-benefit analysis of installing a new filling station at UChicago. These analyses were compiled to provide recommendations for how to increase the use and awareness of filling stations and reduce plastic waste and UChicago's environmental impact.

IIIa. Water Bottle Filling Station Inventory and Map Creation

An inventory of the locations of water bottle filling stations on UChicago's campus was obtained from the Office of Sustainability. However, this inventory was quickly identified as being incomplete, missing several of the filling stations located around campus. Thus, in order to generate a better understanding of the impact of filling stations on campus, I visited all campus

buildings to identify any stations that had not been recorded by UChicago administration. All previously undocumented stations that I newly identified were recorded in a Microsoft Excel spreadsheet, including the location (building name and floor) of the filling station and the manufacturer of the filling station. This list was subsequently analyzed; specific buildings and types of facilities on campus where there are a plethora of stations as well as areas where there are few or no stations were identified in order to highlight where there are opportunities for installing additional stations.

I then created a map of all campus filling stations to help me visualize where the stations were located, using a free online map of UChicago's Hyde Park campus. Teardrops were used to indicate the buildings in which there are filling stations, and different colored teardrops were used to distinguish between the stations that had been documented by the Office of Sustainability and those that had not. A number was put into each teardrop to represent the number of stations in that building.

IIIb. Green Ticker Data Tracking

From this inventory, ten water bottle filling stations were selected for green ticker tracking (Table 2). As mentioned above, each filling station has a "green ticker" that records the number of plastic water bottles that have been saved by using the station.[2] Since there are numerous filling stations on campus, it was not feasible within the time constraints of this study to obtain green ticker data from all stations. Ten stations, therefore, were selected to capture the utilization of these stations across UChicago's campus. The data collected from these ten stations was then extrapolated to estimate the number of water bottles saved at all filling stations campus-wide. These ten stations were selected for green ticker tracking because they are located in areas

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[2] The green ticker counts a "water bottle saved" each time 20 oz. of water are dispensed.

that are believed to represent the various types of facilities and buildings that students frequent. This was crucial because one of the main goals of this research was to understanding how students in particular utilize the filling stations.

Table 2: Water bottle filling stations at UChicago selected for green ticker data tracking.

Station Location	Manufacturer
Regenstein Library, 1st floor	Elkay
Reynolds Club, basement	Elkay
Harper Memorial Library, 1st floor	Elkay
Harper Memorial Library, Harper café	Elkay
Henry Crown Field House, 2nd floor southeast corner	Elkay
Ratner Athletics Center, 2nd floor	Elkay
William Eckhardt Research Center, 1st floor	Halsey Taylor
Cobb Lecture Hall, 1st floor	Elkay
Swift Hall (The Divinity School), 1st floor	Elkay
Reva and David Logan Center for the Arts, basement	Halsey Taylor

The sample includes stations located in two libraries, two athletics facilities, four classroom buildings, one arts center, and one student center. In addition, two of the stations are located next to or near cafes on campus, which are frequently visited by students: the Regenstein Library station, next to Ex Libris Café; and the Harper Memorial Library 3rd floor station, next to Harper Café. These stations were expected to report high numbers of bottles saved due to their proximity to cafés and the potential desire for students to refill their bottles while visiting the cafes. Similarly, the stations in the athletic facilities were anticipated to have high usage due to the need to hydrate during and after exercising. By contrast, the stations chosen for tracking that are located in the Eckhardt Research Center and the Logan Center for the Arts were predicted to be used less frequently, due to the fact that the buildings are not located on UChicago's main quadrangle and are not main classroom buildings. Therefore, it was believed that the sample would produce an average green ticker two-week difference that would serve as a strong estimator of the average green ticker two-week difference of all stations campus-wide. "Initial"

green ticker reads for each of the ten stations were collected and recorded in a Microsoft Excel spreadsheet, and two weeks later (14 days), a "final" green ticker read was recorded. The initial ticker read was subtracted from the final ticker read to obtain the green ticker two-week difference for each station, or the number of bottles saved at each station over two weeks.

IIIc. Student Station Use and Awareness Questionnaire

A questionnaire was developed in Qualtrics, inquiring about students' use and awareness of water bottle filling stations on campus (Qualtrics 2018). The questionnaire was distributed to UChicago students via a link posted in several Facebook groups to which only UChicago students have access, in order to prevent individuals who are not UChicago students from taking the survey.[3] The questionnaire was kept "live" for two weeks (14 days), during which as many responses were collected as possible. The questionnaire was voluntary to complete and specific students were not targeted for responses; further, all responses were anonymous and no identifying personal information (e.g. name, email, student ID number) was collected.

This questionnaire comprised 26 questions, including multiple choice, short answer, and "select all that apply" questions (Appendix 1). In addition, some questions featured built-in survey logic, in which respondents were asked a follow-up question only if they answered the previous question with a certain answer. For example, for the question, "Do you own a reusable water bottle that you use on campus," only the survey participants who responded "yes" were directed to the follow-up question, "How often do you use a reusable water bottle," as this second question would not pertain to individuals who responded otherwise to the previous question. This logic was included so as to continue to obtain important information without

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[3] To further ensure that responses were controlled, the link that students clicked on for the survey was set up so as to limit each respondent to submitting only one response, through an option provided on Qualtrics called "Prevent Ballot Box Stuffing."

forcing individuals to select an "N/A" option every time a question did not relate to them. This helped to limit the amount of time individuals spent on the survey, and, in this way, to increase the participation in and completion of the survey.

There were a number of questions that inquired about individuals' awareness of and interactions with bottle filling stations as well as several opinion-based questions about water bottle filling stations and UChicago's policies on sustainability. Students were also asked about their water bottle preferences, and how frequently they bought bottled water compared to using reusable bottles. Brief demographic questions were asked at the end of the questionnaire to contribute to the researcher's understanding of which student populations express interest in bottle filling stations and sustainability issues on campus.

IIId. Bottle Filling Station Observations

The fourth phase of this research was to observe consumer interactions at three select water bottle filling stations on campus: the filling stations on the first floor of the Regenstein Library; on the first floor of Cobb Lecture Hall; and in the second floor southeast corner of Henry Crown Field House. These specific locations were chosen because it was estimated that these buildings would account for three different activities in which students commonly participate, studying, attending class, and exercising, and I was interested to see if interactions with filling stations differed across locations. For each location, observations were conducted at three separate times (morning, afternoon, evening) on three consecutive Thursdays for a total of nine observations.[4] Each observation period lasted for approximately 30 minutes, and was held at

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[4] With two exceptions (see footnote 5), station observation periods occurred from 8:45-9:15am, 2:00-2:30pm, and 7:00-7:30pm. Stations were observed on Thursdays for three consecutive weeks, on a rotating schedule. For example, on the first Thursday, the Crown station was observed in the morning, the Cobb station in the afternoon, and the Regenstein station in the evening. Thus, on the following Thursday,

the same three times of day each week.[5] Individuals were not informed that they were being observed in order to preserve the objective of understanding how students interact with filling stations on a daily basis. In addition, while this research focuses on undergraduate students' use of filling stations, observations were not limited strictly to students due to the inability to easily differentiate between undergraduate students and other individuals, such as graduate students, faculty, or campus visitors. Thus, observations measured station user activities in general.

During each observation, several data points were recorded in a Microsoft Excel spreadsheet, with separate tabs for each observation period. Each individual who approached the water bottle filling station was labeled in the spreadsheet as "Individual X," where X corresponded to the individual's order number (e.g. Individual 5 corresponded to the fifth person observed approaching the bottle filling station in that observation period). It is important to note that all individuals who approached the filling station were recorded, which includes both those who used the filling station as well as those who used the drinking fountain or completed a different action. For each individual, structured details were recorded to complete the matrix: the time at which the individual approached the station; if the filling station, drinking fountain, and/or hot water tap (at Regenstein Library station) were used; what type of water container was filled, if any (cup, plastic water bottle, reusable water bottle, other); and if the individual poured out water from his/her container prior to filling it up. Any additional behaviors were also noted

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the Regenstein station was observed in the morning, the Crown station in the afternoon, and the Cobb station in the evening. The observations were rotated in this manner until each station was observed once in the morning, once in the afternoon, and once in the evening.

[5] There were two exceptions to this schedule. The first was that the Crown station could not be observed at 7pm on the third Thursday of observations because I had conflict with a prior commitment that could not be missed. Thus, the Crown station was observed from 6:20-6:50pm that day instead. I do not believe that this slight change in observation time has any significant effects on station observation data, as the observation was still conducted in the evening, with only a 40-minute deviation. The second exception was that the Regenstein Library station could not be observed in the afternoon of the third week, as to follow the schedule, because the station had broken the previous evening and was "out of order." The station was under repair for approximately five days, and I did not conduct this observation at all.

in a general comments section for each individual. General notes, reflecting on the setting and station users on a more holistic level, were taken as well. Interactions were then compared across the three locations and across the three different observation periods for the same station.

IIIe. Cost-Benefit Analysis

The final phase of the research aimed to determine the net monetary benefit of filling stations. To do this, cost-benefit analysis was conducted by evaluating both the costs and benefits of one newly installed filling station in the first year. This analysis attempted to estimate both private costs and social costs, such as the environmental costs of plastic bottles. However, little research has been done to calculate the exact environmental cost of the entire life cycle of a single plastic water bottle, from production to consumption to disposal. Calculations were modeled after the Environmental Impact Calculator for bottle filling stations that Elkay makes available on its website, but were adjusted to reflect UChicago's unique circumstances (Elkay n.d.c).

For the filling station's costs, the list price of the most common filling station model at UChicago, the Elkay Single Green ezH2O Model LZSG8WSSK, was found in the Elkay 2017 ELP-6C Commercial Price Guide (Elkay 2017c). Installation costs were estimated by assuming that installation would take two maintenance technicians approximately three hours of work. Filter costs had to be accounted for as well, since each filter has a capacity of approximately 20,000 20 oz. bottles and therefore need to be replaced multiple times during a single year (Elkay n.d.b). The cost of the water used by these stations was included by applying the City of Chicago's water rate (price) to the amount of water used by consumers of the campus filling stations (City of Chicago 2017). The cost of the energy required for generating the amount of tap

water consumed by one filling station was also incorporated into the equation. I reached out to UChicago's Facilities Services to inquire about filling station maintenance, and they reported that not much maintenance on the stations is needed after installation, so maintenance costs were not included in this analysis. All calculations are detailed below (see section *IVe*).

The benefits of a new filling station were conceptualized as the costs offset by using the station and not purchasing plastic bottles. Thus, the average number of plastic bottles saved by each station in two weeks (1,740 bottles saved), as calculated in this research (see section *IVb*), was multiplied by 26 to calculate the average number of plastic bottles saved by a single station in one year. This number was then multiplied by $0.21, the price of a plastic water bottle when purchased in bulk, to calculate the private benefit of the filling station.[6] Social and environmental benefits were considered as well. The cost offset by not using the energy needed to produce the plastic water bottles (saved) was calculated by multiplying the equivalent estimate of oil required for production by the current price of oil. All costs and all benefits were totaled and compared to determine if filling stations are a good investment for UChicago. Calculations are detailed below (see section *IVe*).

Sensitivity analysis was conducted to account for the possibility that the number of water bottles saved as counted in the green tickers on the filling stations may not actually represent the number of plastic water bottles that would be purchased if the station was not used instead. For example, just because someone fills up their reusable water bottle three times per day does not mean that they would necessarily buy three plastic disposable bottles. As it is difficult to

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[6] This was the price listed by Elkay in their Environmental Impact Calculator. This then represents the price of bottled water to UChicago, if it was to provide bottled water to students in place of them using filling stations or drinking tap water. This does not take into account the cost to the consumer, of purchasing the bottled water itself, since this analysis is focused on the costs to UChicago and the costs that it can offset (private and social benefits). If the list price of plastic bottled water that consumers face was substituted for the bulk price, the costs offset (benefits) would increase, and the net benefit would subsequently increase as well.

determine the exact effects of the presence or lack of a filling station on individuals' behaviors and water bottle purchasing versus filling preferences, a conservative assumption was made, where the number of "bottles saved" at filling stations could actually represent twice the number of plastic water bottles purchased and consumed when a filling station is not available. Thus, the calculations for benefits (costs offset) by installing a new filling station were repeated as detailed above, except using an estimate of the number of plastic water bottles saved that was 50% of the estimate in the previous calculations (870 bottles saved).

IV. Results and Analysis

IVa. Filling Station Search Identifies Several Additional Stations

Initial analysis of the inventory of filling stations provided by UChicago's Facilities Services and the Office of Sustainability indicated that the current records kept by university administration on the campus water bottle filling stations are incomplete. Only 61 of the stations were listed in the inventory, indicating that several stations were missing from the records, including the majority of the stations located in buildings on the main quadrangle. When asked about the missing information, the Office of Sustainability responded that the filling stations are largely undocumented, and that this issue is one that could be pursued in the future. This signifies two important ideas: first, UChicago's records are currently insufficient for leading a large project such as the Drink Local campaign at Princeton to encourage students to use filling stations for reducing campus waste and carbon footprint; second, UChicago administration is aware of this problem and is willing to take action to combat it.

After conducting an extensive search of all campus buildings, an additional 41 filling stations were identified in buildings that were not included in Office of Sustainability's inventory

(Table 3).[7] Adding these stations to those already logged in UChicago's official records, the number of stations totals 102 stations. Thus, more than 40% of the filling stations on campus are not documented in official records. The 41 newly identified stations are distributed across 20 buildings, the majority of which are in UChicago's main quadrangle, and therefore, are mostly older University buildings. Although the Office of Sustainability has not confirmed this theory, if UChicago has better records for more recent, large construction projects, this would explain why most of the documented stations are located in newer buildings. Likewise, the undocumented stations could be the result of small, one-time capital projects conducted in older buildings that did not get entered into university records.

The vast majority of the bottle filling stations are "drinking fountains with bottle fillers" (97%). However, the two filling stations in Jones Laboratory are standalone stations, without an attached drinking fountain. In addition, a hot water tap was recently installed on the drinking fountain attached to the bottle filling station in the Regenstein Library, likely with the intended purpose of giving library-goers the more accessible opportunity to get hot water for tea brought from home, without having to go to Ex Libris café (Table 3). There is also a hot water tap on the first floor of Hinds Laboratory, but it is not attached to a filling station.

UChicago has its own coding system for identifying locations within buildings, with which I am not familiar. Therefore, I specified locations by building floor and any other key descriptors (e.g. hallway, stairway, etc.) (Appendix 2). Although my own coding system differs

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[7] The search conducted was as extensive as possible. However, there is still a possibility that not all stations were found. As main hallways and the areas outside bathrooms are the most common locations of stations, these were the general search targets, but it is possible that some buildings have stations in back hallways or corners that may not have been found. In addition, some buildings on campus have restricted access and I was unable to search the building more than by looking through a small window in the door. Further, UChicago Medicine and other hospital buildings, while technically considered part of The University of Chicago, were not included in the search for stations as it was decided that the main focus of this research would be on filling station use by undergraduates. Finally, it is possible that some buildings where academic activities are held were unintentionally omitted from the search.

from that of the UChicago administration, I still believe that categorizing by floor the specific

locations of these newly identified stations will prove extremely useful to Facilities Services and

the Office of Sustainability. Facilities Services could expand upon my inventory to include the

more precise locations of the stations.

The number of filling stations in each building varies widely. Interestingly, some

buildings that do not receive much human traffic, at least according to the estimated occupancies

from the Office of Sustainability, have a filling station on nearly every floor, while some large,

high occupancy buildings only have one station serving the entire building. For example, Swift

Hall (the Divinity School) has one station on nearly every floor (basement, first floor, second

floor, third floor, and fourth floor), but has an estimated total occupancy of only 328 people

(Appendix 2).[8] By contrast, the Regenstein Library only has one station on the first floor next to

Ex Libris café, but has an estimated total occupancy of 810 people (Appendix 2).[9] In addition,

there are several buildings on campus that do not have any filling stations at all. Many of the

buildings in the science quad, as well as buildings including Gates-Blake Hall, Classics, and

Ryerson Laboratory, do have drinking fountains but lack bottle filling stations (not reported).

Another interesting finding was that only the most recently constructed dorm, Campus North

Residential Commons, has filling stations (14 stations). Currently, no other dorms have stations.

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[8] Estimates of total building occupancy for select buildings were obtained from the Office of Sustainability and Facilities Services, via email. Each estimate represents the sum of the building's estimated permanent occupancy, which includes offices and workstations, and the estimated temporary occupancy, which includes space with scheduled seating or stations. It is important to note that all occupancy counts are only a best estimate based on room types and sizes and have not been confirmed with codes, capacities, standards, or actual building occupants. In addition, pedestrian traffic through common areas such as corridors, lobbies, and lounges is not counted in the estimates.
[9] It is likely that this is a very conservative estimate, or an average of the number of people in the Regenstein Library at any given time. During certain times of the quarter, especially during midterms and finals weeks, the occupancy of the library is likely much higher.

The distribution of filling stations within buildings is also of particular note. A majority of the buildings (n=12) where stations were newly identified have stations on the first floor (60%) (Appendix 2). Some buildings also have stations in the basement of the building (n=6) (30%) or on upper floors of the building (n=11) (55%). However, of the buildings that have stations in the basement and/or on upper floors (n=14), eight do not have filling stations on the first floor as well (57.14%). While data was not collected in this research to specifically compare the frequency of station use between different floors within one building, it is expected that first floor filling stations are exposed to more traffic from people entering the building on the first floor, and thus are used more frequently and have a higher potential to save plastic water bottles from entering the waste stream. Future investigations should determine the floors with the most human traffic to identify target locations within buildings for additional station installations.

In an attempt to understand the discrepancies in the distribution of filling stations both across and within buildings, I asked the Office of Sustainability about how decisions are made as to where new filling stations are installed and who is responsible for making these decisions. Their response was brief, and did not indicate that there is any formal process for deciding when and where filling stations are installed. In some cases, specific departments request for a station to be installed in their building. In other cases, a capital project may specify the addition of a filling station. In yet others, filling stations are installed as a replacement upgrade once an older unit had reaches the end of its life. All of these reasons would explain why some buildings have many more filling stations than others. Certain departments may be more interested in installing stations, for environmental or other purposes, and subsequently make requests to the Office of Sustainability. Further, new buildings may include the filling stations in their plans to comply

with updated building codes, which would explain why many of the newer buildings have more stations and also why these stations tend to be more documented by university administration.

A map of all filling stations on campus was created (Figure 1). In this map, the blue teardrops indicate the locations of filling stations that had been previously been documented by university administration and the purple teardrops indicate the locations of filling stations that I identified through my campus search. The number in each teardrop indicates how many filling stations are in each building. As this map provides a visual of the campus filling stations, it is evident that filling stations are fairly well distributed across campus, although they are missing in some buildings, particularly dorms. We can see that the buildings on the peripheries of campus, which also happen to be the newer buildings, contain documented filling stations, while the buildings on the main quadrangle, the older buildings, have stations not currently logged in UChicago's records. Thus, improved record-keeping and building audits are necessary to find and document all stations. This map can serve as a valuable tool for students, faculty, and campus visitors to find the locations where they can fill up their reusable water bottles. Facilities Services and the Office of Sustainability can elaborate upon this map, and include an attached inventory that lists specific locations of filling stations, and make it available online. Further, improved records and a map can assist Facilities Services in determining where additional stations should be installed and in finding stations that may be in need of repair more quickly.

Table 3: Water bottle filling stations at UChicago, including both previously documented and newly identified stations.

Description	Building Name	Number of Stations	Manufacturer	Previously Documented?
Drinking fountain, with bottle filler	1155 East 60th St.	4	Elkay	Yes
Drinking fountain, with bottle filler	950 East 61st St.	6	Elkay	Yes
Drinking fountain, with bottle filler	Campus North Residential Commons	14	Elkay	Yes
Drinking fountain, with bottle filler	Chicago Theological Seminary	5	Elkay	Yes
Drinking fountain, with bottle filler	Facilities Services	2	Elkay	Yes
Drinking fountain, with bottle filler	Henry Crown Field House	6	Elkay	Yes
Drinking fountain, with bottle filler	Laird Bell Law Quadrangle	2	Elkay	Yes
Drinking fountain, with bottle filler	Press Warehouse	1	N/A	Yes
Drinking fountain, with bottle filler	Ratner Athletics Center	2	Elkay	Yes
Drinking fountain, with bottle filler	Reva and David Logan Center for the Arts	8	Halsey Taylor	Yes
Drinking fountain, with bottle filler	Social Service Administration	2	N/A	Yes
Drinking fountain, with bottle filler	William Eckhart Research Center	9	Halsey Taylor	Yes
Drinking fountain, with bottle filler	Anatomy	1*	Elkay	No
Drinking fountain, with bottle filler	Beecher Hall	5	Elkay	No
Drinking fountain, with bottle filler	Biological Sciences Learning Center	1	Elkay	No
Drinking fountain, with bottle filler	Cobb Hall	3	Elkay	No
Drinking fountain, with bottle filler	Eckhart Hall	5	Elkay	No
Drinking fountain, with bottle filler	Erman Hall	1*	Elkay	No
Drinking fountain, with bottle filler	Foster Hall	2	Elkay	No

Table 3 Continued

Description	Building Name	Number of Stations	Manufacturer	Previously Documented?
Drinking fountain, with bottle filler	Goodspeed Hall	1	Elkay	No
Drinking fountain, with bottle filler	Harper Memorial Library	4	Elkay	No
Drinking fountain, with bottle filler	Kent Chemical Laboratory	1**	N/A	No
Drinking fountain, with bottle filler	Pick Hall	1	Elkay	No
Drinking fountain, with bottle filler	Reynolds Club	1	Elkay	No
Drinking fountain, with bottle filler	Rosenwald Hall	1	Elkay	No
Drinking fountain, with bottle filler	Saieh Hall for Economics	1***	N/A	No
Drinking fountain, with bottle filler	Social Sciences Research Building	3	Elkay	No
Drinking fountain, with bottle filler	Swift Hall	5	Elkay	No
Drinking fountain, with bottle filler	Wieboldt Hall	1	N/A	No
Drinking fountain, with bottle filler	Zoology	1*	Elkay	No
Drinking fountain, with bottle filler and hot water tap	Regenstein Library	1	Elkay	No
Bottle filler, standalone	Jones Laboratory	2	Elkay	No
Hot water tap	Hinds Laboratory	0	⸺	⸺

Total: 102 stations

Previously documented: 61
Newly documented: 41

*Restricted access to this building; station was identified by looking through window in door. The potential remains that additional stations in this building were not identified.

**Station was under construction and/or being replaced during the campus filling station search.

***Researcher was informed of the existence of at least one station in this building, but was unable to personally identify stations.
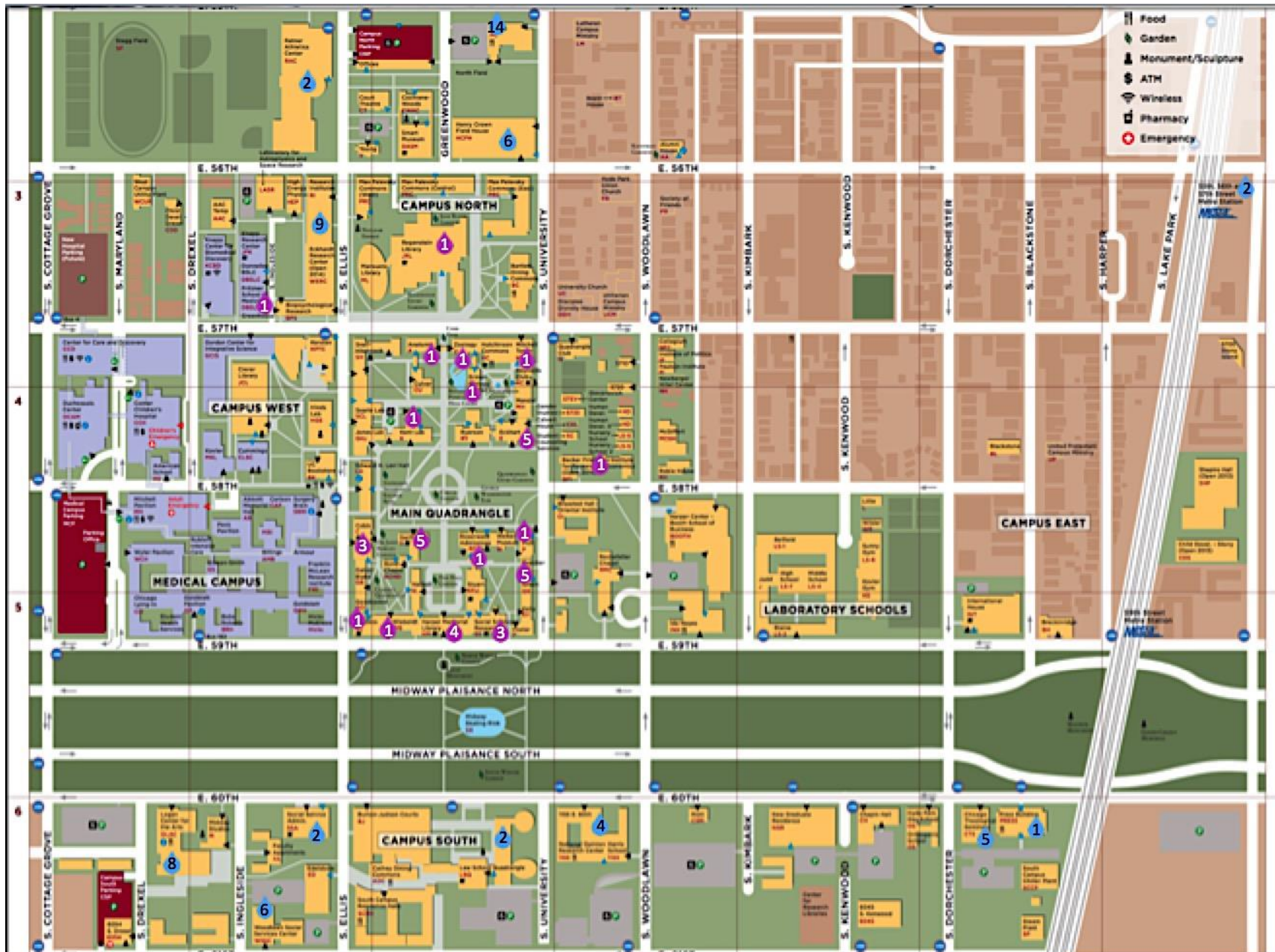
Figure 1: Map of all locations of filling stations at UChicago. Blue teardrop indicates previously documented filling stations and purple teardrop indicates newly identified filling stations. Number in teardrop indicates number of filling stations in that location.

IVb. Green Ticker Tracking Reveals Extensive Use of Filling Stations

As predicted, and likely due to the differences in building occupancies on campus, substantial discrepancies were found in the number of plastic water bottles saved at each of the stations tracked. The two-week green ticker differences for all tracked stations are recorded in Table 4.[10] The green ticker on the 1st floor Harper Memorial Library station was broken during the tracking period, but I still included it in the table to represent how some of the stations' green tickers break on occasion. In addition, the green ticker on Regenstein Library station was reset partway through the two-week period (reason unknown). As a result, since this filling station was of particular interest due to the lack of stations elsewhere in the Regenstein Library and its believed high use by campus-goers, a third meter reading was obtained one week (seven days) after the "final" ticker read at the other stations in order to determine the number of bottles saved at this station. Thus, while the initial and final readings represent the actual numbers recorded for a one-week period (Δ = 2,341), the green ticker difference recorded in Table 4 is doubled to represent the approximate number of bottles saved over two weeks ($\sim\Delta$ = 4,682).

Across the nine stations, approximately 15,662 bottles were saved over two weeks, with a mean of about 1,740 bottles. If we use the total number of bottles saved from these nine stations as a representation of all filling stations on UChicago's campus, extrapolation yields a total of approximately 177,480 plastic bottles saved across 102 filling stations in only two weeks. This means that UChicago's filling stations save more than 4.6 million plastic bottles in one year. This indicates that filling stations are very successful in reducing plastic waste, although there are certainly opportunities to further increase station use.

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[10] As mentioned above, the green tickers on stations only count a "saved water bottle" with every 20 oz. fill. Thus, people who fill up their water bottles halfway or use the station to fill up a cup, glass, or mug may not be reflected accurately in the green ticker data collected. This type of "fill" is still important, as it signifies the number of station users contributing to the waste reduction effort. The station observations conducted in this research helped to combat this problem by counting the number of station users.

Table 4: Green ticker differences for select water bottle filling stations at UChicago.

Water Bottle Filling Station	Initial Reading	Final Reading	Green Ticker Δ
Cobb Lecture Hall 1st floor	88,253	89,511	1,258
Crown Field House 2nd floor (southeast corner)	12,610	12,858	248
Eckhardt Research Center 1st floor	16,928	17,251	323
Harper Memorial Library 1st floor	N/A	N/A	N/A
Harper Café (3rd floor)	133,854	136,040	2,186
Logan Center for the Arts basement	9,253	9,562	309
Ratner Athletics Center (2nd floor)	391,813	396,263	4,450
Regenstein Library 1st floor	1,517*	3,858*	4,682**
Reynolds Club basement	55,130	57,002	1,872
Swift Hall 1st floor	11,709	11,953	244

Total Δ = 15,662
Mean Δ (n=9) = 1,740

*The initial and final readings for the Regenstein Library station represent only one week of tracking.
**This number represents the approximate number of bottles saved at the Regenstein Library station over a two-week period, as it is double the difference obtained from one week of tracking.

The Regenstein filling station was estimated to have the highest number of water bottles saved (4,682 bottles), which is not surprising because of the large number of individuals who visit the library every day. The filling station is also located next to Ex Libris Café, indicating that many individuals may use the station before entering or after exiting the café; the proximity of the station to the café may simply increase use out of convenience for refilling reusable bottles or other containers. The station outside of Harper Café reported a high number of bottles saved (2,186 bottles), likely as a result of similar reasons; it is both next to a café and outside of a popular reading room. The filling station in the weight room on the second floor of Ratner Athletics Center had the highest actually observed green ticker difference, with 4,450 plastic

bottles saved in the two-week span. This result was expected, as filling stations are likely to be used more frequently when located in an athletic facility, especially when in a convenient location such as within the weight room itself, since people need to hydrate when exercising. It is thus possible that the same individual could fill his/her water bottle multiple times within one hour of exercise.

Conversely, the first floor filling station in Swift Hall (the Divinity School) had the lowest number of bottles saved: only 244 bottles. This result is also not very surprising, as the Divinity School has the lowest number of enrolled students (n=268) of any of UChicago's undergraduate or graduate programs, with the exception of the Institute for Molecular Engineering (The University of Chicago Campus & Student Life: University Registrar 2018). This, combined with the low building total occupancy (328 people), helps to explain the fact that the stations in this building have low use.[11] Additionally, since there are five filling stations distributed throughout Swift Hall, it is possible that the first floor filling station simply receives a lower concentration of individuals since there are multiple other options of stations to use, unlike in the Regenstein Library. Further, it is possible that people use the station outside of the Grounds of Being café in the basement of the building more than the station on the first floor, which was tracked. If non-Divinity School individuals do visit the building, it is often to go to the café in the basement of the building, outside of which there is another filling station. Overall, the green ticker data collected were consistent with students' and other campus-goers' activities as well as with building occupancies.

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[11] Estimated total building occupancy obtained from the Office of Sustainability, via email.

IVc. Students Reveal Positive Reactions to Filling Stations in Questionnaire

During the two-week period that the questionnaire was "live" and open to responses, 108 UChicago students filled out the survey.[12] Of the 91 respondents who completed the survey in full, all (100%) were undergraduate students in the college, as was intended for the purposes of this research. However, the distribution of respondents across school years was heavily skewed toward upperclassmen: 6.59% were first year students, 8.79% were second years, 27.47% were third years, and 57.14% were fourth years (Table 5). In addition, there was a strong female skew: 72.53% of respondents identified as "female and 26.37% identified as male (one student identified as "other").[13]

Table 5: Breakdown of survey respondents by college year.

Year in College	%	Count
1st year	6.59%	6
2nd year	8.79%	8
3rd year	27.47%	25
4th year	57.14%	52
Total	100%	91

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[12] There are some areas for potential bias in the survey. Like any survey, those who took it could have simply been more interested or concerned in the issue at hand; in this case, people who decided to complete the questionnaire may have an affinity to bottle filling stations or be concerned about environmental issues. In addition, it is possible that people who know me personally were more likely to complete the survey than those who do not know me. While all questionnaires were completed voluntarily and anonymously, my friends may have felt compelled to not only fill out the survey but also to provide responses that they believed I would have wanted to receive. In addition, the skew toward upperclassmen may be an issue of survey reach. Regardless, as this was a comprehensive study with various other complementary research phases, I believe that the responses received are representative of the larger undergraduate student population and contribute to the holistic perspective gained on student use and awareness of bottle filling stations on campus.

[13] Despite the much higher number of female respondents than male respondents, the Facebook groups in which I posted links to my survey (the official Class groups) can be assumed to have an equal number of female and male students, as there are approximately equal numbers of male and female students in each of the UChicago Classes. In fact, according to the UChicago *Winter Quarter 2018 Census Reports*, there were slightly more male students (51.24%) enrolled in the College than female students (48.76%). Therefore, the fact that more female students responded to the survey is likely not a question of reach. Instead, this could indicate that female students care more about environmental and water issues.

Ninety people (84.11%) responded that they own a reusable water bottle that they use on campus. An additional five said that they used to own one but do not currently (4.67%), and another 12 said that they own one but do not use it on campus (11.21%).[14] No one responded that they have never previously owned a reusable water bottle before. Of the 90 people who responded that they own a reusable bottle that they use on campus, the majority responded that they use their water bottle every day (63.33%) or almost every day (25.56%). Five people said that they use their reusable bottle a few days per week (5.56%), and five said that they use it a few days per month (5.56%). This indicates that most UChicago students do use reusable water bottles frequently, and that the use of these reusable bottles is important to many students.

Students were then questioned as to why they use their reusable bottles, and were asked to rank several potential reasons for using reusable bottles on a scale from 1 (least important) to 5 (most important), with 3 indicating neutrality (Table 6). The cost of purchasing plastic disposable water bottles was shown to have a large influence on students' decisions to instead use reusable water bottles, as 42 students (48.28%) think that this issue is very important and another 27 (24.14%) think that it is important. This suggests that increasing the prices of plastic disposable water bottles may further deter students from purchasing them. A majority of students (74.72%) cited that the convenience of using reusable water bottles is important or very important. Further, an overwhelming majority of students find it important or very important to use reusable bottles because they provide an environmentally friendly option (81.61%). This indicates that students are concerned about environmental issues and likely use reusable bottles to help reduce their ecological impact. While some students appear to consider health when

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[14] The respondents who stated that they do not currently use or own a reusable bottle were not asked as to why they do not, but understanding how to capture this population for using reusable bottles is important for future research to undertake.

choosing to use reusable water bottles, others seemingly do not; the responses were divided

fairly evenly across levels of importance.

Table 6: Students' reasons for using reusable water bottles on campus.

Reason	1	2	3	4	5	Total
Environmentally friendly option	1 (1.15%)	6 (6.90%)	9 (10.34%)	32 (36.78%)	39 (44.83%)	87
Cost of purchasing plastic water bottles	4 (4.60%)	6 (6.90%)	14 (16.09%)	21 (24.14%)	42 (48.28%)	87
Health	14 (16.09%)	11 (12.64%)	27 (31.03%)	18 (20.69%)	17 (19.54%)	87
Convenience	2 (2.30%)	4 (4.60%)	16 (18.39%)	25 (28.74%)	40 (45.98%)	87

It was also necessary to ask about students' consumption of plastic bottled water in order

to provide a more robust comparison to the use of reusable bottles. While a majority of students

responded that they never buy or drink plastic bottled water (52.94%), 33.33% of students buy or

drink 1-3 plastic water bottles per month and 13.72% buy or drink four or more plastic water

bottles per month. This shows that, while students do use reusable water bottles frequently, they

also still consume plastic water bottles. Thus, there is ample opportunity to reduce the number of

plastic bottles of water that students consume, so future research should examine the situations in

which students purchase and/or consume plastic water bottles so as to identify targets for

reducing this consumption.

In addition, a majority of students responded that they always (46.08%) or usually

(30.39%) recycle their plastic water bottles, but some students still only recycle their bottles half

of the time, and otherwise throw them into the trash (14.71%). Eight students claimed that they

usually throw their plastic bottles into the trash (14.71%), and one person answered that s/he

always throws them in the trash. This further supports the importance of decreasing the number

of people using plastic bottles to prevent the chance of creating waste. The fact that students do not universally recycle their water bottles may also indicate that there could be problems with the education of students about recycling. Some students may simply not know which items can be recycled, or where they can recycle their bottles. On this note, this could suggest that recycling on campus is lacking, and that students decide to throw their plastic disposable bottles into landfill trash bins because there are no recycling bins nearby. It may be useful to conduct an audit of all the recycling bins that are on campus, both permanent and portable, to determine where recycling services should be expanded.

Nearly all survey respondents were both familiar with the filling stations on campus and had used a station at least once (both 96.08%, n=98). In addition, when presented with the choice of filling up a water bottle at a bottle filling station or at a regular drinking fountain, a large majority of individuals responded that they would choose the filling station every time (78.85%), some individuals said that they would choose the filling station most of the time (17.31%), and a few individuals said that they were indifferent between the two (3.85%). Not a single survey respondent said they would choose the drinking fountain over the filling station, indicating the positive opinion that students have of filling stations. In addition, when asked what type of container they fill up when using a bottle filling station, 83 students said that they refill reusable bottles (84.69%), 19 said that they refill disposable plastic water bottles (19.39%), and 13 fill up glasses or cups (13.27%).[15] While it is evident that most people refill reusable containers, or even attempt to reuse plastic bottles, the disposable plastic water bottles that are being refilled could potentially end up in the landfill. Therefore, there is an opportunity to decrease the availability of plastic disposable bottles and the chance of producing waste. Further, as discussed above, the

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[15] The number of respondents here exceeds the 98 who use filling stations because respondents were allowed to select more than one container in their response. Percentage totals similarly exceed 100%.

safety of refilling plastic bottles has long been debated, as refilling plastic bottles without cleaning the bottle could lead to the growth of bacteria in the bottle, which poses a significant health risk (Chan 2014). A complete transition to reusable containers, which are healthier and more sustainable options, can be achieved with support from UChicago administration.

Of the 98 individuals who answered that they use filling stations, 55 use stations once per day (56.12%), 29 use stations twice per day (29.59%), and 14 use stations three or more times per day (14.29%). While an initial interpretation of this result may suggest that people do not use stations very often, this would be better interpreted as, if the survey respondents accurately represent the entire student population, a vast majority of students on the UChicago campus (~96%) use filling stations at least once per day, with approximately 40% of students on campus using stations more than once per day. The importance of campus filling stations to UChicago students is evident. Thus, if filling stations are better incorporated into UChicago's Sustainability Plan, there is an opportunity to further encourage station use and reduce the university's environmental impact.

Students were asked to rank a number of different potential explanations for why they choose to use filling stations on campus, with 1 being the least important, 5 being the most important, and 3 indicating neutrality (Table 7). The two reasons that were most important to the highest number of students were the ease of filling up a water bottle in a filling station (52.17%) and convenience, or the fact that a filling station was the only option available in the surrounding area (44.57%). The offer of a sustainable and environmentally friendly option was also deemed "most important" by 28 individuals (30.43%) and important by 29 individuals (31.52%). It is thus evident that, while students enjoy using filling stations for their convenience and ease of filling up stations (as opposed to tilting their bottle to refill it in a drinking fountain), many

students are also very environmentally-conscious when using the filling stations. Interestingly, few people were influenced by the possibility of an improvement in water taste or quality by using a filling station. Some people found the filter status (red, yellow, or green) on the filling station or the green ticker on the filling station important (19.57%) or very important (7.61%), but filter status does not appear to be a deciding factor in the choice to use a filling station.

Respondents were also asked what they thought about the current number of filling stations on campus. The responses were mixed: 50 individuals responded that there should be additional filling stations on campus (53.76%); 13 responded that the number of stations on campus is fine (13.98%), but that some of the stations should be moved to different locations; and 25 responded that the number of stations currently on campus is perfect (26.88%).[16] The 50 people who answered that there should be more filling stations on campus were fed into a follow-up, short answer question that inquired as to where they believe additional filling stations should be installed. This question received 48 responses (96%), which varied in content and length. Some responses were more vague, but still informative, simply suggesting that there should be at least one filling station in every building, that stations should be installed wherever there is currently only a drinking fountain, or that there should be stations on upper floors of buildings in addition to the first floor stations. However, many responses identified specific buildings or locations in which there should be stations installed. Some themes stood out; various students mentioned that stations should be installed on the upper floors of the Regenstein Library and near Mansueto Library (17 mentions), on the first or second floor of Reynolds Club or Hutchinson Commons (seven mentions), in dorms (eight mentions), and in academic/classroom

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[16] An additional five people selected "Other" to this question. Two people were indifferent or did not know. One person said that s/he only ever uses on station and was thus unsure. A fourth person said that the number on the main campus is fine, but mentioned that there are no stations in his/her dorm. The final person said that s/he does not drink water much, so it does not affect him/her, which raises the question, why did this student make it to the end of the survey just to say that?

buildings (20 mentions).[17] These responses indicate that students do notice where there are filling

stations missing from buildings as well, and that students desire more stations across campus,

especially in certain buildings, likely those that they visit most frequently. The locations that

were repeatedly mentioned by students are those that should be prioritized for getting more

stations installed.

Finally, students were asked about what other sustainability efforts they would like

UChicago to take to reduce environmental impact. As this was an optional short answer question,

it is not very surprising that only 31 students answered this question (28.7%). However, many of

those who did respond provided detailed and specific answers. Many students discussed wanting

more expansive waste and recycling services. Several students recommended increasing the

number of recycling bins on campus, both on the quad and inside buildings, and some requested

having composting services as well as providing compostable utensils and dishware. Other

individuals suggested providing students with more reusable bottles, not distributing plastic

bottled water at events, and not having plastic silverware or plates at the dining halls. Some

students mentioned ensuring that the filling stations are working, i.e. that their filters and green

tickers are not broken. A few students even talked about more large-scale changes, including

transitioning to renewable energy sources on campus, such as solar or wind power. These

comprehensive recommendations reveal the concerns that many students have about

environmental issues, as well as the fact that many students have contemplated potential

strategies to mitigate or eliminate both their own and UChicago's environmental impact.

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[17] It is a bit surprising that few people indicated that they want stations to be installed in the dorms, as only one dorm, Campus North Residential Commons, has filling stations (Table 3).

Table 7: Students' reasons for using water bottle filling stations on campus.

Reason for using filling station	1	2	3	4	5	Total
Convenience/only option available in the location	1 (1.09%)	4 (4.35%)	14 (15.22%)	32 (34.78%)	41 (44.57%)	92 (100%)
Ease of filling up a water bottle	2 (2.17%)	2 (2.17%)	13 (14.13%)	27 (29.35%)	48 (52.17%)	92 (100%)
Taste	14 (15.22%)	13 (14.13%)	28 (30.43%)	22 (23.91%)	15 (16.3%)	92 (100%)
More sanitary than drinking water fountains	15 (16.3%)	16 (17.39%)	33 (35.87%)	12 (13.04%)	16 (17.39%)	92 (100%)
Provision of cleaner, filtered water	9 (9.78%)	11 (11.96%)	26 (28.26%)	25 (27.17%)	21 (22.83%)	92 (100%)
Sustainability/environmental friendliness	2 (2.17%)	6 (6.52%)	27 (29.35%)	29 (31.52%)	28 (30.43%)	92 (100%)
Manufacturer reputation	58 (63.04%)	15 (16.3%)	18 (19.57%)	1 (1.09%)	0 (0%)	92 (100%)
Meter data on filling station	44 (47.83%)	13 (14.13%)	19 (20.65%)	12 (13.04%)	4 (4.35%)	92 (100%)
Filter status (red, yellow, green) on filling station	26 (28.26%)	8 (8.7%)	33 (35.87%)	18 (19.57%)	7 (7.61%)	92 (100%)
Lack of plastic bottled water as an alternative	53 (57.61%)	14 (15.22%)	11 (11.96%)	9 (9.78%)	5 (5.43%)	92 (100%)

IVd. Station Observations Indicate Differences in Interactions Based on Time and Location

As was expected, student interactions with filling stations and their attached drinking

fountains differed greatly across location and time of day (Figure 2). The second floor southeast

station of Crown received the least amount of traffic compared to the other two stations, with a

total of only 11 individuals approaching the station across the three observation periods:

morning, afternoon, and evening (Figure 2a). Not a single person approached the Crown filling

station during the morning observation, but there were also few people using the athletic facility

at the time. Two individuals used the drinking fountain attached to the filling station during the

afternoon observation. The evening observation occurred during a peak time at Crown, and I saw

the most use of the filling station, as nine people approached the station. However, only two of

the nine individuals used the station to refill their water bottles (22.22%), and the rest used the

drinking fountain. Both of the water bottles refilled were reusable: one was a metal reusable

bottle and the other was a plastic reusable bottle (Figure 4). The infrequent use of the filling

station compared to the much higher use of the drinking fountain could potentially be explained

by the idea that people want to hydrate quickly after exercising. An individual may prefer to

drink from the fountain rather than retrieving his/her water bottle from where they stored their

belongings and then filling it up, which could be viewed as more accessible in a large facility.

The filling station on the first floor of Cobb Lecture Hall received more traffic than the

station observed in Crown, with a total of 21 individuals approaching the station during the three

observation periods (Figure 2b). Likely because few classes are held in the early morning, only

three people approached the filling station during this morning observation period. However, two

of these three individuals used the filling station (66.67%), both of whom used plastic reusable

bottles. The afternoon observation had the highest number of individuals approach the station

(n=10), likely because the observation period occurred during peak class time. In fact, a majority of the people who used the filling station or the drinking fountain did so in the two minutes right after the class period started at 2pm (n=6; 60%). Six of these individuals (60%) used the filling station, and they filled a variety of different containers; five used non-waste producing containers, in this case, reusable bottles or mugs (83.33%) (Figure 5b). The evening observation was surprisingly busy, as several student organizations that were meeting in the building's classrooms. Eight individuals approached the station, and three used the filling station (37.5%) (Figure 2b). All three of these individuals used reusable plastic bottles.

Although an afternoon observation could not be conducted at the Regenstein Library (see footnote 7), it was clear that this station receives the most traffic of the three stations, consistent with the green ticker data reported above (Table 4). A total of 33 individuals approached the station during the two observations, 15 in the morning and 18 in the evening. Interestingly, on multiple occasions, the same individual would use more than one of the three water dispensers, including the attached hot water tap, which accounts for the number of "station activities" exceeding the number of individuals (Figure 2c). For example, two people during the morning observation filled up their metal reusable bottle halfway with hot water and halfway with cold water from the filling station. During the morning observation, eight people used the filling station (42.1%), one used the drinking fountain (5.26%), and ten used the hot water tap (52.63%). Many of the people who used the hot water tap seemed to be filling up their reusable containers, such as metal reusable bottles and mugs, with hot water for tea (Figure 5a). In the evening, the filling station was used nine times (47.36%), the drinking fountain was used six times (31.59%), and the hot water tap was used four times (21.05%). Many people who used the drinking fountain seemed to be getting a drink of water before leaving from the library, as they

had their jackets and backpacks on. Metal reusable and plastic reusable bottles combined accounted for 70% and 67% of the containers used during the morning and the evening observations, respectively, which is consistent with the survey data indicating that many people use reusable water bottles, whether in an effort to reduce waste or for another reason (Figure 6).

On a separate note, I did not treat the inability to conduct an afternoon observation at the Regenstein station as a limitation to my research. Instead, it contributed to my understanding of the filling stations on campus, as this is evidence that stations do occasionally require repairs. Therefore, it is crucial to improve record-keeping to find where broken stations are located more quickly. In addition, it is crucial that the system for reporting a broken station is streamlined, so Facilities Services can repair the station in a timely manner and so the station can continue to contribute to reducing the reliance on disposable bottles and the production of plastic waste.

Although the Regenstein Library station had the highest total number of filling station users, when comparing the percentage of filling station users out of the number of "approachers," the Regenstein Library and Cobb stations are much more comparable (Figure 3). In fact, slightly more "approachers" ended up using the filling station in Cobb (52.38%) than in the Regenstein (51.52%). This suggests that filling stations are very important assets in both of these locations. This is also not to say that the filling stations in Crown are not important, but that they may serve a different purpose from the filling stations in other campus buildings, as the attached drinking fountains are still a crucial element for individuals exercising in the athletic facility. In addition, there are six filling stations in Crown, so station use may be less concentrated than in Cobb or the Regenstein, but still high overall. The wide variety of containers used across all three stations suggests that filling stations serve many extremely useful purposes, allowing students, faculty, and other campus-goers to get a glass of water or to fill up an entire water bottle.
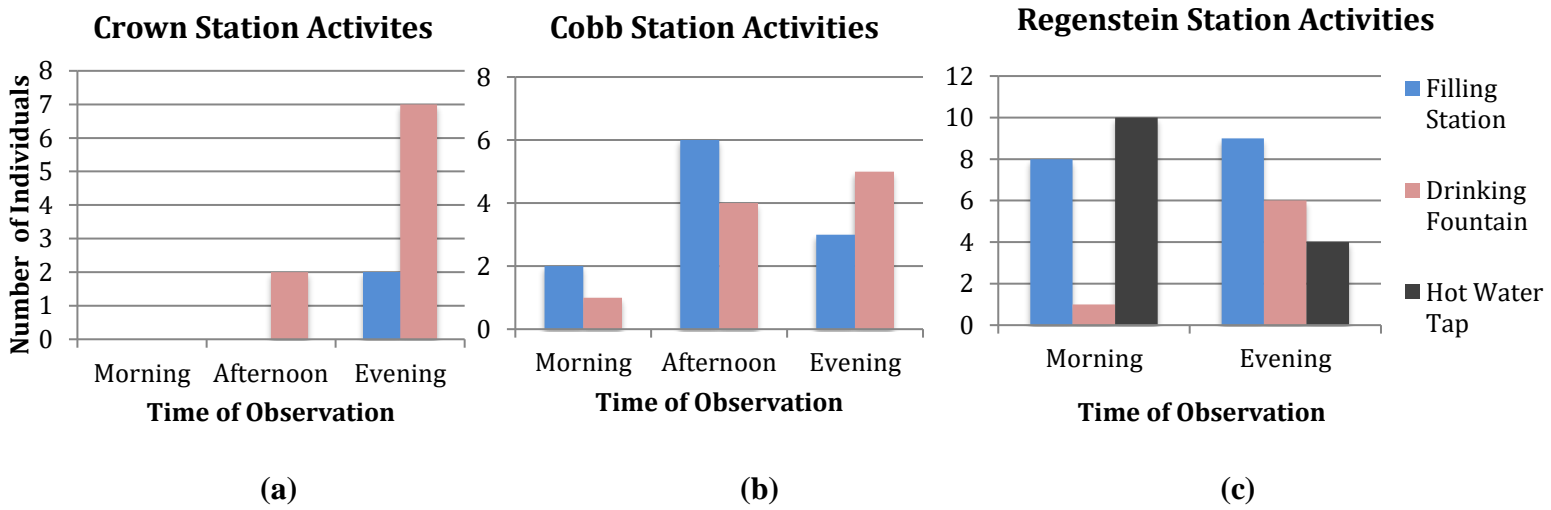
Figure 2: Filling station activities observed at three selected station locations at UChicago. All three charts have the "number of individuals" as the vertical axes, and the key applies to all three charts. (a) Filling station activities observed at Henry Crown Field House. (b) Filling station activities observed at Cobb Lecture Hall. (c) Filling station activities observed at Regenstein Library. Observations were limited to the morning and evening at the Regenstein Library filling station due to the station being broken during the afternoon observation period.
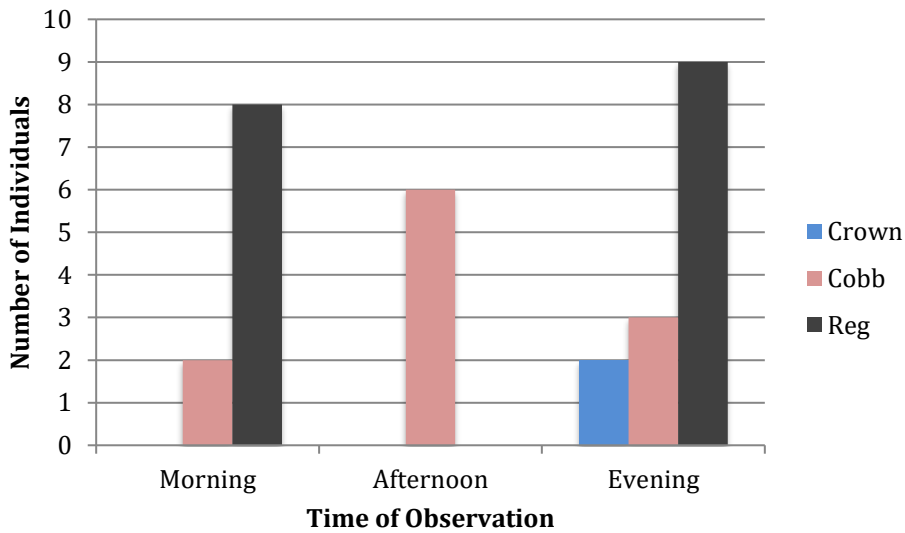
Figure 3: Number of times that the three filling stations were observed being used. This serves as a comparison across the three different times of day and across the three different filling station locations: Henry Crown Field House, Cobb Lecture Hall, and Regenstein Library.

Crown Evening Containers
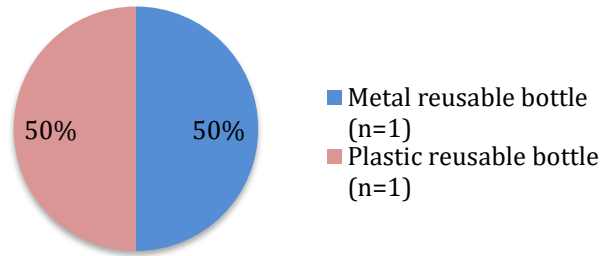
Figure 4: Containers used at the Henry Crown Field House second floor southeast filling station during the evening observation. Containers used were split evenly between metal reusable and plastic reusable bottles. The morning and afternoon observations are not included here as no containers were used during either of those observations.

Cobb Morning Containers
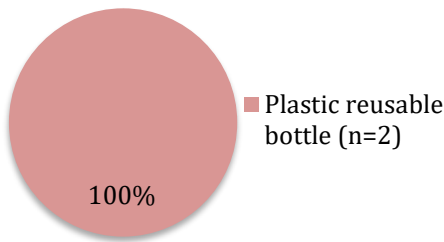
(a)

Cobb Afternoon Containers
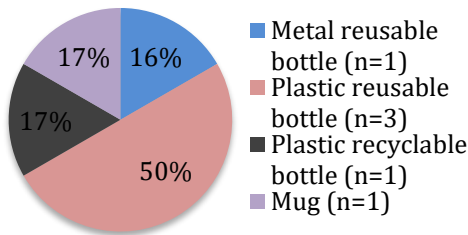
(b)

Cobb Evening Containers
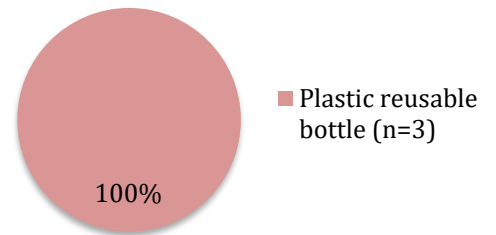
(c)

Figure 5: Containers used at the Cobb Lecture Hall first floor filling station during three observational periods. (a) All containers used at the Cobb filling station during the morning observation were plastic reusable bottles. (b) Individuals used a wide range of containers at the Cobb filling station during the afternoon observation. (c) All containers used at the Cobb filling station during the evening observation were plastic reusable bottles.

Regenstein Morning Containers
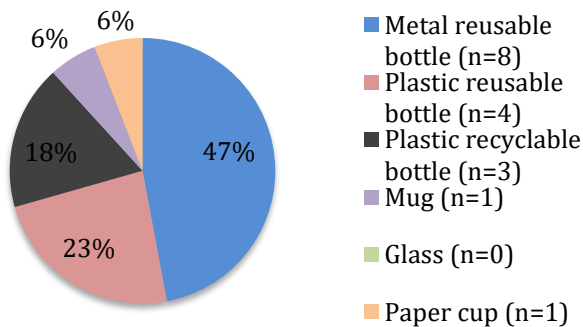
(a)

Regenstein Evening Containers
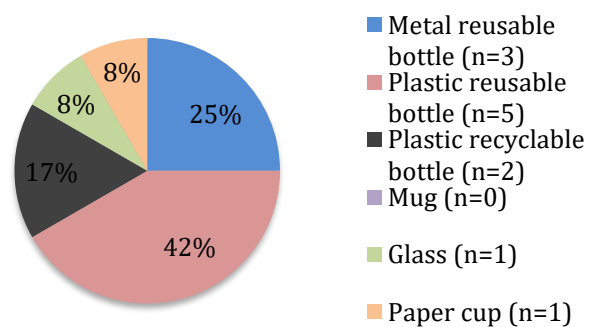
(b)

Figure 6: Containers used at the Regenstein Library first floor filling station during two observational periods. (a) Individuals used a wide range of containers at the Regenstein filling station during the morning observation. (b) Individuals used a different, but still wide range of containers at the Regenstein filling station during the evening observation. Observations were limited to the morning and evening due to the filling station being broken during the afternoon observation period.

IVe. Filling Stations Have Positive Net Benefits

       After calculating the costs and the benefits of filling stations, it was determined that

filling stations have a positive net monetary benefit. The cost of a new filling station in the first

year must take into account the price of the station, the installation cost, the cost of water to the

UChicago based on the City of Chicago water rates, and the purchase of replacement filters

(Table 8). Total costs for the first year of a new station are estimated to be $2,271.88 (Table 8).

Table 8: Costs of a single new filling station in the first year.

Filling Station Costs	Cost ($)	Calculation
Price of Station	$1,784	Price of Elkay Single Green ezH2O Model LZSG8WSSK as listed in Elkay 2017 Commercial Price Guide (Elkay 2017c)
Installation	$120	2 maintenance technicians * 3 hours work * $20/hour = $120
Replacement Filters	$339	~1,740 bottles/2 weeks[18] = ~870 bottles/week 20,000 bottles/filter / 870 bottles/week = 23 weeks/filter 52 weeks/year / 23 weeks/filter = 2.26 filters/year Round to 3 filters/year, each priced at $113 (Elkay n.d.a) 3 filters * $113 = $339
Cost (Price) of Tap Water	$27.43	1,740 bottles/week * 52 weeks/year = 45,240 bottles/year 45,240 bottles/year * 20 oz./bottle = 904,800 oz/year 904,800 oz/year / 128 oz/gallon = 7,068.75 gallons/year 7,068.75 gallons/year * $3.88/1000 gallons water[19] = $27.43/year
Energy Cost of Tap Water	$1.45	0.005 MJ energy/liter tap water[20] 904,800 oz tap water/year / 33.814 oz/liter = 26,758.148 liters/year 0.005 MJ energy/liter * 26,758.148 liters/year = 133.791 MJ/year 5.6 MJ energy/liter bottled water * 33 billion liters consumed/year = 184.8 billion MJ energy/liter bottled water = 32 million barrels oil/year => 133.791 MJ energy/year for tap water = 0.023 barrels oil/year for tap water 0.023 barrels oil/year * $63.08/barrel oil[21] = $1.45
Total Costs	$2,271.88	$1,784 + $120 + $339 + $27.43 + $1.45 = $2,271.88

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[18] See Table 4.

[19] This estimate was obtained from the City of Chicago's website, to which I was directed by UChicago's Office of Sustainability when I inquired about the cost of tap water to the university (City of Chicago 2017).

[20] Gleick and Cooley determined the energy implications of bottled water and compared this estimate to the estimated energy required for producing tap water (2009). The estimated energy required to produce tap water is included in the calculations of filling station costs, and the estimated energy required to produce bottled water is included in the calculations of filling station benefits.

[21] This number represents the West Texas Intermediate crude oil trading price at 7pm on April 5, 2018, according to Bloomberg Markets. This price is used below in the benefit calculations as well.

Conversely, the costs offset, or the benefits of having a filling station, must take into account both the private benefits to UChicago of not having to provide the equivalent amount of plastic bottled water to students as well as social benefits. The social benefits can be perceived as the costs offset by not demanding the amount of energy required to produce plastic water bottles. The total benefit for the first year of a new station is estimated to be $11,697.92 (Table 9). Thus, the net benefit of a filling station, in the first year, is $9,426.04 (Table 9). In addition, in the years following installation, the net benefit of a filling station increases as the list price of the station and the installation cost are sunk costs that do not have to be paid annually. While calculating the cost of the energy needed to produce plastic water bottles attempts to measure the social cost of plastic bottles, there are likely additional social and environmental costs that were not included in this analysis, such as the cost of the environmental harm caused by plastic waste and the cost of the pollution generated during production. Research has yet to examine these costs, so estimations of the true social cost of plastic bottled water should be made in the future. Including these costs will further increase the net benefit of filling stations, encourage more use of filling stations, and further justify the argument for UChicago to invest in filling stations.

Sensitivity analysis was conducted to address the possibility that the consumption of plastic disposable bottles is not equal to the number of bottles saved by the station, as counted by the station's green ticker (Table 10). As mentioned above (see section *IIIe*), a conservative assumption was made that people would buy one plastic disposable bottle for every two refills of a reusable bottle. With this assumption, the sensitivity analysis yields a smaller, yet positive net benefit of $3,591.28 in the first year of a new station's installation (Table 10). For more precise cost-benefit analysis, future research should investigate how plastic bottle consumption in the absence of filling stations differs from consumption when there are filling stations available.

Table 9: Benefits (costs offset) of a single new filling station in the first year.

Filling Station Benefits	Benefit ($)	Calculation
Price of Plastic Water Bottles (Private Cost)	$9,500.40	1,740 bottles saved every two weeks[22] * 26 * $0.21[23] = $9,500.40
Energy for Production of Plastic Water Bottles (Social Cost)	$2,199.39	5.6-10.2 MJ energy/liter bottled water = 32-54 million barrels of oil for bottled water industry in U.S[24]
		Average = 43 million barrels of oil for bottled water in U.S.
		33 billion liters of bottled water consumed annually[25]
		43M barrels oil / 33B liters water = .0013 barrels oil/liter
		.0013 barrels oil/liter / 33.814 oz/liter = .000039 barrels oil/oz
		.000039 barrels oil/oz * 904,800 oz/year (from bottles saved at one filling station annually) = 34.867 barrels oil/year
		34.867 barrels oil/year * $63.08/barrel oil = $2,197.52
Total Benefit	$11,697.92	$9,500.40 + $2,197.52 = $11,697.92
Net Benefit	$9,426.04	$11,697.92 - $2,271.88 = $9,426.04

Table 10: Sensitivity analysis of benefits (costs offset) of a new filling station in the first year.

Filling Station Benefits	Benefit ($)	Calculation
Price of Plastic Water Bottles (Private Cost)	$4,750.20	870 bottles saved every two weeks[26] * 26 * $0.21 = $4,750.20
Energy for Production of Plastic Water Bottles (Social Cost)	$1,112.96	5.6-10.2 MJ energy/liter bottled water = 32-54 million barrels of oil for bottled water industry in U.S
		Average = 43 million barrels of oil for bottled water in U.S.
		33 billion liters of bottled water consumed annually
		43M barrels oil / 33B liters water = .0013 barrels oil/liter
		.0013 barrels oil/liter / 33.814 oz/liter = .000039 barrels oil/oz
		.000039 barrels oil/oz * 452,400 oz/year (50% of bottles saved at one filling station annually) = 17.644 barrels oil/year
		17.644 barrels oil/year * $63.08/barrel oil = $1,112.96
Total Benefit	$5,863.16	$4,750.20 + $1,112.96 = $5,863.16
Net Benefit	$3,591.28	$5,863.16 - $2,271.88 = $3,591.28

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[22] As mentioned above, the number of bottles saved the number of 20 oz bottles saved at the stations. Since plastic disposable water bottles generally range from 16.9 oz to 23.7 oz, using the number of bottles saved by using the filling station, as counted by the green ticker, was assumed to be an appropriate estimate of the actual bottles offset.

[23] This is the price of plastic disposable water bottles in bulk, as listed by Elkay in their Environmental Impact calculator (Elkay n.d.c.).

[24] As mentioned in footnote 19, Gleick and Cooley estimated the amount of energy required to produce one liter of water (2016). In their calculations, they accounted for two different types of water bottle production, which explains why they include a range in their estimates, approximately 5.6-10.2 MJ energy/liter bottled water. They then converted this to the equivalent number of barrels of oil that would be required for this production, still including a range of estimates. For simplicity, I took the average of this range and used it in my calculations.

[25] This is an estimate of how much water is consumed annually, made by Gleick and Cooley (2009).

[26] This number is now 50% of the number of bottles saved in the above benefit calculation, to account for changes in consumer behavior between when a filling station is and is not available. All following calculations use the same numbers as above, and have the same references.

V. Policy Recommendations

  As per the findings from this research study, several policy recommendations have been developed for increasing the use of filling stations on campus and reducing UChicago's environmental impact. The hope is for UChicago to serve as a leader and a model for other universities and institutions to follow in increasing sustainability and reducing plastic waste.

Va. Improve Record-Keeping for Bottle Filling Stations on Campus

  As evidenced by the incomplete documentation maintained by UChicago regarding bottle filling stations on campus, it is essential that UChicago improve its record-keeping on water bottle filling stations. My research will prove extremely beneficial to UChicago, as I have identified several additional stations that were missing from UChicago's inventory. Each new station installed should be immediately added to UChicago's official records. It would likely be helpful to also include the date of installation for each station in order to gain a better sense of when the station's "life" may end and will need to be replaced.

  Some, although not many, survey respondents expressed concern about the color of the filter status displayed on the filling stations when they fill up their water bottles. By knowing the locations of the filling stations on campus, Facilities Services will be able to efficiently conduct quarterly audits of the stations to determine which filters need replacing and subsequently replace them in a timely fashion. Students have noticed that some stations' filters have been "on red" for many months, and the question arises as to why the filters have not yet been replaced. The problem may simply be that Facilities Services is unaware of these stations' filter statuses. More information should thus be provided about how to contact Facilities Services if a station's filter status indicates that the filter needs replacing. On this note, Facilities Services should

record every time a filter is installed in a station in order to help estimate when the filter will need to be replaced, as each filter's lifespan is approximately 20,000 bottles (Elkay n.d.b.). Improved records and communication will likely increase efficiency and have positive health implications, as dirty and old filters will be replaced in a timelier manner.

A complete inventory with the locations of all the campus filling stations should be posted on the Office of Sustainability's website in order to allow students, faculty, and other campus-goers to more easily find stations where they can refill their water bottles. The map that I created can also be elaborated upon by the Office of Sustainability and posted online, similarly to what Princeton, Harvard, and other peer institutions have done (Sustainability at Princeton n.d.; Harvard University Sustainability n.d.). Further, filling stations are not currently mentioned in UChicago's Sustainability Plan as part of the efforts that UChicago is making to reduce its environmental impact, even though filling stations are making a strong contribution to waste reduction and help save an estimated more than 4.6 million plastic water bottles annually. This is something of which UChicago should be proud, so the Office of Sustainability should incorporate filling stations more fully into UChicago's Sustainability Plan, as filling stations offer a low-cost option for reducing waste. By committing to improving the flow of information between university administration and students, the Office of Sustainability can encourage engaged participation in waste reduction through the increased use of filling stations.

Vb. Install Additional Bottle Filling Stations

While UChicago has installed numerous water bottle filling stations on campus over the past several years, there are still many locations on campus where there are few or no stations. Installing additional stations offers an opportunity for to reduce plastic waste by providing easily

accessible options for refilling reusable water bottles rather than purchasing plastic bottles of water. Of the 48 individuals who responded to the short answer question in the questionnaire inquiring as to where additional stations should be installed, 17 individuals identified the Regenstein Library as being in need of more stations (35.42%). Currently, the Regenstein only has one filling station on the first floor that serves the entire building and the attached Mansueto Library. Students expressed a desire for having filling stations on all seven floors of the Regenstein, as well as having one in the hallway near Mansueto. Given that the station on the first floor of the Regenstein Library is used frequently, as evidenced by the station observations and the green ticker data, it is likely that additional stations distributed throughout other areas of the building would be extremely beneficial in serving students' needs and in reducing plastic waste. Several hundred students visit this library every day, so installing more stations in this location is an opportunity for long-run cost-savings with regard to waste and carbon output.

Another building that was identified as a potential location for installing additional filling stations was Saieh Hall for Economics (SHFE). Some students indicated in their survey responses that they would like to see more stations in SHFE. Currently, some of the upper floors of the building have filling stations, but the first floor does not have a station. The estimated total occupancy of SHFE is 1,473 people, indicating that a large number of people visit this building every day, and this estimate does not include the number of people who pass through or visit the Starbucks in the building. Further, this building is already LEED Silver Certified, indicating the UChicago's dedication to making SHFE a low-impact building. I believe that installing at least one more filling station on the first floor of this building could provide a great waste-saving opportunity, as the high number of building occupants could take advantage of the station instead of relying on plastic disposable bottles and generating plastic waste.

I also recommend the installation of filling stations in all campus dorms. Currently, Campus North Residential Commons is the only dorm that has filling stations. Several students indicated in the questionnaire that they want stations to be installed in the dorm. As the dorms house approximately half of the undergraduate students, installing stations in these buildings seems like a logical next step, as the stations would likely be used frequently, which would contribute to significant waste reduction on campus.

The costs of installing and maintaining additional filling stations and the limited funds that Facilities Services and the Office of Sustainability are allotted by higher university administration may be prohibitive to installing a multitude of stations around campus. However, it is evident through the cost-benefit analysis conducted here that investing in bottle filling stations has significant short- and long-term net benefits, so additional filling stations should be installed. In the future, the Office of Sustainability could partner with student groups to conduct research investigating which locations on campus receive the most human traffic and yet do not have filling stations. By targeting high-traffic locations that are more likely to be cost-efficient, up-front costs to UChicago can be reduced, consumer demand can be met and a large amount of plastic waste can be offset.

Vc. Reduce Plastic Bottled Water Sales and Distribution

Many students indicated in their questionnaire responses that they still buy or drink plastic water bottles. Therefore, UChicago has the opportunity to reduce this number by implementing various policies that reduce or restrict the sale and/or distribution of plastic water bottles, therefore decreasing the chance of generating plastic waste in the first place. One option is to prohibit, or at least severely decrease, the sale of bottled water in campus convenience

stores, cafés, and vending machines. This will provide a high incentive for students and other campus-goers to fill reusable bottles and containers in the campus filling stations. Implementing policies as such would require the installation of more filling stations on campus to ensure that students have access to clean and healthy water in all buildings. This would ideally result in a significant increase in the use of filling stations and the reduction of plastic waste.

These restrictions or reductions on plastic bottled water distribution should be combined with the distribution of additional reusable bottles. Although UChicago already provides complimentary reusable water bottles to first years upon move-in on the first day of Orientation Week, these bottles may get broken, lost, or dirty over a span of four years. Thus, UChicago should provide additional water bottles during "Class Giveaway Days" to increase the chances that reusable bottles are used. These "Giveaway Days" could also offer an opportunity to inform studies about the positive effects that using reusable bottles can have on the environment, and to encourage students to use reusable bottles instead of plastic recyclable bottles. Materials could be distributed at these events that inform students about the negative impacts that plastic disposable bottles have on the environment, and maps of the filling stations on campus, like the one I created in this research and that would ideally be posted online, could be distributed as well. In addition, to ensure the safe consumption of water, the bottles distributed should be manufactured from BPA-free materials to reduce exposure to harmful chemicals (Cooper et al. 2011).

While access to plastic water bottles on campus would ideally be entirely restricted, I do recognize that this may not be a feasible reality. Even if the sale and distribution of plastic water bottles is prohibited, students, faculty, and other campus-goers could bring plastic bottles to campus that were acquired elsewhere. In addition, campus events almost always provide water to their attendees, frequently in the form of plastic water bottles because they are fairly cheap when

purchased in bulk and they require low maintenance. Therefore, it is crucial that recycling

services be expanded throughout campus. There should be a recycling bin next to every garbage

can, especially in the residence halls. Appropriate signage should accompany these bins in order

for individuals to effectively participate in sorting their waste and recycling plastic bottles.

Further, campus events could be encouraged to be run as "Zero Waste" events, or even be

prohibited from selling or distributing plastic water bottles. Similar to Cornell's initiative to

reduce plastic bottle waste, events could have water coolers, or, if located in a building with

filling stations, the event organizers could direct event attendees to the nearest filling station

(Cornell Sustainable Campus n.d.b.). If attendees do not have a reusable water bottle, they could

be given compostable cups, of which could be disposed in composting bins made available at the

event. Thus, composting efforts should also be expanded, something that many students strongly

support, as evidenced by many survey respondents expressing their concern about the lack of

extensive composting services. If campus events provide compostable cups instead of plastic

bottles or plastic cups, the only way that this can be effective is if composting services are

available. While UChicago does not currently have its own composting service available, the

Office of Sustainability could partner with student groups in supporting the connection to

Chicago-based vendors that are able to provide composting services, such as Healthy Soil

Compost (Healthy Soil Compost n.d.).

It should be acknowledged that bottle bans have had mixed results in the cities and on the

university campuses on which they have been implemented. In Concord, MA, the first U.S. city

to ban the sale of plastic bottled water, many residents are in support of the ban, or at least have

become accustomed to it as part of the status quo (Ellsbury 2016). However, some residents find

the ban inconvenient, or even harmful to the local economy, as people instead go to neighboring

towns to purchase bottled water and thus increase their consumption of goods outside of Concord (Sullivan 2014). Further, the University of Vermont banned disposable plastic water bottles from its campus in 2013, as part of a student-driven initiative to reduce plastic waste (Berman 2015). However, a study conducted in 2015 found that while the number of plastic water bottles decreased, the number of plastic bottles entering the waste stream increased (Berman 2015). Campus-goers likely substituted buying plastic water bottles with buying less healthy bottled beverages, such as soft drinks and juices. The consequences of these plastic water bottle bans must be taken into consideration if the decision is made to restrict the sale and distribution of plastic water bottles at UChicago. Namely, it is crucial to offer healthy and sustainable alternatives to disposable water bottles, including providing reusable water bottles to all students at the beginning of every school year. This will enable students to increase their consumption of tap water, especially through the use of filling stations, limit their consumption of plastic disposable bottles or their substitution to unhealthy plastic bottled beverages, and reduce the amount of plastic they contribute to the waste stream.

Vd. Increase Educational Signage

It is crucial that the efforts of installing additional bottle filling stations and reducing access to plastic water bottles are accompanied by endeavors to increase awareness of both filling stations themselves as well as the various problems surrounding plastic water bottles and plastic waste. Previous research conducted by the Environment, Agriculture, and Food Working Group at UChicago found that an effective, low-cost option for raising awareness about critical environmental issues is increasing signage that provides key information on the relevant issue (2016). Airports across the country are more widely installing bottle filling stations, and these

stations are often accompanied by signage to bring attention to and encourage airport-goers to use them (Brockman 2017). For example, signs above filling stations in Atlanta's Hartsfield-Jackson International Airport state in large fonts, "Help Delta & Atlanta's airport keep Georgia's Flint River flowing [and] fill your water bottle at a filling station on this concourse."[27] Highlighting the positive environmental and economic impacts that bottle filling stations can have is likely to motivate individuals to use the filling stations and reduce plastic bottle waste.

Informational signs should be posted by the filling stations, to encourage students and other individuals to use the stations. Other signs providing facts and figures about waste in general should be posted in places where students could generate waste, such as cafes on campus, dining halls, and campus convenience stores, as well as in high-traffic areas where students are likely to see the signs. As mentioned above, informational signage should also be hung above trash, recycling, and composting bins in order to help individuals appropriately sort their waste. Providing information about waste is a very simple and low-cost yet very important method that can encourage people to participate in waste reduction initiatives.

Ve. Enact Subsidies on Filling Stations and Taxes on Plastic Water Bottles

Despite the clear benefits that water bottle filling stations can have, the sizeable up-front costs associated with installing them cannot be ignored. As a result, implementing larger-scale policies should be considered. Grants have been made available by various foundations nationwide for schools that need assistance in funding the installation of bottle filling stations within their facilities (Johnson 2016). However, a step further could be taken, in that federal and state governments could offer subsidies for universities and other institutions that wish to install

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[27] I saw this sign when I was at the Atlanta airport in November 2017. There are likely many similar signs in other airports around the country that I have not seen personally.

bottle filling stations, similar to how tax credits and rebates are offered for installing renewable energy sources such as solar panels. Although this places a cost burden on the government, subsidies for bottle filling stations could be viewed as an investment by the government to help reduce future (and current) economic and environmental costs by providing opportunities to decrease the nation's carbon footprint.

In addition to offering subsidies for filling stations, local, state, and federal governments could help dissuade the purchase of plastic bottled water in the first place to help reduce waste. As mentioned above, many cities and states have implemented taxes on bottled water. Chicago imposes a $0.05 tax on every water bottle sold (City of Chicago 2008). It is important to note, however, that Chicago's Bottled Water Tax does not extend to all plastic bottles, such as soft drink or juice bottles. Ten states (CA, CT, HI, IA, MA, ME, MI, NY, OR, and VT) currently have "Bottle Bills" in place, which provide the opportunity for the tax imposed to be "reimbursed" to the purchaser if the bottle is returned to a specific bottle return site, where the bottle will be recycled (Container Research Institute n.d.). These Bottle Bills apply to plastic water bottles as well as other plastic bottle containers. Bottle Bills have been shown to increase recycling rates, although the number of bottles recycled is still low (Saphores and Nixon 2014). The effectiveness of the New York State Bottle Bill was examined shortly after its enactment in the 1980s and it was found that the five-cent deposit on bottles and cans decreased the amount of returnable litter, but had no effect on non-returnable bottles and cans (Levitt and Leventhal 1986). Therefore, the deposit-refund could be increased to encourage more recycling of plastic bottles. Increasing the tax on plastic water bottles and other plastic bottles could also help to further discourage individuals from purchasing plastic bottles and further encourage the transition to sustainable alternatives such as using water bottle filling stations.

VI. Conclusion

      In recent decades, the University of Chicago has made great strides to reduce its carbon footprint, by hosting campus events to increase awareness about critical environmental issues and by adopting energy-saving options in campus buildings. While often overlooked, the water bottle filling stations at UChicago are a successful initiative for improving campus sustainability while providing clean and healthy water to campus-goers. My research found that the 102 campus filling stations save more than 4.6 million plastic water bottles annually. In addition, the private and social benefits of installing filling stations greatly outweigh the costs to UChicago, suggesting that filling stations offer a low-cost opportunity to greatly reduce the reliance on plastic water bottles, the generation of plastic waste, and UChicago's overall environmental impact. UChicago should take efforts to improve the record-keeping of filling stations, to install additional filling stations in buildings with high foot traffic to meet student demand, and to reduce the sale and distribution of plastic water bottles. For these policies to be effective, recycling and composting services must be expanded throughout campus. Taking these actions will hopefully encourage more individuals to use reusable water bottles and participate in campus-wide sustainability efforts. The results from this research and the recommendations I offered will help UChicago serve as a leader amongst universities worldwide and a model for other institutions to follow when striving to reduce their own carbon footprints.

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Appendix 1: Student Station Use and Awareness Questionnaire

Survey: Water Bottle Filling Stations at UChicago

By selecting 'I agree' and continuing to complete the survey, you consent to participate.

○ I agree (1)

Do you own a reusable water bottle that you use on campus?

○ Yes (1)

○ I used to, but I do not anymore. (2)

○ I own one, but I do not use it on campus. (4)

○ No, I have never owned a reusable water bottle. (3)

How often do you use a reusable water bottle?

○ Every day (1)

○ Almost every day (2)

○ A few days per week (3)

○ A few days per month (4)

○ Never (5)

Why do you use a reusable water bottle? Please rate the following reasons on a scale from 1 (least important) to 5 (most important).

	1 (least important) (1)	2 (2)	3 (neutral) (3)	4 (4)	5 (most important) (5)
Environmentally friendly option (1)	○	○	○	○	○
Cost of purchasing plastic water bottles (2)	○	○	○	○	○
Health (3)	○	○	○	○	○
Convenience (4)	○	○	○	○	○

If given the choice between filling up your water bottle at a water bottle filling station (e.g. Elkay EZH20, Figure 1) and a regular drinking water fountain (Figure 2), which would you choose?

Figure 1   Figure 2

○ Water bottle filling station, every time (1)

○ Water bottle filling station, most of the time (2)

○ I am indifferent between the two options (3)

○ Water fountain, most of the time (4)

○ Water fountain, every time (5)

End of Block: Reusable Water Bottles

Start of Block: Plastic Water Bottles

How many plastic (recyclable) water bottles do you buy/drink per month?

○ 0 (1)

○ 1-3 (2)

○ 4-6 (3)

○ 7-10 (4)

○ More than 10 (5)

When you buy or drink plastic (recyclable) water bottles, what do you do with them when you are finished with them?

○ I always recycle them. (1)

○ I recycle them most of the time. (2)

○ I recycle them about half the time, and throw them into normal trash about half the time. (3)

○ I throw them into normal trash most of the time. (4)

○ I always throw them into normal trash. (5)

End of Block: Plastic Water Bottles

Start of Block: Water Bottle Filling Station Use

Are you familiar with the water bottle filling stations on campus? Please only reflect your use of water bottle filling stations at UChicago's Hyde Park campus in your answer to this question and all following questions.

○ Yes (1)

○ No (2)

Have you ever used one of the water bottle filling stations on campus?

○ Yes (1)

○ No (2)

○ I don't remember. (3)

Besides water bottle filling stations, where do you fill up your water bottles on campus? Please select all that apply.

☐ Bathroom sink (1)

☐ Kitchen sink in apartment/dorm/home (2)

☐ Water fountain (3)

☐ Refrigerator water dispenser (4)

☐ Other (5) _____

Approximately how many times per day do you use bottle filling stations?

○ Once (1)

○ Twice (2)

○ Three or more times (3)

Which of the following are important to you when choosing to use a water bottle filling station? Please rate on a scale of 1 (least important) to 5 (most important).

	1 (least important) (1)	2 (2)	3 (neutral) (3)	4 (4)	5 (most important) (5)
Convenience/only option available in the location (1)	○	○	○	○	○
Ease of filling up a water bottle (2)	○	○	○	○	○
Taste (3)	○	○	○	○	○
More sanitary than drinking water fountains (4)	○	○	○	○	○
Provision of cleaner, filtered water (5)	○	○	○	○	○
Sustainability/environmental friendliness (6)	○	○	○	○	○
Manufacturer reputation (7)	○	○	○	○	○
Meter data on filling station (8)	○	○	○	○	○
Filter status (red, yellow, green) on filling station (9)	○	○	○	○	○
Lack of plastic bottled water as an alternative (10)	○	○	○	○	○

Display This Question:

If Have you ever used one of the water bottle filling stations on campus? = Yes

At which locations have you used a bottle filling station? Please select all that apply.

- ☐ Regenstein Library 1st floor (1)

- ☐ Harper Memorial Library 1st floor (2)

- ☐ Harper Memorial Library Cafe (3)

- ☐ Cobb Hall 1st floor (4)

- ☐ Kent Hall (5)

- ☐ Basement of Reynolds Club (6)

- ☐ Ratner Athletic Center (7)

- ☐ Henry Crown Field House 2nd floor (8)

- ☐ Residence Hall (9) _____

- ☐ Other (10) _____

X→

How frequently do you use the bottle filling stations at each of the following locations?

	Never (1)	1-2 times per month (2)	1-2 times per week (3)	3-5 times per week (4)	Every day (5)
Regenstein Library 1st floor (x1)	○	○	○	○	○
Harper Memorial Library 1st floor (x2)	○	○	○	○	○
Harper Memorial Library Cafe (x3)	○	○	○	○	○
Cobb Hall 1st floor (x4)	○	○	○	○	○
Kent Hall (x5)	○	○	○	○	○
Basement of Reynolds Club (x6)	○	○	○	○	○
Ratner Athletic Center (x7)	○	○	○	○	○
Henry Crown Field House 2nd floor (x8)	○	○	○	○	○
Residence Hall (x9)	○	○	○	○	○
Other (x10)	○	○	○	○	○

Do you believe there are differences in water quality across various filling stations on campus?

○ Yes (1)

○ Maybe (2)

○ Probably not (3)

○ No (4)

If yes, please explain:

_____

What do you fill up when using a bottle filling station? Please select all that apply.

☐ Glass/cup (1)

☐ Plastic water bottle (2)

☐ Reusable water bottle (3)

What do you think about the number of bottle filling stations currently on campus?

○ The number of bottle filling stations currently on campus is perfect. (1)

○ The number of bottle filling stations is fine, but some of the stations should be moved to different locations. (2)

○ There should be additional bottle filling stations installed on campus. (3)

○ Other (4) _____

Where on campus should additional bottle filling stations be installed?

_____

What other sustainability efforts should the University take to reduce environmental impact?

_____

End of Block: Water Bottle Filling Station Use

Start of Block: Demographic Questions

Which do you identify with most?

○ Male (1)

○ Female (2)

○ Other (3) _____

Which applies to you?

○ Undergraduate student (1)

○ Graduate student (2)

○ Staff/faculty (3)

○ Non-university (4)

Which year are you in the college?

○ 1st year (1)

○ 2nd year (2)

○ 3rd year (3)

○ 4th year (4)

Please share any further comments about your experiences with water bottle filling stations.

_____

End of Block: Demographic Questions

Appendix 2: Locations of newly identified water bottle filling stations.

Description	Location	Building Name	Manufacturer
Drinking fountain, with bottle filler	First floor hallway	Anatomy	Elkay
Drinking fountain, with bottle filler	First floor hallway	Beecher Hall	Elkay
Drinking fountain, with bottle filler	Second floor hallway	Beecher Hall	Elkay
Drinking fountain, with bottle filler	Third floor hallway	Beecher Hall	Elkay
Drinking fountain, with bottle filler	Fourth floor hallway	Beecher Hall	Elkay
Drinking fountain, with bottle filler	Fifth floor hallway	Beecher Hall	Elkay
Drinking fountain, with bottle filler	First floor lobby	Biological Sciences Learning Center	Elkay
Drinking fountain, with bottle filler	Basement, outside Cobb café	Cobb Hall	Elkay
Drinking fountain, with bottle filler	First floor hallway	Cobb Hall	Elkay
Drinking fountain, with bottle filler	Second floor hallway	Cobb Hall	Elkay
Drinking fountain, with bottle filler	Basement hallway	Eckhart Hall	Elkay
Drinking fountain, with bottle filler	First floor hallway	Eckhart Hall	Elkay
Drinking fountain, with bottle filler	Second floor hallway	Eckhart Hall	Elkay
Drinking fountain, with bottle filler	Third floor hallway	Eckhart Hall	Elkay
Drinking fountain, with bottle filler	Fourth floor hallway	Eckhart Hall	Elkay
Drinking fountain, with bottle filler	First floor hallway	Erman Hall	Elkay

Description	Location	Building Name	Manufacturer
Drinking fountain, with bottle filler	Second floor hallway	Foster Hall	Elkay
Drinking fountain, with bottle filler	Third floor hallway	Foster Hall	Elkay
Drinking fountain, with bottle filler	Second floor hallway	Goodspeed Hall	Elkay
Drinking fountain, with bottle filler	First floor hallway	Harper Memorial Library	Elkay
Drinking fountain, with bottle filler	Second floor hallway, west tower	Harper Memorial Library	Elkay
Drinking fountain, with bottle filler	Third floor, next to Harper Café	Harper Memorial Library	Elkay
Drinking fountain, with bottle filler	Third floor, next to east elevator	Harper Memorial Library	Elkay
Hot water tap	First floor hallway	Hinds Laboratory	N/A
Bottle filler, standalone	Second floor stairwell	Jones Laboratory	Elkay
Bottle filler, standalone	Third floor stairwell	Jones Laboratory	Elkay
Drinking fountain, with bottle filler	First floor lobby	Kent Chemical Laboratory	N/A
Drinking fountain, with bottle filler	Basement hallway	Pick Hall	Elkay
Drinking fountain, with bottle filler and hot water tap	First floor, next to Ex Libris	Regenstein Library	Elkay
Drinking fountain, with bottle filler	Basement	Reynolds Club	Elkay
Drinking fountain, with bottle filler	Basement	Rosenwald Hall	Elkay
Drinking fountain, with bottle filler	Fourth floor hallway	Saieh Hall for Economics	N/A

Description	Location	Building Name	Manufacturer
Drinking fountain, with bottle filler	First floor lobby	Social Sciences Research Building	Elkay
Drinking fountain, with bottle filler	Second floor corner	Social Sciences Research Building	Elkay
Drinking fountain, with bottle filler	Third floor corner	Social Sciences Research Building	Elkay
Drinking fountain, with bottle filler	Basement, outside Grounds of Being café	Swift Hall	Elkay
Drinking fountain, with bottle filler	First floor lobby	Swift Hall	Elkay
Drinking fountain, with bottle filler	Second floor hallway	Swift Hall	Elkay
Drinking fountain, with bottle filler	Third floor hallway	Swift Hall	Elkay
Drinking fountain, with bottle filler	Fourth floor hallway	Swift Hall	Elkay
Drinking fountain, with bottle filler	Second floor	Wieboldt Hall	Elkay
Drinking fountain, with bottle filler	First floor hallway	Zoology	Elkay

Caitlin Piccirillo-Stosser
caitlinps702@uchicago.edu
(914) 924-7554
5442 S. Woodlawn Ave, Apt 1N
Chicago, IL 60615

EDUCATION

THE UNIVERSITY OF CHICAGO   Chicago, IL
Bachelor of Arts in Economics and Public Policy   Expected, June 2018
Cumulative GPA: 3.71/4.00

OSSINING HIGH SCHOOL   Ossining, NY
Advanced Regents Diploma   June 2014
Honors Included: Valedictorian, National Merit Commended Scholar, Intel Science Talent Search 2014 Semifinalist, Siemens Math: Science: Technology Competition 2013 Semifinalist

EXPERIENCE

Regeneron Pharmaceuticals, Inc.   Tarrytown, NY
Regeneron Genetics Center, LLC Business Operations and Legal Intern   June-September 2017
- Learned several legal terms and collaborated with several Legal team members to develop a matrix to summarize, compare, and analyze contract terms of all RGC collaboration agreements
- Analyzed international data protection laws and provided recommendations for expanding partnerships

Regeneron Genetics Center, LLC Business Operations Intern   June-December 2016
- Improved marketing strategies by developing resources for showcasing RGC capabilities
- Wrote editorial review paper on cost-effectiveness of genetic screening for a prevalent disease

UChicago Environment, Agriculture, and Food (EAF) Working Group   Chicago, IL
Student Coordinator   March 2017-Present
- Design and manage website, blog, and social media for scholarly working group
- Act as the key facilitator for EAF-sponsored events and group meetings

Researcher and Event Coordinator   March 2015-Present
- Conduct research projects such as improving sustainability practices in student-run campus cafes, reducing food waste in dining halls, and decreasing campus water consumption
- Organize on-campus events to increase awareness about sustainability and food initiatives

The University of Chicago College Housing   Chicago, IL
Program Coordinator   September 2015-June 2016
- Planned and implemented successful programs and events for dorm members alongside Housing Staff members
- Organized dormitory-wide study breaks and trips to Broadway shows, sporting events, and others

LEADERSHIP ACTIVITIES

Frizzell Speaker and Learning Series Committee, The University of Chicago   Chicago IL
Event Coordinator   September 2016-Present
- Develop programming for the year around topics related to agriculture, environment, and health
- Curate events and activities for the year, including hosting a keynote speaker in the spring

ArtShould, The University of Chicago   Chicago, IL
Mentor   January 2017-Present
- Teach arts and crafts to students at a local elementary school in Hyde Park
- Help students develop confidence to express themselves creatively through art

SKILLS
Language: Proficient in Spanish; basic skills in French; basic skills in Portuguese
Computer: Proficient in Microsoft Office suite; website and blog development (WordPress); basic skills in STATA

INTERESTS
Travel, intramural sports, Irish step dancing, baking